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Nutraceutical and Phytomedicinal Survey of Sclerotium of *Pleurotus Tuber-regium (ọsụ)*

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Abstract: *Pleurotus tuber-regium* is an edible marcofungi found in tropical and subtropical regions of the world and flourishes very well in South-Eastern Nigeria. The sclerotium (ọsụ) and the sporophores (ero) are edible non-poisonous marcofungi. The sclerotium of *Pleurotus tuberregium* is a compact dark brown mass of hardened fungal mycelium containing food reserves which help the fungi survive environmental extremes and it is viable for 7 years or more after harvest. Sclerotium of *Pleurotus tuber-regium* has been reported to have remarkable nutritional and medicinal values Nutritional, phytochemical and elemental analyses of sclerotium of *Pleurotus tuber-regium* have been investigated. The sclerotium was harvested from a decaying *Treculia africana* (breadfruit) tree. Proximate, phytochemical and GC-FID analyses were performed on the samples. Also, the elemental compositions of the sample was determined using atomic absorption spectrophotometer. The nutritional compositions of the sclerotium were 57.27% of carbohydrate, 6.06% of fiber, 3.50% of protein, 1.24% of fat and 0.57% of ash, with approximately 31.36% of moisture content. The presence of flavonoids (43.14%), tannins (3.23%), saponins (14.28%), alkaloids (8.89%), phenolic (4.39%), steroids (8.79%), organo-oxygen (9.19%) and anti-nutrients (8.12%) were also detected. The major elements identified in the sample were phosphorus (9.278ppm), copper (8.454ppm), magnesium (7.844ppm), zinc (7.565ppm), iron (5.125ppm), calcium (4.996ppm), sodium (4.454ppm), potassium (3.226ppm), and selenium (2.454ppm). The sclerotium is rich in moisture and nutritional constituents with high concentrations of carbohydrate, fiber and protein. Most of the compounds identified in the sample have medicinal prowess and the major elements detected showed that the sclerotium is a good source of essential minerals.

Keywords: Bioactive, Macrofungi, Ọsụ, Sclerotium

1. Introduction

Mushroom is one of the paramount known example of macrofungi. Unlike green plants, mushrooms are heterotrophs, and do not have chlorophyll; hence, they cannot produce food by photosynthesis, but instead take nutrients from other sources. *Pleurotus tuber-regium* is an edible marcofungi found in tropical and subtropical regions of the word and thrives very well in South-Eastern Nigeria. Both the sclerotium and the sporophores grown from it are eaten [1-4]; hence, they are non-poisonous. During the rainy season, different species of both edible and non-edible species commonly grow on several natural substrates such as garden soil, decaying wood, termite nest, palm wastes, leaf litters, under the shade provided by cocoa, teak, coffee and rubber plantations [5]. The fungi typically infect dehydrated wood, where they produce the sclerotia, frequently concealed within the wood tissues but also located between the wood and the bark [6]. Mushrooms have been known as a source of high quality food as they contain proteins, sugars, glycogen, lipids, vitamins, amino acids and crude fibres [7]. It is highly nourishing containing decent quality proteins and carbohydrates with little fat [8]. It has been reported that Pleurotus tuber-regium sclerotium contains good measure of essential amino acids, histidine, leucine and phenylalanine; also it has sufficient mineral elements: copper, iron, magnesium and manganese [2].

In Nigeria, the sclerotium of *Pleurotus tuber-regium* is known as “rumbagada” or “katala” in Hausa, “ọsụ” or “ero-ọsụ" or "ike- ọsụ" in Igbo, "umoho" in Igede, "ohu" in Yoruba, and "awu" in Igala [6, 9]. The sclerotium of *Pleurotus tuberregium* is a compact mass of hardened fungal mycelium containing food reserves which help the fungi survive environmental excesses [8]. It is often dark brown on the outside and white on the inside [2, 7]. The sclerotia are typically collected from decomposing logs [7].

