FUNGI: A REVIEW ON MUSHROOMS

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ABSTRACT
This paper reviews a fungus – mushrooms. In this paper, identification, cultivation, uses, side effects, nutritional and medicinal values, storage, marketing and other uses of mushrooms were discussed. From the review too it was observed that its usefulness surpasses the side effects. These side effects could be eliminated if proper 'processing' could be employed. Due to advances in both basic knowledge and practical technology relevant to mushroom farming, mushroom products and mushroom bioremediation, developing countries should harness the potentials of mushrooms as this would boost the revenue income and healthy living. It is hoped that this paper would add to existing information on this fungus.

INTRODUCTION
The organisms of the fungal lineage include mushrooms, rusts, smuts, puffballs, truffles, morels, and yeasts, as well as many less well known organisms (Blackwell *et al*, 2011). More than 700, 00 species of fungi have been described however, some estimates of total numbers suggests that 1.5 million species may exist (James *et al*, 2006).

Edible mushroom (Figs 1 & 2) have for a long time been recognized not only as a delicacy, but also for their use as food in man's diets. Mushrooms have been found to be rich sources of protein, lipids, amino acids, glycogen, vitamins and mineral elements (Okhuoya *et al*., 2010). According to Rambeli (1983), the mineral salt content of mushrooms is superior to that of meat and fish and nearly twice that of the most common vegetables.

Nigeria is a country of many tribes, the Hausa in the North, Yoruba in the West, Urhobo in the Mid – West and the Ibo in the East, to mention a few. Each tribe has recognized mushrooms for many years, and the people have made use of a number of them economically in their daily life.

The Yorubas have recognized mushrooms for many years as in fungi have always played an important role in their everyday life. They have descriptive Yoruba names for their species of mushrooms as well as mythical stories and beliefs, which explain the origin of some of them. These myths and beliefs sometimes play a role in determining which of the mushrooms are edible and which of them may be used for medical purposes by the Yoruba native doctors.

The nutritional and medicinal values of mushrooms have long been recognized. In recent times, however, mushrooms have assumed greater importance in the diets of both rural urban dwellers. For example, they are being marketed along major highways and urban centers where the trade now booms. It is conceivable that the increased demand for mushrooms is contingent upon the phenomenal rise in the unit costs of the conventional sources of meat (e.g beef, pork, chicken, etc).

Edible mushrooms have been placed into five categories according to the derivation of their names, viz., those named according to the taste, morphology, growth habit, texture, and habitat (Oso, 1975). Examples in each category are: taste (*Volvariella volvacea*, *Volvariella esculenta* Yor. Ogiri agbe) *Termitomyces clypeatus* (Yor. Takete): Morphology (*Termitomyces manniformis*) (Yor. Rooro) *Termitomyces robustus* (Yor.Ewe) *Schizophyllum commue* Fr (Yor. Ese-adie) *Agrocyber broadway* (Murr) (Yor. Gunnugu); growth habit (*Termitomyces globulus*, *Pleurotus tuber-reguim*) (Yor. Olu); texture (*Pleurotus squarrouslus*) (Yor. Erirokiro), *Psathyrella atroumbonata* (Yor.Wowo); habitat (*Francolimus bicalcaratus*)

(Yor.Isoaparo). In addition to the above, the natives have observed the growth of many fungi on different kinds of dead wood and have named each fungus after the wood on which it grows.

Besides the edible mushrooms, the natives also recognize some poisonous or none edible fungi a few of which are listed here. *Coprinus africans* (Yor. Ajeimutin), *Phallus aurantiacus*, *Phallus industiatus*, *Phallus rubicundus* and *Mutinus bambustnus* (Yor.Akufodewa), *Celtis zenkeri* (Yor.Asa-ita), *Coprinus enphemerus* (Yor.Olu-gbongaga).

There has been a recent upsurge of interest in mushrooms not only as a health vegetable (food) which is rich in protein but also as a source of biologically active compounds of medicinal value. Uses include complementary medicine/dietary supplements for anticancer, antiviral, immunopotentiating, hypocholesterolemic, and hepatoprotective agents. This new class of compounds, termed *mushroom nutriceuticals* are extractable from either the mushroom mycelium or fruiting body and represent an important component of the expanding mushroom biotechnology industry. It has been shown that constant intake of either mushrooms or mushroom nutriceuticals (dietary supplements) can make people fitter and healthier. In addition, mushroom cultivation can also help to convert agricultural and forest wastes into useful matter and reduce pollution in the environment. Therefore, mushroom cultivation can make three important contributions: production of health food, manufacture of nutriceuticals, and reduction of environmental pollution.

