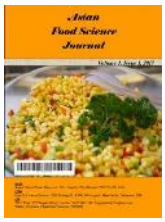

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Phytochemical Screening, Proximate Composition and Antibacterial Activity of Oyster Mushroom, *Pleurotus ostreatus* Collected from Etim Ekpo in Akwa Ibom State, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study determined the phytochemical, elemental and proximate nutritional compositions of *P. ostreatus* as well as the antibacterial potentials of the macro fungus collected during the tropical rainy season on selected bacteria.
Methodology: The disease-free oyster mushroom fruiting body was collected from the wild bush at Etim Ekpo, in Akwa Ibom State, Nigeria. Preparation of the oyster mushroom material, ethanolic and aqueous extracts; bacterial culture, isolation and identification, screenings for phytochemical and nutritional constituents were done according to standard methods, while antimicrobial screening was carried out by agar well diffusion technique.
Results: The preliminary phytochemical analysis of the extracts showed the occurrence of active polar compounds at varying amounts such as glycosides, alkaloids, saponins, flavonoids, reducing compounds, polyphenol, tannins, steroids/triterpenoids, proteins and amino acids. The wild edible

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oyster mushroom displayed varying degrees of inhibition on the test organisms. Ethanol extract had good antibacterial activity against all the test isolates compared to aqueous extract as indicated by the mean diameter of inhibition zones in the order of 27.50±0.02 mm > 25.30±0.01 mm > 24.40±0.01 mm for *Staphylococcus aureus*, *Proteus sp*ecies and *Escherichia coli* respectively. *E. coli* was the most sensitive organism in aqueous extract (20.60±0.01 mm). The only resistant organism was *S. aureus* (15.80±0.02 mm) in aqueous extract. Proximate analysis revealed high levels of moisture (78.28±0.02 mg/100 g), carbohydrate (52.74±0.02 mg/100 g) and .crude protein (28.40±0.1 mg/100 g). Ethanol extract showed good nutritional potentials, with Vitamin A (295.72±0.02), proteins (28.40±0.1) and carbohydrates (52.74±0.02) present in a higher amounts. Elemental nutrients such as Fe=167.42 mg/100 g dry weight and Ca=32.08 mg/100 g dry weight were also detected.

Conclusion: The results obtained in this study have shown the potential of oyster mushroom extract as a good therapeutic agent and food supplement. It could find applications as dietary supplements and possibly as alternative antibacterial agents.

Keywords: Antibacterial; extracts; oyster; phytochemicals; Pleurotus ostreatus.

1. INTRODUCTION

The wild edible oyster mushroom, *Pleurotus ostreatus* (Jacq.) P. Kumm, (Oyster mushroom) has long been regarded as a good source of nutritional food with excellent therapeutic potentials. It is regarded as a popular delicacy in Nigeria mostly because of its health benefits [1]. Mushroom is broadly defined as the fleshy spore bearing fruiting body of a fungus that could either be epigenous or hypogenous when produced and is large enough to be seen with unaided eye and to be picked by hand [1,2]. Wild edible mushrooms have a worldwide distribution and remain a popular source of delicacy in many countries of the world [3]. Edible mushrooms are the fleshy and edible fruit bodies of several species of fungi. Edibility may be defined by criteria that include absence of poisonous effects by human and desirable taste by aroma. Edible mushroom include many fungal species that are either harvested wild or cultivated. Easily cultivatable and common wild mushrooms are often available in market and those that are more difficult to obtain may be collected on a similar scale by private gatherers. Some preparations may render certain poisonous mushrooms fit for consumption. Before assuming that any wild mushrooms are edible, it should be identified and tested. Proper identification of the species is the only safe way to ensure edibility [2,3]. Some mushrooms that are edible for most can cause allergic reactions in some individuals, and old or improperly stored mushroom can cause food poisoning. Deadly poisonous mushrooms that are frequently confused with edible mushrooms are responsible for many fatal poisonings. These include several species of the *Amanita* Pers. genus, in particular, *Amanita phalloides,* the *death cap. Agaricus bisporus* contains carcinogens called hydrazines. However, the carcinogens are destroyed by moderate heat when cooking [4].

