Mushrooms in Nigeria: Neglected but beneficial Nutraceutical and Functional Food

Comfort O. Bamigboye, Julius K. Oloke, Elijah A. Adebayo, Iyabo O. Omomowo

Microbiology Unit, Department of Pure and Applied Biology, Ladoke Akintola University of Technology, P. M. B. 4000, Ogbomoso, Nigeria.

Abstract

Mushrooms are macroscopic fungi consumed for their rich nutritious taste, aroma and health benefits. Mushrooms grow naturally in the wild as saprophytes and are available in most African countries in the rainy season. Mushrooms have long been recognised as functional foods and nutraceuticals due to the many health benefits attributable to their richness in bioactive components.

Some health benefits include anticancer, hepatoprotective, anti-viral, cholesterol-lowering, immune-boosting, antioxidant and anti-ageing properties. Despite these established uses, many mushrooms have not been popularly domesticated in Nigeria, thereby hindering the functional use of this nature's gem as promising nutraceuticals. Besides, the mycophobic attitudes of many citizens have significantly prevented their exploitation.

This review showcases mushrooms as affordable and exotic functional foods, rich in phytochemicals with great benefits for wellness. This suggests that a further boost in knowledge is required for the populace to embrace mushrooms' cultivation, consumption, and medicinal applications.

Keywords: Functional food, Mushroom, Nutraceuticals, Bioactive compounds, mushroom production, mushroom potentials
1 INTRODUCTION

Mushroom is the fruiting body of a particular group of macrofungi, which can be found growing above or below the topsoil, seen macroscopically with the unaided eye and often collected for food or medicine [1]. Mushroom are highly valued for their distinctive taste and nutritious nature. They are delicious food regarded as a good protein source and rich in vitamins, minerals, and most essential amino acids [2]. In some continents, Europe and Africa inclusive; mushrooms are usually collected from the wild and are used directly as food or added to soups, stews, teas and can even be used as a replacement for meat.

Mushrooms are highly nutritious basidiomycetes that are artificially cultivated on lignocellulosic waste materials. They are poor in fat and calories but known to be rich in minerals, protein and crude fibre [3]. Mushrooms have a broad geographical distribution being the earliest form of fungi that has been incorporated into cultural diets. In Nigeria, several people living in the rural areas plus a few in the urban regions can identify edible mushrooms growing in the wild, some of which have been exploited for income, food and medicine. Until recently, many edible and medicinal mushrooms have been sourced from the wild forests since there are very few commercial mushroom farms, especially in Nigeria. This could be partly due to less craving for mushrooms due to mycophobic attitudes or preference for the naturally wild and uncultivated species available for sale in some parts of the country. Mushrooms are yet to be fully utilised due to low enlightenment, limited spawn availability (especially in Nigeria) and poor preservation methods. However, regular mushroom consumption can supply essential nutrients and prevent malnutrition. This review enlightens the dual role of mushroom (as a food and drug), its diversity and its current status in Nigeria.

2 DIFFERENT VARIETIES OF MUSHROOM IN NIGERIA

The word ‘mushroom’ encompassed diverse types of fungi. Mushrooms can be edible or poisonous, large with the pileus up to 30 cm wide, (e.g. *Pleurotus tuberregium*, *Termitomyces giganteus*) or tiny (with pileus up to 1–2 cm wide (e.g. *T. microcarpus*). Some mushrooms produce additional underground sclerotia below the ground surface, while others only produce fruiting bodies above the soil surface. From the ecological point of view, mushrooms can be broadly classified into four groups. The mycorrhizal groups occurring in symbiotic association with certain tree species [4] such as *Tuber melanosporum* and *Tricholoma matsutake*. The second group are commonly found in association with insects such as *Termitomyces sp*. The third group exist as parasites deriving food substrates from living animals and plants, thus causing a massive loss to these hosts. Examples of these include *Coremiopleurotus*, a tree pathogen causing the white-rot of hardwood trees. The saprophytes obtain nutrients from dead organic materials, including *Pleurotus sp* and *Lentinus sp*. There are well over 300 genera of mushrooms and related fleshy basidiomycetes. Notably, in Nigeria, Osun State is endowed with many *Termitomyces sp*. At the same time, Ore in Ondo state is home to *Pleurotus tuberregium*, *Agaricus sp.*, *Marasmius sp.*, *Termitomyces globulus*, *Coriolus versicolor* and *Fomes sp.* [5]. Some wild mushrooms are often available for sale in these selected places seasonally. There are diverse mushroom species in the West, while Northern Nigeria has very few if any at all. *Tricholoma sp.*, *Pleurotus sp.*, *Lentinus sp.*, *Psathyrella atroumbonata*, *Schizophyllum commune*, *Auricularia polytricha*, *Volvariella volvacea*, *Daldinia concentrica*, *Daedalea elegans*, *Coriolopsis occidentalis*, *Ganoderma sp.* are some mushroom species available in Nigeria [5,6,7].

