MEDICINAL USES OF MUSHROOMS IN NIGERIA: TOWARDS FULL AND SUSTAINABLE EXPLOITATION.

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Abstract

For centuries, mushrooms have been appreciated as sources of food nutrients and pharmacologically important compounds useful in medicine. Yet not all the medicinal properties of mushrooms have been exploited. The above statement is more pertinent to mushrooms that are indigenous to Nigeria. There are inadequate data on the identity and medicinal properties of these wild mushrooms. Information on the ethnomedicinal uses of some mushrooms such as *Pleurotus tuber-regium* used for headache, stomach pain fever, cold, constipation; *Lentinus squarullosus* for mumps, heart diseases; *Termitomyces microcarpus* for gonorrhea; *Calvatia cyathiformis* for leucorrhea, barreness; Ganoderma *lucidum* for treating arthritis, neoplasia; *G. resinaceum* used for hyperglycemia, liver diseases (hepatoprotector); *G. applanatum* used as antioxidant and for diabetes had been gathered through survey. The above information is mostly obtained from traditional herbalists who in most cases will not disclose their preparation compositions. A lot of these mushrooms are obtained only in the wild. Scientific documents of the identities and medicinal properties are still scanty. Preliminary studies on some species of *Temitomyces, Lenzites* and *Lentinus* species showed that they possess appreciable antimicrobial and antioxidant properties. Moreover, molecular characterization also reveals that they are not 100% homologous with existing sequences under the same name in GenBank. It is therefore pertinent that well structured studies on their ecology, identification and medicinal uses be carried out. This will make the full exploitation of the medicinal potentials of mushrooms indigenous to Nigeria realizable.

Keywords: mushroom, use, Nigeria, full, sustainable, exploitation

Introduction

The term mushroom is not a taxonomic division. Mushrooms are macrofungi with distinctive fruiting body, which can be hypogeous or epigeous, large enough to be seen with the naked eye and to be picked by hand (Chang and Miles, 1992). Mushrooms have long been used as a valuable food source and as traditional medicines around the world, especially in Japan and China. Records of health promoting properties such as antioxidant, antimicrobial, anticancer, cholesterol lowering and immunostimulatory effects have been reported for some species of mushrooms (Anderson, 1992; Mizuno, 1999; Mau *et al*., 2004).

The above health enhancing properties of mushrooms have been attributed to the presence of some bioactive compounds in mushrooms. Some of these biologically active substances are: glycolipids, compounds derived from shikimic acid, aromatic phenols, fatty acid derivatives, polyacetylamine, polyketides, nucleosides, sesterterpenes, and many other substances of different origins (Lorenzen and Anke, 1998; Wasser and Weis, 1999; Mizuno, 1999). Most of these bioactive compounds derived from mushrooms are known to function as biological response modifiers (BRM). Biological response modifiers are substances that stimulate the body's response to infection and disease. The body is known to produce these substances but not in appreciable quantity hence, exogenous supply through diet or dietary supplements are needed. Mushroom nutraceuticals may unarguably be the source of this exogenous supply because edible mushrooms are known to be safe and devoid of undesirable side effects. They have been part of human food from time immemorial. In recent years mushroom polysaccharides have drawn the attention of chemists and immunobiologists (Borchers *et al*., 1999; Wasser and Weis, 1999; Leung *et al*., 1997). This is because many polysaccharides isolated from mushroom are considered to be biological response modifiers (BRM) and have been shown to enhance various immune responses (Kim *et al*., 2006). In medicine, biologically active substances are used to immodulate both humoral and cellular immune factors in the body (Wasser, 2002). Bohn and Bemiller (1995) reported that a polysaccharide from *Lentinus edodes* is an immunological strengthener, which can be used to cure viral hepatitis and various other diseases caused by low immunological diseases. Productions of these biologically active substances are from the fruiting body and the mycelium of mushroom (Barros *et al*., 2007; Ferreira *et al*., 2007). Some of these substances are also present in broth used in submerged cultivation. In general, there is normally a higher level and number of different polysaccharides extracted from fruit bodies than from the other cultural sources (Reshetnikov *et al*., 2001).