Wild edible mushroom, *P. ostreatus* commonly known as oyster mushroom remains one of the most important edible mushroom worldwide owing to its unique nutritional and medicinal values, characteristic aroma and taste [5]. Oyster mushroom is often regarded as being highly rich in nutritional constituents and with potential economic value. It is regarded as a good source of nutraceuticals, and has been widely used in traditional medicine for a broad range of disease because of its medicinal value [6]. Many species of wild edible mushrooms, including *P. ostreatus* are regarded as excellent therapeutic foods for their anti-carcinogenic, antibacterial, anti-cholesterolaemic and anti-viral properties [7]. Wild edible mushrooms are used medically for diseases involving depressed immune function, allergies, fungal infection, cancer, bronchial inflammation, heart disease, frequent flu and colds, hypertension, diabetes and hepatitis [8].

The fruiting body and mycelium of wild edible oyster mushroom composed of compounds with wide range of antibacterial activity. The cell wall glucans or the carbohydrate components are prominent for their immunomodulatory properties together with a good number of external secondary metabolites that are lethal to bacteria and viruses, hence they are known to be rich sources of antimicrobials [9,10]. It is also noted that many species of mushroom contain antimicrobial compounds that serve protective function allowing them to survive in their natural

environment, while some of them play beneficial roles in humans when consumed [11].

Several preliminary studies have shown that oyster mushroom accumulates a variety of phytochemicals and nutritional constituents, such as glycosides, carbohydrates, phenols, tannins, phytosterols, alkaloids, saponins, vitamins, terpenoids, proteins, fats and elemental nutrients in varying amounts depending on the extract used [12,13,14]. Currently, a lot of researches have been carried out using methanol and aqueous extracts as solvents to obtain pharmacologically active compounds, phytochemicals, antioxidants and nutritional compounds from the wild edible oyster mushroom [8,15]. In Nigeria, and Akwa Ibom State in particular, indigenous oyster mushroom are harvested from forests and farmlands for subsistence use and commercial purposes. The need for commercial production of all edible mushrooms in the State cannot be overemphasized in view of its potential use as nutraceuticals and as a source of cheap protein [16]. Therefore, this study was aimed to investigate the phytochemical, elemental and proximate nutritional compositions of wild edible mushroom collected from the wild bush in Etim Ekpo Local Government Area, as well as the antibacterial activity of different extracts on selected bacteria.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out between March, 2018 and September, 2018 at the Microbiology Laboratory of Obong University, located at Etim Ekpo Local Government Area. Etim Ekpo, created from the former Abak division is one of the Annang-speaking areas with GPS coordinates 5°1'N 7°37'E and time zone UTC +1 (WAT). According to the National Population Commission of Nigeria (web) and the National Bureau Statistics (web), the population statistics of Etim Ekpo is 148, 800 (2016 population census). It is a town situated in Akwa Ibom State, South-South geopolitical zone of Nigeria.

2.2 Collection and Identification of the Mushroom Material

The disease-free oyster mushroom fruiting body was collected from the wild bush at Etim Ekpo Local Government Area of Akwa Ibom State and was labeled as sample no. 15. It was kept in a dry sterile plastic bag to reduce decomposition and transported in this form to Calabar, Cross River State, where it was properly identified by the Biochemistry Department of the University of Calabar, Calabar, Nigeria as *P. ostreatus*.

2.3 Laboratory Preparation of Wild Oyster Mushroom Material

After identification, the fruiting body of oyster mushroom was brought to the laboratory in a sterile plastic bag, washed thoroughly with sterile distilled water to remove sand and other contaminants before sundried for 2 days. The dried samples were pulverized using electric blender to obtain fine powder. The pulverized sample with characteristic white color was sieved (0.2 mm) and stored in sterile airtight containers until required for further laboratory investigation.

2.4 Source of Test Bacteria and Identification Techniques

Three clinical bacterial isolates namely, *Escherichia coli*, *Proteus species*, and *Staphylococcus aureus* stored in Bijou bottles at 4-8°C were obtained from Microbiology Laboratory of the University of Uyo Teaching Hospital and transported in ice park to the study laboratory. Identity of the isolates was confirmed microscopically after sub-culturing by Gram's staining. They were further identified using the following biochemical tests: Indole, catalase, oxidase, coagulase and sugar fermentation tests.