3 NUTRITIONAL COMPOSITION OF MUSHROOMS

Mushrooms are considered a superfood, rich in protein, vitamins and dietary fibre. They constitute a source of vitamin D that is non-animal-based thus can be consumed by vegetarians. Mushrooms are poor in fat and calories but rich in minerals [3]. A lot of mushrooms are consumed and treasured for their exotic taste, economic and ecological values, coupled with various therapeutic properties over the years. Generally, mushrooms are composed of approximately 10 and 90% dry matter and water, respectively. They are rich in fatty acids, mainly oleic, palmitic and linoleic acids [8]. Mushrooms have high moisture content (81–95%) and are rich in amino acids (valine, aspartic acid, leucine, glutamic acid and glutamine) [9]. In addition, they have high mineral content, mainly magnesium, potassium, zinc, phosphorus, iron, copper and calcium. Sugar content includes fructose mannitol, trehalose, glucose [10] and is also rich in vitamins such as thiamine, pantothenic acid, riboflavin, niacin, and folic acid.
3.1 Mushrooms as both Functional Foods and Nutraceuticals

About 2400 years ago, Hippocrates advised that “let your food be your medicine and your medicine your food” [11,12]. Mushrooms have dual usage; they are useful foods, likewise good medicine. Usually, functional foods are available as food or part of the main diet for consumption to derive some physiological or health effect resulting in the overall wellness and disease prevention or management. On the other hand, nutraceuticals are taken as capsule, pill, syrup or tablet that is partially or wholly purified extract or dehydrated biomass of either the fruiting body or mycelia for therapeutic applications [13]. However, some authors believe that the two terms undoubtedly refers to the same thing – dietary supplements [11]. Some inherent bioactive compounds have been linked to the wide applications of mushrooms in the prevention or management of diseases and health problems, whether as a nutraceutical or functional food. Some of these bioactive molecules and their associated functions have been demonstrated by many researchers in different parts of the world (Table 1).

Past studies have shown that some lipids extracted from Pleurotus giganteus and Hygrophorus eburneus (mainly poly-unsaturated fatty acids, essential fatty acids and saturated fatty acids) displayed antibacterial and antifungal activities [14,15]. Triterpenoids and sesquiterpenoids from Ganoderma lucidum and Flammulina velutipes had notable hepatoprotective and anticancer effects [16-19]. Lentinan was reported to enhance human immunity [20-24]. Additionally, specific polysaccharide extracts from Grifola frondosa, P. ostreatus and P. tuberregium have been used to cure hypertension, diabetes, some viral diseases and also protects the liver [25-27]. As functional foods, mushrooms have been collected, domesticated and used by men in some countries [28]. Mushrooms that have been used in Japan, Nigeria and China include Schizophyllum commune, Pleurotus ostreatus, P. tuberregium, Ganoderma lucidum, Lentinus squarrosulus, Grifola frondosa, Inonotus obliquus, Lentinus edodes and Trametes versicolor [29]. Most of these mushrooms are rich in essential fatty acids. Nutritiually, dietary lipids are essential due to their functions in the body; these include thermal insulation, energy reserve and protection of internal organs [30]. Humans cannot synthesise linoleic and linolenic acids. Thus they constitute the essential lipids or fatty acids that must be obtained through the diet [31]. Amanita caesaria is an important mushroom found in Turkey, with thirty-seven (37) different fatty acids in its sporocarp [32]. In Nigeria and Ethiopia, P. ostreatus was rich in linoleic acid up to 27.6 and 61.1%, respectively [33, 34]. The fatty acid richness of some mushrooms based on their regions were analysed in detail by some authors [30].