Figure 1. *a. Unpilled and b. Pilled sclerotium of Pleurotus tuber-regium (ọsụ).*

Sclerotium of *Pleurotus tuber-regium* has been reported to have tremendous nutritional and medicinal values [7-8, 10]. Sclerotium of *Pleurotus tuberregium* is used as a soup thickener [11]. Ref [8] submitted that apart from its nutritional value, sclerotium is consumed due to its aroma and taste. It is comparatively inexpensive source of protein when related to animal proteins, mushrooms could also hold distinct attraction and may be recommended for people with cholesterol-related ailments [5, 7]. It has been reported that sclerotia of *P. tuberregium* contain polysaccharides and other compounds with positive medicinal benefits [10, 12]. Extracts of *Pleurotus tuber-regium* sclerotium in conjunction with some herbs can be used in preparations for treatment of malnutrition in infants, osteoporosis, kidney stones, colds and fever, smallpox headache, diabetes, obesity, sterility, anemia, mumps, stomach ailments, asthma, high blood pressure and also serve as good antitumor, anti-hyperglycemic and antihypertensive agents [11, 13-15]. It has been demonstrated that the sclerotium of Pleurotus tuber-regium is not toxic to experimental mice at the highest dose of 5000 mg/kg [3]. Therefore, they concluded that the extract from sclerotium of Pleurotus tuber-regium is reasonably safe when administered orally. Ref [16] reported that extracts of Pleurotus tuber-regium sclerotium can be used as substitute for conventional antibiotics; in fact, the antimicrobial activity against *pseudomonas aeruginosa* was significantly higher compared to standard antibiotics. It has been demonstrated that the sclerotium of Pleurotus tuber-regium can serve as a suitable tablet disintegrant [17-18]. Besides, *Pleurotus tuber-regium* has been reported to have been used in bioremediation [19-21]. Pleurotus tuber-regium was noted to have the ability to increase nutrient contents in soils polluted with oil.

Sclerotia are hard in nature and may be viable for 7 years or more after harvest. The sclerotia can also be cut into pieces and buried in the soil, and then watered regularly to produce the sporophore (mushroom) which is consumed. Sclerotia give rise to fruiting bodies in most environments at high temperatures. In this study the nutraceutical and phytomedicinal survey of sclerotium of Pleurotus tuber-regium (ụsọ) will be conducted.

2. Methods and Materials

Fresh sclerotium of *Pleurotus tuberregium* was harvested from a decaying *Artocarpus altilis* (breadfruit) tree. It was identified by Prof Ukpaka C. G. a Professor of botany in the department of biological sciences, Chukwuemeka Odumegwu Ojukwu University, Uli. 3.0kg of the sample was thoroughly washed with distilled water and dried in dust free condition for three weeks. The dark brown back was carefully removed with sterilized knife and inner white component was ground into fine particles for analyses.

2.1. Proximate Analysis

The proximate analysis of the a portion of the powdered sample was conducted to determine the moisture, protein, fat, ash, fiber, and carbohydrate contents, all of which were carried out in triplicates according to standard methods [22]. Total energy was evaluated using the relationship given in equation 1 [23].

$$Energy = 4(protein + carbohydrate)g + 9(fat)g \quad (1)$$

2.2. Phytochemical Analysis

Phytochemicals were determined by the ratio between the area and mass of internal standard and the area of the identified phytochemicals. The concentration of the different phytochemicalss express in ug/g.

2.2.1. Extraction of Phytochemicals

1g of sample was measured and put into a test tube and 15ml ethanol and 10ml of 50%m/v potassium hydroxide were added. The test tube with its content was allowed to react in a water bath at 60°C for 60mins. At the end of the reaction, the reactants contained in the test tube were transferred to a separatory funnel. The tube was washed with 20ml of ethanol, 10ml of cold water, 10ml of hot water and 3ml of hexane, which was all transferred to the funnel. This extracts were combined and washed three times with 10ml of 10%v/v ethanol aqueous solution. The solution as dried with anhydrous sodium sulfate and the solvent was evaporated. The sample was solubilized in 1000ul of pyridine of which 200ul was transferred to a vial for analysis.