2.5 Ethanol Extraction

Ethanolic extract of *P. ostreatus* was prepared using 75% ethanol. Exactly 10 g of the powdered wild oyster mushroom was weighed out into a sterile beaker container containing 100 mL of 75% ethanol, stirred, wrapped with aluminum foil and allowed to stay for 72 hours at room temperature (25°C). After 72 hours, it was filtered and the solvent was heated in a water bath to evaporate completely. The slurry left behind was then stored in McCartney bottles and kept at 4°C until required for use [17,18].

2.6 Aqueous Extraction

A portion (5 g) of powdered mushroom material was soaked in 50 mL of sterile distilled water, stirred and left overnight. After 24 hours, the suspension was filtered using Whatman No.1 filter paper and the filtrate was heated in a water bath at 70°C to allow the solvent to evaporate to dryness to eliminate the water. The extract was

labeled and stored in the refrigerator until required for further analysis [1,17].

2.7 Screening for Antibacterial Activity by Agar Well Diffusion Assay

Screening for antibacterial activity was done by agar well diffusion technique as described by Adeniyi et al. [18]. Plates of Mueller Hinton Agar (MHA) were inoculated with 0.1 mL of a 24 hr broth culture (equivalent to 0.5 MacFarland turbidity standard) of each bacteria isolate in sterile Petri-dish. The seeded plates were rocked to obtain homogenous distribution of the isolates and allowed to set. Holes were bored on the plates with the aid of a sterile cork borer of 5mm diameters and equal volumes of 50µL of extract were introduced in the wells using a micropipette. The plates were allowed to stand for an hour at room temperature to allow for proper diffusion of the extract, before incubation for 24 hr at 37°C. After incubation, the diameter of zones of inhibition was measured, including the 5 mm diameter of the hole using a digital caliper. The experiments were carried out in triplicates and the mean values were calculated and recorded in millimeter. Antibacterial activity was recorded when the zone of inhibition was greater than 15 mm. For positive control, Ofloxacin (5 µg) disc was used while; a solution of only dimethylsulfoxide (DMSO) and water in equal ratios was used as negative control.

2.8 Preliminary Phytochemical Screening

The freshly prepared ethanolic and aqueous extracts were subjected to phytochemical analysis using the following tests:

2.8.1 Test for alkaloids

Three tests, Dragendoff's, Mayer's and Wagner's tests were performed for the presence of alkaloids. A 2 mL portion of each extract was stirred with 5 mL of 1% aqueous HCl in water bath. 1 mL of the filtrate of each sample was treated with few drops of Dragendoff's reagent and a second 1 mL with Mayer's reagent. Turbidity and white creamy precipitate was observed in either of those reagents as evidence for the presence of alkaloid. For Wagner's test, a few drop of Wagner's reagent was added to 1 mL of the sample. An orange precipitate appeared indicating the presence of alkaloids.

2.8.2 Test for glycosides

Legal's Test: Few drops of 10% NaOH was added to the extract to make it alkaline before the addition of a freshly prepared sodium nitroprusside. Development of blue color indicates the presence of glycosides.

Keller-Killiani Test: To 5 mL of the extract, 2 mL of glacial acetic acid was added followed by 1 drop of 5% $FeCl_3$ and then con. H_2SO_4. The appearance of a reddish brown ring at the junction of the two liquid layers indicates the presence of glycosides in the extract.

2.8.3 Test for saponins (Frothing test)

A 2 mL portion of each extract was diluted with 10 mL of distilled water and heated in a water bath. After heating, this was shaken vigorously and left undisturbed for 20 min. A formation of stable froth indicated the presence of saponins.

2.8.4 Test for tannins

Two millimeters of wild edible oyster extract were stirred with 10mL of distilled water and heated in the water bath. A portion of 1 mL of 1% $Fecl_3$ was added. Blue-black precipitate or coloration was an indication for the presence of tannins.