As nutraceuticals, mushrooms have promising potentials as immunomodulatory, anticancer, antidiabetic, cardioprotective, antioxidative, hypercholesterolaemia, wound healing, antihypertensive, hepatoprotective, and antimicrobial agents [28]. These activities have been attributed to the presence of some compounds, including phenols [35], tocopherols, volatile oils, organic acids, alkaloids, carotenoids, glucans (anticancer) [36], dietary fibre, lectin, proteoglycan and many others [37]. Bioactive molecules from mushrooms differ from pharmaceuticals because of their extremely low toxicity, even at high doses. Some polysaccharides associated with mushroom cell walls have high molecular weight sugar polymers that function as anti-tumour and anti-cancer agents [38].

Mushroom polysaccharides are a unique source of antitumor molecules compared to those from bacteria, plants, marine animals and seaweed [36]. Some polysaccharides demonstrate significant activities by enhancing the body's immune system, such as natural killer cells, cytotoxic T cells, macrophages, and secretary products [39]. About 45 different antibacterial compounds were detected in Agaricus bisporus with various therapeutic properties [40]. A range of terpenoids (triterpenes, diterpenes, sesquiterpenes and monoterpenes) have been linked to antiviral, anticholinesterase, antimalarial and anti-inflammatory properties [9].

4 CURRENT STATUS OF MUSHROOM AVAILABILITY IN NIGERIA

Mushroom hunting has existed for many years and is carried out primarily by women and children [41]. In folk medicines, mushrooms have been used since ancient times and are referred to by some as ‘the ultimate health food’. Approximately twenty-five species of mushrooms are known to be edible based on the knowledge inherited from the aged group via oral communication [42]. When these edible mushrooms are sourced from farmlands, forests and plantations, they are sold, smoked, sundried or cooked fresh. Lately, some mushrooms are
dried and powdered for use as flavour in soups. Fresh mushroom cooked by treating with warm salty water and necessary ingredients such as chopped onions, oil, tomatoes, and pepper, or cooked along with vegetables.

Most of the African populace rely on wild edible mushrooms, which has significantly hindered the advancement of commercial mushroom farming despite the available mushroom resources [43]. To date, there are very few interests in the commercial cultivation of mushrooms. In Nigeria, mushrooms cannot be purchased from many supermarket stalls. The populace is probably unaware of the health benefits of consuming mushrooms or little quantity produced by a few involved in its cultivation. Also, another factor that can hinder its prospect is the poor post-harvest preservation methods as many delicious mushrooms (such as Termitomyces spp) breed maggots if kept for more than 24 h. However, in developed countries, wild mushrooms are preserved in brine or frozen [44], while they are commonly dried for future use in Nigeria. It is important to determine other preservation techniques applicable to different mushrooms in Nigeria and other developing countries.

Nigeria is gradually appreciating the science and practice of mushroom cultivation as an enjoyable agricultural activity included in the youth and women empowerment programme. This will positively influence the economic livelihood of farmers, poor citizens and labourers. One significant benefit of mushroom cultivation is that most