Mushrooms are among the largest fungi, which have attracted the attention of naturalists before microscopes, or even simple lenses had thought of. Mushrooms date back to antiquity and are even associated with some past. For example, the Romans attributed the appearance of mushrooms and truffles to lightning hurled by Jupiter to the earth. Even, the Indians of Mexico and Guatemala believe that the appearance of certain mushrooms such as the "fly agaric" *Amanita muscaria* is correlated with a relationship between thunder, lightning and the earth.

CEREMONIAL USES OF MUSHROOMS

For centuries, some mushrooms have been used in religious ceremonies of many ancient people and primitive tribes.

Mushrooms are believed by the Romans to have properties that could produce super human strength, help in finding lost objects and lead the soul to the realm of the gods (Grube *et al.*, 2001). Here in Nigeria, the people of Ohia, in Abia State during one of their festivals consume the fungi (Lebo, 2004).

CULTIVATION OF MUSHROOMS

As a group, mushrooms occur in different parts of the world, ranging from arctic to the tropics. While some species occur only in restricted areas, others exist in areas that are widely separated geographically. However, most species seem to show a preference for a certain type of habitat. Some are, for instance, found primarily in upland wooded areas; others exist in swamps and still others prefer open areas such as gardens, lawns or pasture e.g Pleurotus tuber-regium. Many species particularly the mycorrhizal forms are associated with certain types of vegetations. Within a certain habitat, mushrooms may also show a preference for a particular substratum. Basidiocarps of some are typically produced on the soil and are generally referred to as terrestrial forms. Others are found on dead leaves (follicolous) or litter e.g *Cortinarius melliolens* and *Tricholoma lobayensis*, on wood (lignicolous) e.g *Lentinus edodes* or on dung (corpophilous) e.g *Coprinus lagopus*. A few grow on nasidiocarps of other mushrooms and are termed fungicolus.

Mushrooms are mostly found on wastes such as sawdust, garbages and composting materials (Gbolagade *et al.*, 2006). Statemet (2001) noted that garden mushrooms were propagated from fermented horse dung and moist litter all the year round. Miles and Chang (2004) deduced from the evidence presented in various early publications, that mushroom cultivation started in France about 1630, since then, series of studies have been conducted to monitor different growth parameters in both natural and pure culture. Compositing

progress was measured by changes in temperature, hydrogen ion concentration (pH), and ability of compost top support growth of mushroom mycelia.Growth of mushroom was observed to take place over a wide range of pH, i.e pH 3.4 – pH 9.0 (Adebayo *et al*., 2009). The investigation carried out on *Coprinus cinerus* and *Volvariella volvacea* in relationship to pH showed that a drop in pH enhanced the growth of *C. cinerus* while neutral pH favors *V. volvacea*.

A combination of condition such as temperature, pH, light, physical properties of subtraction and proportion of nutritional factors have effect on the growth of mycelia as well as production of fruiting bodies.

During mycelia growth on their substrate, mushroom produce a number of enzymes which breakdown complex organic compounds such as cellulose and lignin into soluble production, which are absorbed by the hyphae. Different types of mushrooms were qualitatively examined for their ability to hydrolyse starch. Kuforiji and Fasidi, (2008) proved that *Lentnus adodes* mycelia are known to grow on various agar media and liquid cultures. Composts supplemented with organic material containing vitamin B-complex were claimed to enhance greater yield of mushroom.

The general pattern carbon source utilization of *Agaricus bisporus* is similar among the various reports despite considerable difference in strains, time and place of study. Generally glucose, fructose and xylose are reported as good carbon sources. All fungi require a nitrogen source.

Investigations on the effect of several environmental factors on mushroom both independently and in different conditions were carried out by Adenipekun and Fasidi, (2005); Kuforiji and Fasidi, (2007); Ukoima *et al*., (2009a & b). They found out that a combination of condition such as temperatures, pH, physical properties of substratum of proportion of nutritional factors have effect on the growth of mycelia. Mycelia are produced as a result of spore germination. It is the fruit body that attracts the attention of mushroom hunters because it is fleshy and also more conspicuous.