2.8.5 Test for reducing compounds

Fehling's Test: Two millimeters of wild edible oyster mushroom extracts were put in test tubes and 5 mL of Fehling solution added and heated in the water bath for 5 min. The formation of brick-red precipitation or coloration indicated the presence of reducing sugar.

Molisch's Test: To 5 mL of each extract, 2 drops of alcoholic solution of α-naphthol was added and the mixture well shaken. This was followed by the addition of 1mL of conc. H_2SO_4. The formation of a violet ring in the test tube within few minutes indicated the presence of carbohydrates.

Benedict's Test: A portion of 1 mL of Benedict's reagent was added to 2 mL of the extract and heated on a water bath for 2 minutes. The development of a characteristic colored precipitate indicated the presence of sugar.

2.8.6 Test for flavonoids (Magnessium hydrochloride reduction test)

A portion of 2 mL of each extract was added to a few pieces of aluminum metal and concentrated HCl added. The formation of orange, red, crimson or magnetic colour after few minutes showed the presence of flavonoids.

2.8.7 Test for polyphenol

Two millimeters of wild edible oyster mushroom extract were treated with 5 mL of distilled water and heated for 30 min in a water bath containing 1 mL of 1% Potassium ferrocyanide solution. The formation of green-blue colouration indicated the presence of polyphenol.

2.8.8 Test for anthraquinones

A portion of 2 mL of wild oyster mushroom extract was shaken with 10 mL benzene. This was filtered and 5 mL of 10% NH_3OH was added. The mixture was shaken and the presence of pink/red or violet coloration in ammonical (lower) phase indicated the presence of free anthraquinones.

2.8.9 Test for steroids and triterpenoids

Salkowski Test: Two millimeters of each extract was treated with few drops of conc. Sulfuric acid, shaken and allowed to stand for few minutes. Formation of a red color at the lower layer indicates the presence of steroids while the formation of yellow colored layer at the interface indicated the presence of triterpenoids.

Libermann Butchard's Test: The extracts were treated differently with few drops of acetic anhydride, heated and allowed to cool to a temperature of <40°C in test tubes. The formation of brown ring and green color at the junction of two layers and upper layer respectively on addition of conc. Sulfuric acid indicated the presence of steroids while deep red color indicated the presence of triterpenoids.

2.8.10 Test for proteins and amino acids

Millon's Test: To 2 mL of the extracts, few drops of Millon's reagent was added. Formation of white precipitate indicated the presence of proteins.

Biuret's Test: An aliquot of 2 mL of the extracts were first treated with 1 drop of 2% $CUSO_4$ solution. To this, 1 mL of 95% ethanol followed by excess KOH pellets was added. The formation of pink color in the ethanolic layers indicated the presence of proteins.

2.9 Proximate and Nutritional Analyses of the Oyster Mushroom

Analysis of the proximate compositions of wild edible oyster mushroom, *P. ostreatus* was carried out using both the official method (dehydration) described by AOAC [19] and the DNS colorimetric and Kjeldahl method [20]. Elemental compositions of the mushroom were determined by the wet digestion extraction method as described by AOAC [19]. All the calculations were carried out on the dry weight basis of the oyster mushroom and expressed in mg/100 g dry weight. The proximate nutritional compositions were determined by the spectrometric method [19,21], and the amount of vitamins and other nutrients present were expressed as mean values ± standard deviation.

3. RESULTS

Table 1 shows the results of the preliminary phytochemical screening of *P. ostreatus.* Alkaloids, glycosides, saponins, tannins, reducing compounds, flavonoids, polyphenols, steroids/triterpenoids, proteins and amino acids were detected in both extracts. Only anthra-quinones was not detected. Comparatively, ethanol extract yielded more phytochemicals than aqueous extract.

Results of the quantitative estimation of the phytochemical constituents in wild edible oyster mushroom are presented in Table 2 of the 6 phytochemicals analyzed quantitatively, alkaloids were the most predominant (33.30±0.1 mg/100 g dry weight) while the least abundance was saponins (18.10±0.01 mg/100 g dry weight).