2.2.2. Quantification by GC-FID

The analysis of phytochemical was performed on a BUCK M910 Gas chromatography equipped with a flame ionization detector. A RESTEK 15 meter MXT-1 column (15m x 250um x 0.15um) was used. The injector temperature was 280^{o}C with splitless injection of 2ul of sample and a linear velocity of 30cms^{-1}, Helium 5.0pa.s was the carrier gas with a flow rate of 40 m/min^{-1}. The oven operated initially at 200°C, it was heated to 330°C C at a rate of 3°C min^{-1} and was kept at this temperature for 5min. The detector operated at a temperature of 320°C.

2.3. Minerals Analysis

The elemental composition of the sclerotium of *Pleurotus tuberregium* was conducted using Varian AA240 Atomic Absorption Spectrophotometer (AAS). A series of standard metal solutions in the optimum concentration range was prepared, the reference solutions were prepared by diluting the single stock element solutions with water containing 1.5ml concentrated nitric acid/litre. A calibration blank was prepared using all the reagents except for the metal stock solutions. Calibration curve for each metal was prepared by plotting the absorbance of standards versus their concentrations.

3. Results and Discussion

Proximate analysis of sclerotium of *Pleurotus tuberregium* is presented in table 1. The proximate analysis of the sclerotium indicates that it is rich in moisture and nutritional constituents. The results are expressed as percentage concentration which is the same as gram per 100gram with mean value of the triplicate results ± standard deviation. The moisture content of the sample has an average value of 31.36g/100g which is apparently high. The level of moisture in conjunction with rich nutritional constituents will promote the growth of fungi and bacteria if not properly preserved. Ref [8] reported that blended sclerotium can easily grow moldy on storage. Consequently, proper drying is necessary to preserve sclerotium for medicinal and nutritional purposes without putrefaction. Ref [24] submitted that the moisture content of food crops could be reduced to 5.98% which is within the recommended range of 4-7%. Such drying condition is achieved using convective environment, and following two-term exponential drying model [25]. Properly dried sclerotia can stay viable for more than seven years after harvest.

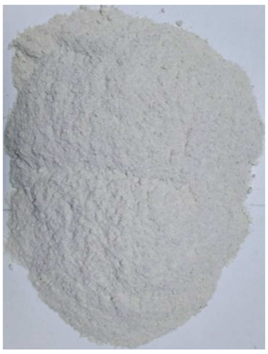

Figure 2. *Dried sclerotium of Pleurotus tuber-regium (ọsụ) grounded powder.*

Carbohydrate is the most available nutritional component in the sample with an average value of 57.27g/100g. The result is almost the same value as earlier reported by [16] and lower when compared with the values reported by other authors [8, 11]. The carbohydrate content reported for sporophores of *Pleurotus tuberregium* was slightly higher [14]. Carbohydrates are known to be responsible for providing energy, biological recognition processes, breaking down of fatty acids, building macromolecules and regulation of blood glucose. The high concentration of carbohydrate makes sclerotium consumption a healthy practice.

The fiber content of the sclerotium of *Pleurotus tuberregium* has an average value of 6.06g/100g. It is the second highest nutritional component in the sample besides carbohydrate. The value is lower than that earlier reported in the sclerotium of *Pleurotus tuberregium* [11, 16] but higher than the value reported for the sporophores of *Pleurotus tuberregium* [14]. It has been reported that fiber consumption may contribute to reduction in the incidence of certain diseases like diabetes, coronary heart disease, colon cancer, high blood pressure, obesity, and various digestive disorders [6]. It is necessary for healthy condition, curing of nutritional disorders and for food digestion [26]. Crude fibres add slight to nutritional value of foods but help in proper peristaltic functioning of the alimentary system [27]. Fiber is very important dietary content for vegetarians.

Protein content of the sample has an average value of 3.50g/100g. This is almost same as reported earlier [11] but it is less than the value reported for the sporophores of *Pleurotus tuberregium* [14]. Protein is noted for its immune function and tissue building, making *Pleurotus tuberregium* valuable in combating of malnutrition in infants. Protein is needed to form blood cells, protects, forms, rebuilds, maintains and grows tissue, skin, hair, muscle, connective tissue, bone marrow and vital organs. Protein deficiency can lead to reduced intelligence or mental retardation [26]. Proteins are vital constituent of diets required for normal growth and cell development. Proteins supply the essential amino acids needed for body building and upkeep of proper pH in nutrition [27].