Lots of researches have been carried out in Nigeria. Some of the works include cultivation on sawdust of different plants (Okhuoya (1998); Gyar and Ogbonna (2006); Kuforiji and Fasidi, (2008), agricultural and agro industrial wastes (Fasidi and Kadiri, (1993); Adenipekun and Fasidi (2005); Ayodele and Okhuoya (2007); Kuforiji and Fasidi, (2007); Onuoha *et al*. (2009); Ukoima *et al*. (2009), cotton waste and cassava peel (Adebayo *et al*. 2009) and culture media (Ukoima *et al*. 2009). Elsewhere, examples of the different formulas for spawn substrates are: Mother grain spawn: (i) Wheat/rye grain C 1.5% gypsum or slaked lime. (ii) Cotton seed hull 40%, sawdust 38%, wheat bran 20%, sugar 1%, and gypsum 1%. (iii) Sugar cane bagasse 40%, sawdust 38%, wheat bran 20%, sugar 1%, and gypsum 1%. Planting spawn: A number of materials, mostly agricultural and forest wastes, can be used to prepare mushroom planting spawn. Three of them are given here as examples: sawdust 78%, rice/wheat bran 16%, sugar 1.5%, corn flour 1.7%, ammonium sulphate 0.3%, calcium superphosphate 0.5%, and gypsum 2%; sawdust 64%, wheat bran 15%, spent coffee grounds 20%, and gypsum/lime 1%; and sawdust 78%, sucrose 1%, wheat bran 20%, and calcium carbonate 1%.(Chang, 2008).

Apart from cultivation from wastes, there is the mushroom industry. Mushroom industry can be considered to be composed of cultivated edible mushrooms, medicinal mushrooms, and wild mushrooms (Chang, 2006).

According to the Training manual on Mushroom Cultivation Technology, (2008), there are advantages of mushrooms cultivation, these are highlighted below:

1. Wastes such as cereal straws are largely burnt by the farmers, which causes air pollution. However, these raw materials can actually be used for the cultivation of mushrooms. This kind of bioconversion exercise can greatly reduce environmental pollution.

2. It serves as means of generating employment, particularly for rural women and youths in order to raise their social status.
3. It provides the people with an additional vegetable of high quality, and enrich the diet with high quality proteins, minerals and vitamins which can be of direct benefit to the human health and fitness. The extractable bioactive compounds from medicinal mushrooms would enhance human's immune systems and improve their quality of life.
4. Mushroom cultivation is a cash crop. It improves economic standards of the people some warm mushrooms, e.g. *Volvariella volvacea* (Straw mushrooms) and *Pleurotussajor-caju* (Oyster mushrooms) are relatively fast growing organisms and can be harvested in 3 to 4 weeks after spawning. It is a short return agricultural business and can be of immediate benefit to the community.

IDENTIFICATION

Macroscopic structure of mushrooms must be understood before identification can be made. Most of them are Basidiomycetes and gilled. Their spores called basidiospores are produced on the gills and fall in a fine rain of powder from under the caps as a result. At the microscopic level the basidiospore are short off basisia and then falls between the gills in the dead air space. As a result, for most mushrooms, if the cap is cut off and placed gill – side – down overnight, a powdery impression reflecting the shape of the gills is formed. The color of the powdery print, called a spore print is used to help classify mudrooms and can help to identify them. Spores prints colors include white, brown, black, purple-brown, pink, yellow and cream, but almost never blue, green, or red.

A good reference material, usually a book with color, pictures of the different mushrooms known, is a basic requirement. A key is usually provided to simplify identification in most reference texts (Carlucccio, (2003); Fuhrer, (2005). In using the reference, it is essential that one knows some specific characteristics of the mushroom being identified. These characteristics are (1) size, color, and consistency of the cap and the stalk; (2) mode of attachment of the gills to the stalk; (3) spore color in mass; and (4) chemical tests or reactions.

There is no single reference work in which all mushrooms are illustrated or described. In most cases, mushroom species in publications are grouped by region or locality, for example, North American mushrooms, mushrooms of the Western Hemisphere, mushrooms of South Africa and those found in Nigeria. While certain mushrooms are easy to identify, many are not. In fact, there are a great number of look-alikes. To avoid any unpleasant experiences, especially when identifying mushrooms for the purpose of determining edibility, experts should always be consulted.

NUTRITIONAL VALUES OF MUSHROOMS

Edible mushrooms are important sources of food. They form very nourishing meals especially for invalids, for they are easily digestible. They are consumed not only for their innate flavour and taste, but also for their important nutritional value. On fresh weight basis mushrooms are superior in protein content (Aremu *et al*., 2009) to all vegetables and fruits, but are inferior to meat and dairy products, which are the conventional protein sources. On dry-weight basis, however, mushrooms are similar with respect to dried-yeast and superior to dried peas and beans. The nutrient content varies from species and depends on their growth requirement. Mushrooms have a high percentage of water 93-95% as compared to learn beef (70%) and fresh vegetables (92%). They also contain valuable minerals such as iron, potassium, phosphorus, calcium and copper, 56% carbohydrate, 30% protein, 2% fat and also 10% ash on dry weight basis. They are also rich in vitamin B and vitamin D.