Table 3 shows the antimicrobial activity of the extracts on the test bacteria in terms of diameter of inhibition zones. Ethanol extract of *P. ostreatus* was the most effective on *S. aureus* (27.50±0.02). The highest diameter of inhibition zone in aqueous extract was recorded against *E. coli* (20.60±0.01). In general, ethanol extract was the most effective. However, the results of the antimicrobial activity of Ofloxacin antibiotic used as positive control showed increased zones of inhibition on the test organisms compared to the two extracts.

Table 4 shows the proximate food composition of the oyster mushroom in mg/100 g dry weight. The results showed the presence of high moisture content (78.28±0.02); and abundance of carbohydrate (52.74±0.02) and crude protein (28.40±0.1).

Table 5 shows the mean±SD values of vitamins in wild oyster mushroom. Of the 6 classes of vitamins detected, Vitamin A was the most abundance (295.72±0.02) while Niacin was the least abundance (10.12±0.02).

Table 1. Preliminary phytochemical screening of *P. ostreatus*

Phytochemical constituents	Test	Observation	
		Ethanol	Aqueous
Alkaloids	Dragendoff's test	-	+
	Mayer's test	+++	+
	Wagner's test	+++	+
Glycosides	Legal's test	++	–
	Keller-Killiani test	+	-
Saponins	Frothing test	+	-
Tannins	$Fecl_3$ test	+	+
Reducing compounds	Fehling's test	-	-
	Molisch's test	++	+
	Benedict's test	+	+
Flavonoids	$Mg(OH)_2$ reduction test	++	-
Polyphenol	Potassium ferrocyanide test	+++	+
Anthraquinones	NH_3OH test	-	-
Steroids and triterpenoids	Salkowski test	+	+
	Libermann Butchard's test	++	++
Proteins and amino acids	Millon's test	++	++
	Biuret test	++	++

Key: + = present, ++ = present in moderate amount, +++ = present in excess, - = absent

Table 2. Quantitative estimation of wild oyster mushroom (mg% / 100 g dry weight)

Phytochemical constituents	Quantity (Mean ± SD)
Glycosides	22.51 ± 0.01
Saponins	18.10 ± 0.1
Flavanoids	20.18 ± 0.02
Alkaloids	33.30 ± 0.1
Polyphenol	26.38 ± 0.02
Reducing compound	22.60± 0.02

Each value represent the mean of 3 determination ± SD

Table 3. Zone inhibition of ethanol and aqueous extracts of *P. ostreatus*

Diameter of inhibition zones (mm±SD) of *P. ostreatus* exracts				
Test organism	Ethanol extract	Aqueous extract	-ve control (DMSO)	+ve control (Ofloxacin) (mm)
E. coli	24.40±0.01	20.60±0.01	-	28±0.01
S. aureus	27.50±0.02	15.80±0.02	-	29±0.02
Proteus sp.	25.30±0.01	18.10±0.01	-	27±0.01

Each value is expressed as mean±SD of three replicates; - indicates no activity

Table 4. Proximate composition of wild oyster mushroom (mg/100 g dry weight)

Food constituents	Amount (Mean ± SD)
Moisture	78.28 ± 0.02
Ash	16.68 ± 0.02
Crude protein	28.40 ± 0.1
Fat	12.46 ± 0.02
Crude fiber	19.55 ± 0.02
Carbohydrate	52.74 ± 0.02

Each value represents the mean of 3 determination ± SD

Table 5. Mean values of vitamins in wild oyster mushroom

Vitamin	Amount (Mean ± SD)
Vitamin A	295.72 ± 0.02
Total Vitamin C	82.46 ± 0.01
Soluble Vitamin C	34.60 ± 0.1
Thiamin	10.18 ± 0.02
Riboflavin	10.43 ± 0.02
Niacin	10.12 ± 0.02

Each value represents the mean of 3 determination ± SD

Table 6. Elemental composition of wild oyster mushroom (mg /100 g dry weight)

Element	Composition	Range of reported literature values
K	2.45	2500-4100 [32]
Na	1.71	6.0-95 [33]
Ca	32.08	1.8-59 [33]
Mg	25.98	60-250 [32]
Fe	167.42	1.46-83.5 [34]
Zn	1.37	2.98-30.6 [34]
Cu	9.06	6.48-29 [34]
Mn	4.85	1.81-10.3 [35]

Table 6 shows the elemental nutrient composition in mg/100 g dry weight of wild oyster mushroom. Eight (8) different mineral elements were detected, of which iron (Fe = 167.42 mg/100 g dry weight) was the most abundance followed by calcium (Ca = 32.08 mg/100 g dry weight). The least abundant mineral element was zinc (Zn = 1.37 mg/100 g dry weight).