The sclerotium of *Pleurotus tuberregium* has low fat content of about 1.24g/100g which makes it a healthy diet for humans since undue fats in diet might lead to cardiovascular disorders such as atherosclerosis [8]. Although fats formed a major source of energy in the body, [28] recommends a maximum daily intake of 30 calories for adult to avoid obesity, diabetes and heart diseases [27]. The variation in the nutritional content of sclerotium as observed when compared with earlier researches could be influenced by a number of factors that may include growing site, type of substrates, and developmental stages of sclerotia [7, 11, 29]. The total energy of the sclerotium of *Pleurotus tuberregium* is 254.24 kcal. The total energy is relatively lower than energy values reported for other food spices; fruit of tetrapleura tetraptera: 292.17 kcal [30], piper guineense seeds: 350.34 kcal [31] and ginger: 386.06 kcal [32].

Table 1. *Proximate Composition of sclerotium of Pleurotus tuberregium.*

Parameter	ASH	MOISTURE	FIBER	FAT	PROTEIN	CARBOHYDRATE
Conc. %	0.57±0.10	31.36±2.03	6.06±0.32	1.24±0.04	3.50±0.06	57.27±4.24

Table 2. *Phytochemical composition of sclerotium of Pleurotus tuberregium.*

Type of Phytochemical	Component	Retention	Area	Height	Concentration (µg/ml)	Composition (%)
Flavonoids (43.14%)	Catechin	2.390	12079.7082	223.098	4.2431	2.47
	Anthocyanin	4.120	6303.2894	116.993	8.6765	5.05
	Rutin	6.016	18223.8885	330.217	11.3086	6.58
	Flavan-3-ol	12.970	6155.5198	113.128	4.2908	2.50
	Naringin	17.966	11123.6380	204.891	10.3419	6.02
	Flavonones	20.313	12481.4190	228.894	7.3861	4.30
	Kaempferol	25.650	10006.5650	182.904	9.0087	5.24
	Flavone	32.996	14308.4383	260.056	8.8790	5.17
	Epicatechin	34.600	5872.8319	109.164	7.5947	4.42
	Proanthocyanin	42.276	3495.6477	63.894	2.3927	1.39
Tannins (3.23%)	Tannin	7.470	8302.5352	253.827	5.5447	3.23
Saponins (14.28%)	Sapogenin	10.366	19532.1202	355.819	24.5408	14.28
Alkaloids (8.89%)	Lunamarin	0.279	4275.0612	368.972	5.4768	3.19
	Spartein	15.460	4882.1464	89.919	2.0607	1.20
	Epihedrine	44.170	10559.9278	191.980	7.7433	4.50
Phenolic (4.39%)	Resveratol	39.200	10092.8634	185.203	7.5543	4.39
Steroids (8.79%)	Steroids	22.730	9444.2704	173.278	15.1060	8.79
Organooxygen (9.19%)	Cyanogenic glycoside	27.536	11372.0654	208.605	15.7945	9.19
Anti-nutrients (8.12%)	Phytate	29.860	5353.2078	98.885	7.0153	4.08
	Oxalate	36.876	6756.7168	125.509	6.9462	4.04

The phytochemical analysis of sclerotium of *Pleurotus tuberregium* is presented in table 2. The result indicated that it contains flavonoids (43.14%), tannins (3.23%), saponins (14.28%), alkaloids (8.89%), phenolic (4.39%), steroids (8.79%), organo-oxygen (9.19%) and anti-nutrients (8.12%). Similar results had been reported by other researchers [16, 33]. Flavonoids consist about 74.1654 µg/ml of phytochemical composition of the sclerotium. The flavonoids identified include catechin, anthocyanin, rutin, flavan-3-ol, naringenin, flavonones, kaempferol, flavone, epicatechin and proanthocyanin. Among the flavonoids, rutin had the highest concentration of 11.31 µg/ml while proanthocyanin had the lowest concentration of 2.23 µg/ml. Flavonoids had been reported to have health benefits such as antifungal, antibacterial, anti-inflammatory, antioxidant, anti-allergic, antiplasmodic, anti-thrombotic, anti-carcinogenic, anti-mutagenic, and enzyme modulatory functions [34-38].