It has been estimated that the number of mushrooms on earth is about 140,000 yet only 14,000 (10%) are known (Hawksworth, 2001). In essence, pharmacological potentials of about 90% of mushrooms on earth are yet to be exploited. A large number of the unknown species of mushrooms whose health promoting properties are unknown may be in Africa and probably in

Nigeria. This is because there are little or no information about these mushrooms and their medicinal potentials. Most available data are on the nutritional compositions of mushrooms obtained from the wild (Aletor, 1993; Alofe *et al*., 1996; Ola and Oboh, 2001). Nigeria with her unique climatic conditions of tropical rain forest in the south and sub-saharan condition in the north is a home to diverse species of mushrooms. Those that are common belong to the following species; *Termitomyces, Pleurotus, Lentinus, Lenzites, Trametes, Ganoderma, Pycnoporus, Coriolopsis* etc.

Presently, in most parts of sub-Saharan Africa, mushrooms provide a low- cost alternative source of high quality protein. Ethnomycological survey of utilization of mushrooms in North central Nigeria reveals that most people consume mushrooms based on their nutritional (81.7%) and palatability (93.5%) characteristics while only 15.1% utilize mushroom based on their medicinal properties (Ayodele *et al*., 2009). Most information on their medicinal uses is obtained from local herbalists who in most cases will not totally disclose how their preparations are made. Reports on the ethnomedicinal uses are obtained through survey. In essence, well structured studies on their medicinal uses are scanty. This write-up tends to point out the fact that mushrooms in Nigeria had been underutilized and steps needed to bring about maximum and sustainable exploitation.

Ethnomedicinal Uses of Mushrooms in Nigeria

Mushroom had been used from ancient times and is connected with mysticism (Griensven, 2009). Ironically, the first record of mushroom used as hallucinogenic agent was credited to the Yoruba tribe of Nigeria in Africa (Griensven, 2009). The record dates back to the Paleolithic period (7000 – 9000 years ago) (Samorini, 1992). In Eastern Countries like China and Japan the knowledge on the use of edible and medicinal mushrooms had been passed on from one generation to the other in documented form. For example, over 2,500 years ago, many medicinal mushrooms had been recorded and depicted in the earliest Chinese material medica book, *Shennong Bencao Jing*, and other succeeding Chinese medical book (Zhu, 2009). It was not so in Nigeria. Information on the indigenous use of mushrooms had been passed orally from one generation to another (Akpaja *et al*., 2003). It is possible that some of this undocumented information had been lost. Women who sells vegetables and mushrooms and elderly people are usually most helpful in supplying information about ethnomycological uses of mushrooms in South west Nigeria (Oso, 1977). The same observations were also made in other parts of the country where survey were carried out (Akpaja *et al*., 2003). In essence, the younger generation in Nigeria has little or no knowledge about ethnomycological uses of mushrooms. Some edible/medicinal mushrooms in Nigeria had also been extinct as a result of human activities during farming and annual wild fire out break (Ayodele *et al*., 2009).

However, in the last 3 to 4 decades, scientist in Nigeria had been gathering information on medicinal uses of mushrooms through survey. The use of these mushrooms varies from one ethnic group to the other. Ethnomycological uses of edible and medicinal mushroom by the Yoruba people of South West Nigeria had been reported (Oso, 1975, Alabi, 1990). Moreover, reports of the ethnomedicinal uses of mushroom by the Ibos in South East and the Igalas in north central Nigeria had also been reported by Akpaja *et al*. (2003) and Ayodele *et al*. (2009) respectively. Information gathered include ethnomedicinal uses of the following mushrooms: *Pleurotus tuber-regium, Lentinus squarullosus, Termitomyces microcarpus, Calvatia cyathiformis, Ganoderma lucidum, G. resinaceum, G. applanatum, Schizophyllum commune, Volvariella volvaceae, and Deldinia concentrica*. For instance, *P. tuber-regium* is used for alleviating headache, stomach pain fever, cold, constipation; *L. squarullosus* for mumps, heart diseases; *T. microcarpus* for gonorrhea; *C. cyathiformis* for leucorrhea, barreness; *G. Lucidum* for treating arthritis, neoplasia; *G. resinaceum* is used hyperglycemia, liver diseases (hepatoprotector); *G. applanatum* used as antioxidant and for diabetes. Table 1 gives a summary of the use of these mushrooms in Nigeria.