Mushrooms provide a high protein and low caloric diet and can thus be recommended to heart patients. They also contain all the essential amino-acid required by an adult (Koyyalamudi *et al*., 2009). Tryptophan and lysine are present in high concentrations as compared to cystein and methionine.

Mushrooms is reported to be an excellent source of riboflavin and nicotinic acid; a good source of pantothenic acid and ascorbic acid (Ukpebor *et al*., 2007). The carbohydrate and fat contents of edible mushrooms are quite low. The absence of starch in mushrooms makes it an ideal food for diabetic patients and for persons who wants to shed excess fat.

Edible mushrooms known as the meat of the vegetable world (Haas and James, 2009) can be prepared into a variety of delicious dishes and as flavours for other dishes. Among the Nigerian mushroom dishes are mushrooms with vegetable, mushroom with vegetable and melon soup, mushroom in okro soup, and mushroom in stew. These soups are used to eat a variety of foods. Some people use mushrooms as a substitute for meat in their stews (Abulude, 2005).

There is evidence that consumption of plant foods such as fruits and vegetables, provide protection against various diseases, especially chronic degenerative diseases (Selvi *et al* (2007). This protection can be explained by the free –radical scavenging capacity of antioxidants in plant foods. Plant foods are a good source of polyphenols, which have been reported to be effective radical scavenger and inhibitors of liquid peroxidation (Makam and Konig, 2001). Kettawan *et al*., (2011) and Selvi *et al* (2007) have demonstrated that mushrooms contain antioxidants.

Apart from their nutritive values, mushrooms also have potential medicinal benefits especially as antitumour. Abulude, (2005); Kuforiji and Fasidi, (2008) and Kettawan *et al*., (2011) elaborated on the medicinal uses of Pleurotus tuber-regium in Nigeria. The stated that these mushrooms can be used in combination with other herbs as ingredients to care ailments such as chest pain, cold, dropsy, fever, headache, smallpox and stomach pains. The low carbohydrate content of mushrooms makes it an ideal food for diabetics and people w1ho intend to control their body weight.

SIDE EFFECTS OF MUSHROOMS

Mushrooms can also cause disease, decay and destruction in their search for food, since they have no chlorophyll, they must obtain organic material in prepared form, for example, *Armillaria mellea* "Honey fungus" causes serious damage to ramiferous tress and may attack shrubs and even herbaceous plants such as potatoes, and strawberries (Lange and Hora, 1963).

Cultivation of mushrooms on commercial scale is new to many developing countries of which Nigeria is one. This fact is due to the scantiness of information on the growth requirement of many indigenous mushrooms. In Nigeria, there are lots of industrial and agricultural wastes that may serve as potential source of raw material for commercial cultivation of mushroom at minimum cost.

Ita *et al*,(2008) in their study on bioaccumulation potential of heavy metals in sporocarps from Niger Delta region of Nigeria, revealed that certain mushrooms accumulate heavy metals. The accumulating potentials are affected by the species, substrate composition, age of mycelium and intervals between fructifications. Studies on metals in mushrooms have shown a correlation between fungal metals concentration and point sources of metal pollution (Isildak *et al*, 2004; Gyar and Ogbonna, 2006).

Human activities have been reported to impact negativity on arable lands contaminating them with pesticides, petroleum hydrocarbons, heavy metals and waste engine oil pollutants, and consequently causing arable land shortage and other environmental challenges (Okhuoya *et al*, 2010; Oghenekaro *et al*, 2008). These challenges may exert negative effect such as kidney damage, impairment of circulatory, reproductive and nervous system damage (Abulude *et al*, 2004) on man and animals when consumed (Ita *et al*, 2008).

Apart from the side effects, Mushroom mycelia can produce a group of complex extracellular enzymes which can degrade and utilize the lignocellulosic wastes in order to reduce pollution. It has been revealed recently that mushroom mycelia can play a significant role in the restoration of damaged environments.

Saprotrophic, endophytic, mycorrhizal, and even parasitic fungi/mushrooms can be used in mycorestoration, which can be performed in four different ways: mycofiltration (using mycelia to filter water), mycoforestry (using mycelia to restore forests), mycoremediation (using mycelia to eliminate toxic waste), and mycopesticides (using mycelia to control insect pests). These methods represent the potential to create a clean ecosystem, where no damage will be left after fungal implementation (Training Manual on Mushrooms cultivation, 2008).