Naringenin has anti-inflammatory, anti-diabetic, anti-hyperlipidaemia, antioxidant and antidepressant properties, capacity to assist in the management of cancer, cardiovascular diseases and osteoporosis, can reduce oxidative stress [38]. Flavonones have antioxidant, antihyperlipidemic and anti-inflammatory properties [38]. Rutin has the properties of antioxidant, cytoprotective, vasoprotective, cardioprotective, neuroprotective and anti-carcinogenic [38].

Kaempferol has anti-diabetic, anti-cancer, anti-inflammatory properties [38]. Cathechin possesses enormous health benefits such as anti-obesity, anticancer, hepatoprotective, antidiabetic, and neuro-protective effects while epicatechins are known to possess cardio-protective, antioxidant, anti-diabetic and anti-cancer activities [38].

The concentration of tannins is about 5.5447 µg/ml. Tannins are a very complex group of plant secondary metabolites, which are soluble in polar solution and are distinguished from other polyphenolic compounds by their ability to precipitate proteins [6, 39]. Tannins possess antibacterial, antiviral, astringent, antimicrobial, anti-inflammation and antioxidant activities, and had been used in wound healing and treatment of diarrhea, gastrointestinal ulcers and tumours [6, 37-38, 40].

Sapogenin, a sponins, has the highest concentration of 24.54 µg/ml representing 14.28% of the total composition. They exhibit anti-inflammatory and immune-boosting properties as well as antibacterial effects Saponins possess immune-boosting, anti-inflammatory, antifungal, antiviral, antibacterial, and anti-carcinogenic properties [34-35, 38]. These chemicals may help reduce cholesterol levels, scavenge oxidative stress and inhibit tumor growth, improve lipid metabolism and could help avert and ameliorate obesity. Owing to their antibacterial and foaming properties, these compounds are added to shampoos, soap, household cleaners and makeup products.

Alkaloids consist 15.2808 µg/ml of phytochemical composition of the sclerotium representing 8.89% of the total content. The three forms of alkaloids detected are Lunamarin, Spartein and Epihedrine. Alkaloids have diverse and important physiological effects on humans and other animals. The medicinal properties of alkaloids are quite diverse. Many alkaloids are valuable medicinal agents that can be utilized to treat various diseases including malaria, diabetics, cancer, and cardiac dysfunction [41]. They have been suggested to perform analgesic, antibacterial, antimicrobial, antiprotozoal and antiplasmodic effects [35, 38, 42]. Lunamarin is a quinolone alkaloid with the potentials of anti-estrogenic anticancer, immunomodulatory, and anti-amoebic. Spartein can serve as antiarrhythmic agents and cervical cancer chemotherapy [43]. Ephedrine is a phenethylamine alkaloid with potential of bronchodilatory and anti-hypotensive activities. It can be used for the treatment of allergic rhinitis often caused by pollen, a common allergic condition causing itchy, watery eyes, sneezing and other similar symptoms and bronchial asthma.

Steroids are another component of the phytochemical analysis of sclerotium with composition of 15.1060 µg/ml. Steroid could be corticosteroid or anabolic steroid; anabolic steroids are often used illegally by some people to increase their muscle mass. Nevertheless, corticosteroids are anti-inflammatory and affect the immune system. They are used in the treatment of asthma, arthritis, autoimmune diseases such as lupus and multiple sclerosis, skin conditions such as eczema and rashes, some kinds of cancer.

The sclerotium contains about 7.55 µg/ml of phenolic. Phenolics are broadly distributed in the plant kingdom and are the most abundant secondary metabolites of plants and hence an integral part of human diets. It acts as an anticlotting agent, immune enhancer and hormone modulator [44]. It has antioxidant effect and inhibits the growth of cancer hence it intervenes at all stages of cancer development [45].