---

**Table 1. Bioactive nutrients in Mushrooms and their Applications**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Bioactive component</th>
<th>Mushrooms</th>
<th>Applications</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipids</td>
<td>Poly-unsaturated fatty acids (Omega-3, palmitoleic acid, Docosahexaenoic acid) Essential fatty acids (Linolenic and Linoleic acids) Saturated fatty acids (stearic and palmitic acids)</td>
<td><em>Pleurotus giganteus, Hygrophorus eburneus</em></td>
<td>Antifungal, antibacterial</td>
<td>14, 15</td>
</tr>
<tr>
<td>Vitamins</td>
<td>E, C and D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proteins, peptides, amino acids and terpenes</td>
<td>Triterpenoids and sesquiterpenoids (flammulinol) Mushroom derived bioactive peptides.</td>
<td><em>Ganoderma lucidum; Flammulina velutipes Morchella esculenta, P. eryngii</em></td>
<td>Hepatoprotective, anticancer Antimicrobial, antioxidant, antitumor, immunomodulatory Immune stimulant, antiproliferative</td>
<td>16, 17, 18, 19</td>
</tr>
<tr>
<td>Carbohydrates (mainly polysaccharides)</td>
<td>Lectins, leucine and valine Lentinan</td>
<td><em>A.bisporus, Pholiota adipose Lentinus edodes</em></td>
<td>Protects against stomach cancer, enhances human immunity</td>
<td>20, 21</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lung and breast cancer, antimicrobial, enhances the immune system</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Stimulate the immune system, a potent antioxidant</td>
<td>23, 24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Treats hypertension, HIV, viral hepatitis and hyperlipidemia</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Immunomodulatory, anti diabetic</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hepatoprotective</td>
<td>27</td>
</tr>
</tbody>
</table>

---

agricultural substrates, hitherto regarded as wastes required for production, are available at little or no cost. Most of these wastes, including straws, husks and fibres, constitute a nuisance and burn by farmers. Instead of burning, these wastes can be bio-converted towards mushroom farming, thus preventing air pollution. In addition, when pilot-scale mushroom cultivation is practised, jobs could be created for youths and village women while easing the availability of this nature's gift as a nutritious source of high-quality protein, vitamins and minerals. The bioactive metabolites extracted from mushroom fruiting bodies also enhance consumers' fitness and general health status [45]. Mushrooms are potential export commodities. Sclerotia or fruiting bodies can be sold in local markets to improve the farmers’ standard of living or export (if they meet the international export standard), improving the country's economic status. Volvariella volvacea, P. sajor-caju and other warm mushrooms have a concise life cycle and could grow to full maturity within a few weeks. This favourably increases the income generated by mushroom farmers within a short period. Mushroom farming is an art that can be proven scientifically; while the art is perfected through practical experience, the science is developed by researchers. Nigeria’s government and researchers have been trying to enlighten the populace on the benefits of mushroom consumption, but there is still much to be done. This has been raised previously [46]; however, there is no available documentation that will show the number of mushrooms produced and exported in FAOSTAT Statistics in Nigeria (Figure 1). This gap needs to be filled.

Although there are fundamental principles involved in mushroom production developed in the past years, further development of species-specific farming methods has recently led to species improvement, such as P. tuberregium [48]. The effects of substrate type, growth conditions and species genetic components on the nutraceutical potentials of mushrooms have been previously established [48]. Agricultural wastes, industrial wastes and domestic wastes are abundantly available in Nigeria and can be used as a substrate for mushroom cultivation. Some of these substrates (especially plant straws) can be pretreated by soaking in water containing CaCO$_3$ overnight before autoclaving. Other substrates such as wood shavings or sawdust are left to ferment in heaps for some days to eliminate certain undesirable spoilage microorganisms. Various pre-treatment stages help minimise contamination risks and create a suitable growth medium for the increased mushroom yield.

5 CONCLUSION

Mushroom is a nutritious, healthy food rich in protein, essential fatty acids, minerals and phytochemicals. However, its consumption in Nigeria is limited probably by scarcity (partly due to seasonal variations), mycophobic attitudes/species identification problems, poor funding, documentation and management. To make mushroom production an enticing enterprise, there is a need to educate the rich and poor populace on the nutritional and vigour improvement of mushroom consumption. To do this, radio jingles, television adverts and promotions should be initiated by both researchers and the government. The answer to Covid-19 or/and other viral infections might lie in the consumption of mushrooms due to their antiviral properties.

Conflicts of Interest

The authors declare no competing interests.

Acknowledgements

We wish to appreciate LAUTECH-Ogbomoso for continuous support.

Authors’ Contributions

COB, conceived, designed the study and drafted the manuscript. JKO, EAA and IOO contributed to writing and final review of the manuscript. All authors approved the final copy of the manuscript.
References


Med Mushrooms, 21(4).