From the information gathered from ethnomedicinal uses of mushrooms in Nigeria, there are some issues begging for answer. These are:

(1)Are the ethnomedicinal properties of mushrooms obtained from survey in Table 1 actually true? There is need to verify these claims.
(2)What are the major bioactive constituents in mushrooms found in Nigeria?
(3)Are the bioactive substances found in mushrooms indigenous to Nigeria more efficacious or otherwise than those obtained in mushrooms in other parts of the world?

There are some obvious factors that had been militating against the full exploitation of edible/medicinal mushrooms in Nigeria. Some of these factors are listed below.

(1) Mycophobia as a result of inability to distinguish edible from poisonous types. Most Nigerians do not know their mushrooms intimately hence, they belong to the mycophobe group. This is a group of people who fear, dislike, and do not know their mushrooms (Chang, 2008).
(2) Trade secret by local herbalist who keeps information to enhance patronage. Some medicinal mushrooms preparations are in combination with other herbs. The identity of the other combinations has to be known.
(3) Seasonal nature of mushrooms which make them unavailable throughout the year.
(4) Change in lifestyle and social stigmas in which people consuming traditional foods made from mushrooms are perceived as **'poor'**
(5) Lack of awareness especially among the young generation.

Some Reports on Medicinal Uses of Edible/Medicinal Mushrooms in Nigeria

Over the year, some Nigerian scientist had been able to carry out some well structured studies on the medicinal properties of mushrooms found in Nigeria. The effects of aqueous extract of *Ganoderma lucidum* collected from Zaria, Nigeria on blood glucose levels of normoglycemic and alloxan induced diabetic wistar rats had been reported by Mohamed *et al*. (2007). Oyetayo (2006) reported the hypolipidemic properties of two tropical edible mushrooms *Pleurtotus tuber-regium* and *Termitomyces clypeatus* in altering the plasma levels of some lipids in male albino rats fed high fat diets. Antimicrobial property of several mushrooms had also been reported (Jonathan and Fasidi, 2003; Ezeronye *et al*., 2005; Ofodile et al., 2008; Oyetayo, 2009). Figures 1 to 4 shows the antioxidant property of ethanolic extracts of four wild mushrooms (*Termitomyces clypeatus* (TCE), *Termitomyces robustus* (TRE), *Lentinus subnudus* (LSE) and *Lenzites* species (LZE). The extracts exhibited significant antioxidant activities at concentration of 2mg/ml. The hydroxyl ion scavenging ability of these extracts (Fig. 3) were not significant different ($P>0.05$) from the control (BHT) (Oyetayo, 2009). Other health promoting properties such as anticancer, antiviral, immunostimulatory effects etc had to be verified through contemporary research.

Molecular Identification of some Edible/Medicinal Mushrooms Indigenous to Nigeria

Most researchers in Nigeria identify mushroom by examining with the naked eye based on phenotypic characters. It has been impossible to distinguish between genetically related species by this method. Morphologically, mushrooms belonging to the same and even different genera may look similar. The implication of the above statement is that some mushrooms reported in this area might have been erroneously identified. It is therefore imperative that a combination of morphological and molecular identification based on gene sequence be employed for correct identification. Some data obtained from molecular identification of some of these macrofungi from Nigeria shows that they are not 100% homologous to the gene sequences of their closest relative in the NCBI GenBank (Table 2). The genes in DNA molecule are known to carry the information that controls the organism. In essence, the information on the difference between the genetic make up of some macrofungi indigenous to Nigeria and the genes of their close relatives has a lot of implication on the type(s) of bioactive combines they can produce. The following questions may then arise:

(1) Are these macrofungi able to produce novel bioactive compounds?
(2) Are the bioactives produced by these macrofungi more efficacious than the one produced by their close relatives found in other parts of the world?