The concentration of anti-nutrient is found to be 13.9615 µg/ml representing about 8.12% of the total concentration. Phytate and oxalate are the two anti-nutrients detected with concentration of 7.0153 µg/ml and 6.9462 µg/ml respectively. The value of the anti-nutrient in sclerotium is relatively minimal. Phytate is the principal storage form of phosphorus in many plant tissues. It is the free-acid form of inositol polyphosphate that can form complexes with metals or proteins and therefore reduce their bioavailability. Hence, it has effects on absorption and digestion of some minerals and impacts negatively on some protein and lipid utilisation in the body. This is possible due to its affinity to chelate with cations such as magnesium, calcium, iron, zinc, potassium and copper to form insoluble salts [46]. It is usully found in the storage tissues or reproductive organs of plant. Oxalate occurs in many plants as calcium oxalate deposit, as it helps to get rid of extra calcium in plants by binding with it. The biological roles of oxalate in the plant include calcium regulation, tolerance to heavy metals, and protection against herbivores [46].

Table 3. *Elemental composition of sclerotium of Pleurotus tuberregium.*

S/N	Parameters	Composition (ppm)	S/N	Parameters	Composition (ppm)
1	Phosphorus	9.278	12	Molybdenum	0.111
2	Copper	8.454	13	Silver	0.102
3	Magnesium	7.844	14	Nickel	0.094
4	Zinc	7.565	15	Cadmium	0.045
5	Iron	5.124	16	Lead	0.045
6	Calcium	4.996	17	Silicon	0.045
7	Sodium	4.454	18	Cobalt	0.034
8	Potassium	3.226	19	Aluminum	0.023
9	Selenium	2.454	20	Tin	0.006
10	Chromium	0.499	21	Mercury	0.000
11	Manganese	0.156			

Table 3 revealed the elemental composition of sclerotium of Pleurotus tuberregium. The results show that sclerotium of *Pleurotus tuberregium* is a good source of essential minerals. Previously, Ca, Mg, K, Mn, Cu, Zn and Fe had been indicted in the sclerotium of Pleurotus tuberregium [11]. The major elemental compositions in the present survey are P, Cu, Mg, Zn, Fe, Ca, Na, K and Se. Calcium, magnesium, phosphorus, iron, and potassium help in the maintenance of acid-base balance of hydrogen ion concentration of the body [26]. Phosphorus is the second most plentiful and essential mineral in the body and it is a key component of DNA/ RNA in the body [26]. It is essential component of bone mineral [26, 47]. It plays important roles in energy, and cell metabolism [48]. Deficiency of phosphorus- calcium balance result in osteoporosis, arthritis, pyorrhea, rickets and tooth decay [47]. Sodium and potassium are important intracellular and extracellular cations respectively. Sodium is involved in the regulation of plasma volume, nerve and muscle contraction [47, 49-50]. Potassium assists in the regulation of electrolyte, water and acid base in the body and muscle function [50]. Calcium and iron furnish all the cells and tissues of the body with the elements and the nutritional enzymes which they need [26]. Calcium supports the skeleton by providing rigidity to it and acts as an activator for numerous important enzymes, including pancreatic lipase, acid phosphatase, cholinesterase, ATPase, and succinic dehydrogenase [34, 50-51]. It is an essential mineral for the prevention of osteoporosis and the formation of strong bone and teeth [11]. Its deficiency can cause tetany and malformation of bones in young animals [26]. Iron is vital for numerous body metabolic activities; more importantly as it is component of haemoglobin and oxygen transport in the body system. Its' shortage may lead to anaemia which is commonly associated with fatigue, heart failure/palpitations, pale skin, and breath seizure [26, 47]. Iron is needed for physical development and growth, as well as production of certain hormones [27]. The iron content of 5.124ppm detected in the present study implies that consumption of 200 g of sclerotium of *Pleurotus tuberregium* will provide sufficient iron to meet the recommended daily allowance (RDA) for school age children as suggested by ref [1].