4. DISCUSSION

The wild oyster mushroom, *P. ostreatus* is regarded worldwide as a source of nutritional food and physiologically beneficial medicine [22,23]. Recent increase in multi-drug resistant (MDR) potentials of many pathogenic bacteria such as S*. aureus, E. coli, K. pneumoniae, Proteus spp., P. aeruginosa* to commonly used antibiotics is of great clinical significance. Therefore, it is imperative to seek for alternative treatment option from other sources, for the development of drugs and nutraceuticals [1]. In this study, phytochemical analysis of *P. ostreatus* revealed that its extract contains glycosides, alkaloids, saponins, flavonoids, reducing compounds, polyphenol, steroids/triterpenoids, proteins and amino acids (Table 1). The results are in accordance with reports from previous literature [24,25]. The polysaccharide components of oyster mushroom possess medicinal values and have shown potent anti-tumor and anti-inflammatory effect in both in vitro and animal studies. For instance, flavonoids possess anti-oxidant properties. The specific anti-oxidant called polysaccharide pleuran is efficient in combating colon cancer [10]. This is also true of alkaloids and glycosides. The ability of these compounds in fighting cancer and other infectious diseases also shows the effect of oyster mushroom in strengthening the immune system. Anthraquinones was not detected and this correlates with the result obtained by Egwin et al. [26] that reported absence of anthraquinones and steroids in their work.

Among the two solvents used for extraction, ethanol extract showed more abundance of phyochemical constituents compared to aqueous extract, with alkaloids and polyphenol present in excess. Saponins and flavonoids were the only phytochemicals not detected in aqueous extract. This result was in agreement with that obtained from a similar study by Okwulehie and Ogoke [8]. The reason may be due to differences in polarity of the two solvents and that ethanol evaporates with ease as compared to aqueous extract. These phytochemicals in mushrooms have been reported to have good pharmaceutical properties. For instance, higher amount of flavonoids have been shown to provide protection against oxidative stress; while the presence of alkaloids has been reported to have a stimulating effect and potent antipyretic action. It can also act a powerful anaesthetic and pain reliever [27].

The mean total chemical constituents of wild oyster mushroom, determined by quantitative estimation was also carried out and results recorded and expressed as mg per 100 g dry weight of sample (Table 2). The results clearly

showed the highest chemical constituent to be alkaloids (33.30±0.1 mg/100 g dry extract) and the least being saponin (18.10±0.1 mg/100 g dry extract). Aqueous extract showed the lowest chemical content. This result suggested that extraction by ethanol gave the highest phytochemical contents and so proves it to be an ideal solvent for phytochemical screening. The reason could be that ethanol has the ability to inhibit oxidation of phytochemicals in wild oyster mushrooms. This result agrees with that reported by other authors [25].