These questions can be answered by well structured scientific studies.

Challenges Faced by Researchers working on Edible/Medicinal mushrooms

There are some obvious challenges faced by scientist in Nigeria towards the full exploitation of medicinal properties of mushrooms. The major ones are:

(1) Lack of state of the art equipment for identification and assessing the medicinal properties of these mushrooms.
(2) Poor research funding
(3) Poor attitude of policy makers towards research

The way forward in view of the challenges above can be divided into two:

(1) The first is immediate and this is mainly collaboration of Nigerian scientist with centre(s) where there are facilities for:

- Identification
- Training on cultivation
- Assessing health properties of indigenous Nigeria mushrooms.

The second is long term measure which will include:

(1) Creating awareness on the health promoting effect of edible and medicinal mushrooms among the populace.
(2) Encouragement of small scale farming in the production of mushrooms
(3) Government and corporate sponsorship of research in the area of mycopharmaceuticals.

Sustainable Exploitation of Edible/Medicinal Mushrooms in Nigeria

The major restrain to the full utilization of edible and medicinal mushrooms in Nigeria as earlier stated is their being seasonal in nature. Mushroom cultivation which is both an art and science had been described as a complex business that requires precision (Chang, 2008). Hence, technology for cultivating mushrooms that are indigenous to Nigeria had to be developed. Practical steps in cultivating mushrooms such as selection of an acceptable mushroom species, secretion of a good-quality fruiting culture, development of robust spawn, preparation of selective substrate/compost, care of mycelia (spawn) running, management of fruiting and mushroom development, and careful harvesting of mushrooms listed by Chang and Chiu (1992) and Chang (1998) have to be religiously followed. China is estimated to have about 1500–2000 edible mushroom species with 981 species identified while 92 species had been domesticated (Mau *et al*., 2004). Mycologists in Nigeria have to brace up to document mushrooms indigenous to Nigeria and also domesticate them through appropriate methods of cultivation.

The second major problem militating against the full utilization is the problem of distinguishing edible from poisonous species. A combination of morphological and molecular identification procedures can be used to solve this problem. The populace needs to be enlightened on some morphological features that laymen can use to distinguish edible from non edible/poisonous mushrooms.

In summary, the following action must be taken for full and sustainable exploitation of mushrooms in Nigeria.

(1) Ecological survey of all mushrooms indigenous to Nigeria
(2) Phenotypic and genotypic identification of all species of mushrooms
(3) Extensive screening of bioactives present in the mushrooms.
(4) Well structured studies on the medicinal properties to ascertain the health claim.

Table 1: Ethnomedicinal Uses of Some Mushrooms in Nigeria

Mushroom	**Ethnomedicinal Use(s)**
Pleurotus tuberrigium	For treating headache, cold, fever, stomach ache and constipation
Lentinus squarullosus	For treating mumps and heart disease
Termitomyces microcarpus	For treating gonorrhoea
Calvatia cyathiformis	For treating hiccups, leukorrhea, barreness
Ganoderma lucidum	For treating anthritis and neoplasia
Ganoderma resinaceum	For lowering blood sugar (hypoglycemic), hepatoprotector
Ganoderma applanatum	Antioxidant, hypoglycemic and antihypertension
Schizophyllum commune	For treating diabetes and generally regarded as health food.
Volvariella volvaceae	Antibiotics and antineoplasia
Auricularia auricular	For treating hemorrhoids and hemoptysis
Daldinia concentrica	For treating stomach upset, stomach ulcer, skin disease, whooping cough, and prevention of excessive growth of fetus to enhance easy delivery.
Polyporus officinalis	For treating hernia, cough and catarrh

Source: Akpaja *et al*. (2003); Ayodele *et al*. (2009**)**

Table 2: Genomic identification based on rDNA ITS sequences of some wild mushrooms collected from Nigeria