Mg contributes to the structural growth of bone and also plays an important role in the active transport of calcium and potassium ions across cell membranes, a process that is crucial to nerve impulse conduction, muscle contraction and normal heart rhythm [11]. It is essential in the reduction of blood pressure [26]. It is a cofactor in more than 300 enzymes systems performing indispensable role in energy production and nucleic acid synthesis [27]. Magnesium deficiency may play a major role in some cases of heart disorders; high blood pressure, nervous disorders and anemia [26-27]. Zinc is an essential micronutrient for human growth and immune functions. It is an active component or cofactor for many important enzyme systems zinc plays a vital role in lipid, protein, and carbohydrate metabolism [50]. High zinc content also suggests that increased consumption of edible mushrooms could help reduce the growing incidence of micronutrient shortage [1]. Copper is a powerful pro-oxidant [50]. It acts as metalloproteins and enzymes in the body deficiency and could lead to kidney and liver dysfunction [27]. Copper plays a key role iron metabolism, skin pigmentation, formation of bone and connective tissue [52]. Iron is responsible for haemoglobin formation, regulation of the central nervous system and oxidation of protein, fats and carbohydrates [50]. Selenium participates in the biosynthesis of ubiquinone [50]. It is an essential component of the enzyme glutathione peroxidase and it influences the absorption and retention of vitamin E.

Manganese is vital for bone formation, the rejuvenation of red blood cells, carbohydrate metabolism, and the reproductive cycle [53]. Chromium is a cofactor for the hormone insulin and is key in cholesterol and amino acid metabolism [54]. Chromium (III) is a crucial element for healthy growth while Chromium (VI) compounds are toxics and noxious in humans [27]. Manganese (Mn) is vital for growth and health maintenance; it is related to antioxidant systems, carbohydrate and fat metabolism [27]. Mn deficiency is rare in man but could result in poor skeletal development and low fertility [27]. Cobalt is an integral component of cyanocobalamin (vitamin B12), and as such is essential for red blood cell formation and the maintenance of nerve tissue [50]. Aluminum is a supplementary element and its buildup can cause sequence of illnesses in humans such as central nervous, skeletal, Alzheimer's diseases and hematopoietic systems of humans [27]. The recommended provisional weekly intake of aluminum is 60mg/week for adult [55]. However, [56] opined that most Aluminum consumed does not buildup in the body to the point of toxicity since some ligands such as fluoride and citrate are required for aluminum to be absorbed by the intestine; they are usually excreted from the body.

There were traces of toxic metals (Ni, Cd and Pb) in the sclerotium of *Pleurotus tuberregium*. The concentrations these metals were low in the test sample and low concentrations could be indicative of heavy metals from natural sources only [57]. Lead and cadmium are heavy metals when in excess can cause a deleterious effect in the general performance of an animal [34]. Ref [57] reported that the acceptable daily intake of Pb for adults is between 0.21 and 0.25 mg per day; which implies that the concentration of lead is within acceptable range. They also indicated that sclerotium of *Pleurotus tuberregium* is safe for human consumption.

4. Conclusion

The proximate, phytochemical and elemental composition analysis of sclerotium of *Pleurotus tuberregium* has been investigated. Proximate analysis revealed that it contained 57.27% of carbohydrate, 6.06% of fiber, 3.50% of protein, 1.24% of fat and 0.57% of ash. The nutritional content makes it a good diet for all ages especially for vegetarians. It contains about 31.36% of moisture content which is relatively high. Adequate drying process and condition are needed to reduce the moisture content to acceptable standard, which will discourage the attack of fungi, without compromising the nutritional and medicinal values of the sclerotium. Phytochemical analysis detected the presence of flavonoids, tannins, saponins, alkaloids, phenolic, steroids, organo-oxygen and anti-nutrients. Sclerotium of *Pleurotus tuberregium* therefore has diverse therapeutic values and the consumption can assist in the management of nutrient deficiency related diseases and boosting of the human immune system. Major elements found in the sclerotium of *Pleurotus tuberregium* are phosphorus, copper, magnesium, zinc, iron, calcium, sodium, potassium, and selenium. It also has traces of chromium, manganese, molybdenum, silver, nickel, cadmium, lead, silicon, cobalt, aluminum, and tin. Hence, sclerotium of *Pleurotus tuberregium* is a good source of essential minerals.

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