There is an increase in the knowledge of drug development in recent times as a result of scientific evolution and technological renaissance. Drugs from macro fungi have been shown to be effective, readily available and less expensive with minimal or no side effects [23]. Initial screening for antibacterial potential of *P. ostreatus e*xtract was performed on 3 bacterial isolates by agar well diffusion assay (Table 3). The antibacterial potential of the wild oyster mushroom extracts showed their ability to inhibit different pathogenic organisms, as indicated by their diameter of zones of inhibition in the order of 27.50±0.02 mm > 25.30±0.01 mm > 24.40±0.01 mm for *S. aureus*, *Proteus sp*. and *E. coli,* respectively in ethanol extract. There was observable variation in the antimicrobial efficacy of the different extracts. In aqueous extract, the mean diameter of inhibition zones were in the order of 20.60±0.01 mm > 18.10±0.01 mm > 15.80±0.02 mm for *E. coli*, *Proteus sp*. and *S. aureus* respectively. The maximum antibacterial activity of ethanol extract was found at 27.45±0.02 mm against *S. aureus* and minimum at 24.40±0.01mm against *E. coli*. This is more or less similar to reports from other authors on the antibacterial potential of ethanol and aqueous extracts [28,29]. This may be due to the presence of a broad spectrum of antibiotic compounds present in mushroom coupled with the use of different solvents and test organisms. The antibiotic disc, Ofloxacin (5 µg) included for positive control showed maximum efficacy on the test isolates with zones of inhibition in the range of 27-29 mm. This portrayed the broad spectrum activity of Ofloxacin as a second-generation fluoroquinolone antibiotic, coupled with the fact that the antibiotic is more expensive and less abused. For the Gram negative bacteria, *E. coli* had the highest zone of inhibition in aqueous extract (20.60±0.01 mm), while *Proteus sp.* had the highest in ethanol extract (25.30±0.01 mm). This was not significantly different for the Gram positive isolate*, S. aureus*, where its zone of inhibition was higher in ethanol extract (27.50±0.02 mm) but least in aqueous extract (15.80±0.02 mm). Reports have shown varying susceptibilities of Gram positive and Gram negative bacteria to mushroom extracts. Also, there are documented evidences on the efficacy of oyster mushrooms against drug resistant *E. coli* and Staphylococcal infections [29]. This result implies that the antibacterial efficacy of mushroom extracts will be similar for these test organisms but their difference in effectiveness will be noticeable in terms of species and solvent types [30].

The proximate nutritional compositions of *P. ostreatus* was analyzed to disclosed the mean presence of food constituents and vitamins and well as the elemental compositions in mg per 100 g dry weight of sample. Analysis of the proximate food composition of wild oyster mushroom showed the presence of 6 different food constituents with high moisture content (78.28±0.02) and carbohydrate composition (52.74±0.02). Crude protein and crude fiber occurred in moderate amounts with fat being the least abundance (12.46±0.02). The low fat, high fiber and beneficial protein content of oyster mushroom have been indicated to function in lowering blood sugar levels thus; it can serve as an ideal nutraceutical against diabetes. The low fat content improves blood cholesterol levels, decrease the risk of cardiovascular disease and promote weight loss [29]. Determination of constituent vitamins revealed 6 different vitamins including total and soluble vitamins C. Vitamin A was the predominant constituent (295.72±0.02) while thiamin, riboflavin and niacin occurred in much lower amounts (10.12-10.43±0.02). Studies have shown the involvement of certain fat in the regulation of bodily functions. For instance some vitamins require fat for them to dissolve into the blood stream and provide nutrients. Good vision is enhanced by the presence of vitamin A that can be gotten from oyster mushroom [10,29]. Elemental nutrient compositions of wild oyster mushroom varies, with the most abundant element being Fe (167.42 mg/100 g dry weight), followed by Ca and Mg, 32.08 and 25.98 mg/100g dry weight respectively (Table 6). Research has shown the involvement of these elements in the regulation of certain activities in human cells, tissues and organs. For instance, increase in Ca^{2+} concentration in cells strengthens the contraction of heart muscles while Fe^{3+} is involved in blood circulation. In general, minerals in diets are solely required for metabolic reactions, transmission of

nerve impulses, rigid bone formation and regulation of salt and water balance in the body [29]. According to the findings of our study, the element levels detected in natural mushroom, K, Na, Mg and Zn contents were lower compared to reported literature range values. Iron (Fe) content was highest from literature range. Calcium (Ca), Cu and Mn was determined to be in the range literature [2,30-35].

5. CONCLUSION

The results of these findings have revealed that oyster mushroom, *P. ostreatus* possess excellent pharmaceutical, nutritional and therapeutic properties. It can be concluded that this mushroom can serve as a good source of food supplement supplying the human body with essential minerals, vitamins, proteins and amino acids. It can also be utilized medicinally to treat various health problems such as colon cancer, diabetes, immune system disorder, obesity, inflammatory and bacterial diseases among others. Therefore, there is need for establishment of edible mushroom farms in the state for commercial production and sensitization of the public on the health benefits of consuming edible mushrooms as well as the possibility of exploiting it for drug development in future.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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