Code	Phenotypic identity	Source	Closest relative from NCBI GenBank	% Identity with sequence from NCBI GenBank
LS	*Lentinus subnudus*	Ado Ekiti	*Lentinus tigris*	80
TC	*Termitomyces clypeatus*	Ado Ekiti	*T. striatus*	85
TR	*Termitomyces robustus*	Ado Ekiti	*T. eurhizus*	96
LZ	*Lenzites* species	Ado Ekiti	*Lenzites betulina*	97
GN	*Ganoderma* species	Akure	*Ganoderma applanatum*	94

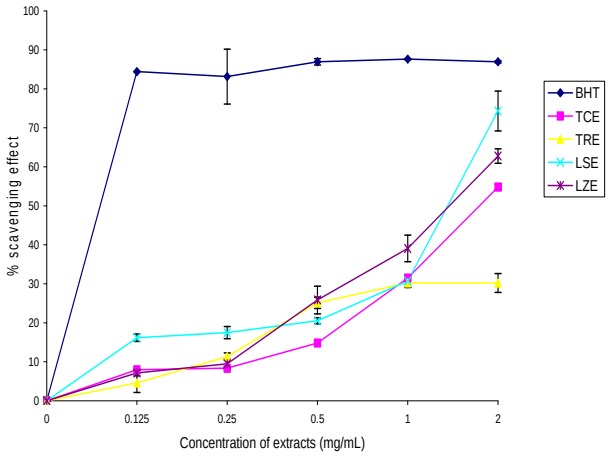

Fig. 1: Scavenging activity of extracts on DPPH radicals. Each value is mean ± standard deviation (n=3).

BHT: Butylated hydroxyl toluene; TCE: *Termitomyces clypeatus;* TRE: *Termitomyces robustus;* LSE: *Lentinus subnudus;* LZE: *Lenzites* species.

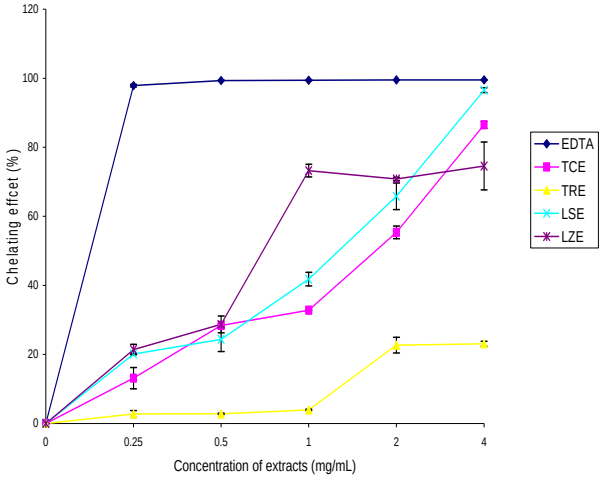

Fig. 2: Ferrous ion chelating effect of extracts. Each value is mean ± standard deviation (n=3).

EDTA: Ethylenediaminetetraacetic acid; TCE: *Termitomyces clypeatus;* TRE: *Termitomyces robustus;* LSE: *Lentinus subnudus;* LZE: *Lenzites* species.

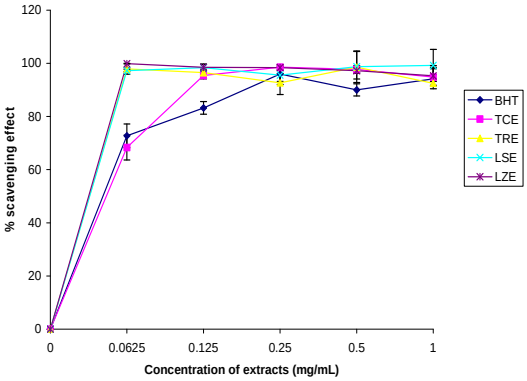

Fig. 3: Scavenging effect of extracts on hydroxyl radicals. Each value is mean ± standard deviation (n=3).