STORAGE OF MUSHROOMS

At the post-harvest stage, mushrooms need to be stored in fresh condition to maintain their qualities and flavor, some common preservation methods are enumerated below which increase the shelf life of harvested mushrooms. Storage in 0.02-0.03mm dense polythene bags with nitrogen at 0^0C is equivalent to 5 weeks of shelf life; storage at 50^0C will give the mushroom a shelf life of 4 weeks while storage at 15^0C under the same condition will preserve the fungi for 2 weeks. It is noted that storage in controlled atmosphere of 9% oxygen and 25% carbon-dioxide; preservation by gamma-radiation will preserve mushroom for 10 days. Mushrooms can also be freeze-dried. Dehydration, grinding and storage in an air tight container could also be employed. The stored powder can be used for making mushroom soup, mushrooms can be treated and canned (Roy, 1984).

MARKETING

About 160,000 metric tons of mushrooms are produced annually in Japan, half of which is dried and exported. It represents a two billion dollars industry which employs about 200,000 people (Anderson and Marconiller, 2006). Worldwide, the business is worth millions of pounds annually, for the countries of Eastern Europe in particular, wild mushrooms are precious exports. Poland and France are two of the major exporters of mushrooms. In a statement from Allbusiness.com (2003), China is the world's largest edible mushroom producer. The country produces about half of all cultivated mushrooms, and around 2.7 kilograms of mushrooms are consumed per person per year by over a billion people.

Authoritative source from Spore (2006) revealed economically, mushrooms growers' association in Uganda sold 44 tons per year to Japan, 40 tons to the US and 2 tons to the Democratic Republic of Congo.

According to Olubanjo *et al*, 2006 in Nigeria, the commercial production and trade s still in its infancy. They attributed this to poor underdeveloped nature of demand for edible, local and cultivated exotic mushrooms. To increase the mushroom marketing, constant advertisement to create awareness, good storage and packaging should be ensured. Good storage and value addition by processing and canning can solve the problem of seasonality in availability (Olubanjo *et al*, 2006). Gradually, mushrooms are income generating.

MEDICINAL VALUE

Medicinal mushrooms are mushrooms, or mushroom extracts, that are used or studied as possible treatments for diseases. *Lentinula edodes* (shiitake), *Grifola frondosa* (maitake), and *Ganoderma lucidum* (reishi), have a history of medicinal use spanning millennia in parts of Asia. Medicinal mushroom research has indicated possible cardiovascular, anticancer, antiviral, antibacterial, antiparasitic, anti-inflammatory, hepatoprotective, and antidiabetic activities (Lentinan, 2009).

In Nigeria benefits of mushrooms such as the nutrition, medicinal and mythological uses have been reviewed (Akpaja *et al*., 2005; Osemwegie *et al*., 2006). Even Labarere and Menini (2000) acknowledged that the uses of mushroom genetic resources are not only of high interest in agronomy, agriculture, human food and animal feed but also for the discovery, production and development of molecules or components with high added value in industries such as chemical and pharmaceutical industries.

Some mushrooms materials, including polysaccharide, glycoprotein and proteoglycens, modulate immune system responses and inhibit tumor growth. Currently, several extracts have wide spread use in Japan,

Korea, and China, as adjuncts to radiation treatments and chemotherapy (Smith *et al*, 2002; Borchers *et al*, 2008). Mushrooms that have psychoactive substances have been used as sacraments for healing (Mental and physical) (Hudler 2000). Certain mushrooms, especially polypores like Reishi were thought to be able to benefit a wide variety of health ailments (Sarfaraz *et al*, 2009).

Ogbe *et al*., (2008), in a research carried out, they found out there were improvements of egg-laying and disease resistant capacity of birds when they used *Ganoderma* species. Beta-glucan based dietary supplements of mushroom origin are effective for the treatment of Buruli ulcer caused by *Mycobacterium ulcerans* in Ghana while *Ganoderma lucidum* (Leyss.) Karst. Tested in separate study for the treatment of *Eimeria tenella* infected broiler chickens in Nigeria (Okhuoya *et al*., 2010).

OTHER USES

According to Wikipedia, the free encyclopedia (2011), mushrooms have been used for dyeing wood and other natural fibers. The chromosphores of mushroom dyes are organic compound and produce strong and vivid colors, and all colors of the spectrum can be achieved with mushrooms dyes. Dyes from them have been the source of many dyes before the synthetic ones (Mussak and Bechtold 2009).

In the US, and other developed countries, mushrooms have been used as fire starters. They have also been applied by Ecovative design LLC to produce biodegradable packaging. Presently, they play a role in the development of new biological remediation techniques and filtration technologies (Wikipedia, 2011)

Mushrooms are used as gun powder (Akpaya *et al*., 2005)

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