BHT: Butylated hydroxyl toluene; TCE: *Termitomyces clypeatus;* TRE: *Termitomyces robustus;* LSE: *Lentinus subnudus;* LZE: *Lenzites* species.

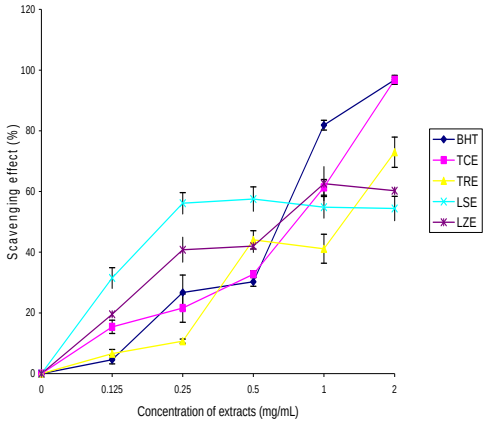

Fig. 4: Scavenging effect of extracts on superoxide anion. Each value is mean ± standard deviation (n=3).

BHT: Butylated hydroxyl toluene; TCE: *Termitomyces clypeatus;* TRE: *Termitomyces robustus;* LSE: *Lentinus subnudus;* LZE: *Lenzites* species.

Conclusion and Future Perspective

The use of edible and medicinal mushrooms can be classified into three categories as follows:

(1) Food: Mushroom as source of nutritional components of food such as protein, carbohydrate, fats, inorganic compounds and essential vitamins.
(2) Health: As sources of biologically active agents which contain ingredients that can aid specific body functions, in addition to being nutritious. Hence terms like mushroom neutraceuticals, dietary supplements have emerged.
(3) Bioremediation: As agent of bioremediation especially in the recycling of lignocellulosic wastes of agricultural origin and in healing the soil (Stamets, 2005).

The first category is more popular in Nigeria especially with the rural dwellers. The utilization of mushrooms by most tribes in Nigeria is more related to consumption as food while the use for health promotion and for cleaning the environment is limited. The market for edible and medicinal mushrooms has been growing over the years especially in Asia, Europe and North America. Presently, it is valued at U.S. $15 billion which represents 10% of the general market of dietary supplements (Wasser, 2009). Chang (2006) divided the mushroom industry into three main categories Viz: edible mushrooms, medicinal mushroom products, and wild mushrooms. The one that is popular in Nigeria is the third category, wild mushrooms market. Mushrooms come in seasons and mostly women and children are the main participants in this industry since they are mainly involve in hunting for wild mushrooms. The level of mushroom gathered in a year depends on the vagaries of weather. When there are favourable conditions for the spores to germinate into fruiting bodies, there will be abundance of mushroom that season. The reverse is the case under unfavourable weather conditions. In countries where the three mushroom industries (edible, medicinal mushroom products, and wild) are thriving, for instance China, there was a 20% increase in fresh and dry mushrooms products sold in 2008 when compared to 2007 (Hu and Chen, 2009). This would have translated to more employment opportunity in the Chinese mushroom industry as a result of increase in production and marketing occasioned by increase in demand.

The challenge then is to promote the three mushroom industries (edible, medicinal mushroom products, and wild) in Nigeria through research and enlightenment of the populace. This will definitely help in alleviating some of the two major problems in Nigeria which are food security and unemployment. Massive cultivation of mushrooms can serve as a two prong fork in solving this problem by providing nutritious and healthy food and also empowering the people economically through employment in myconutraceutical industries.

Conclusively, mushrooms indigenous to Nigeria have enormous potential as sources of bioactive agents for biopharmaceutical exploitation. Ecological survey, molecular identification and assessment of the medicinal potentials of these mushrooms are good research domain. This will ensure the full and sustainable exploitation of these mushrooms. Full and sustainable exploitation of the indigenous Nigerian mushroom may lead to the emergence of myconutraceutical industries which will help in tackling the problem of unemployment and consequently reduce poverty.

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