



*Review*

## Mushroom research, production and marketing in Cameroon: A review

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In Cameroon, edible mushrooms (macrofungi) are referred to as the “poor man’s meat” because it serve as a source of protein for people who cannot afford other protein sources from animal products. Edible and medicinal mushrooms are ubiquitous found in Cameroon constituting a substantial volume of internal trade especially by women in rural areas. The objective of this study was to review published research works on mushroom research, production and marketing in Cameroon. A literature search was done on the internet, university libraries and personal communication with researchers in this area. It was found that, mushroom research in Cameroon is under explored and the few research carried out is mostly concerned with the taxonomy, ecological and ethnomycological studies. There is a dearth of information on the cultivation, nutritional content, biotechnology and bioactivity of compounds for medicinal utility. With the known nutritional and medicinal benefits from mushroom in treating and preventing diseases in many countries, there is a need for more research in these areas in Cameroon. The demand for edible and medicinal mushroom presently exceeds supply due to low capital investment to boost production, lack of trained personnel in mushroom biotechnology and above all poor post harvest storage facilities. This is evident by the number of people mostly children and women who scramble for mushroom after the first drop of the rain, also medical doctors advice patients suffering from diabetes, hypertension, HIV/AIDS, cancer and other ailments to consume mushroom. There is a ready market for mushroom in Cameroon; however this needs to go alongside more research work, sensitization, training of manpower, provision of funds by the government of Cameroon and International organizations for mushroom research and commercialization. This will go a long way to better the health and nutrition of the people of Cameroon.

**Key words:** Mushrooms, research, production, market, Cameroon

### INTRODUCTION

Macro-fungi include fungi distinguished by forming fruiting-bodies and commonly referred to as mushrooms visible to naked eye. They form an important role in forest ecosystems such as forest flourishing through mycorrhizal associations and nutrient cycling through saprobic life (Boa, 2004). Macrofungi are also very useful in food industries (Lindequists et al, 2005). Edible mushrooms provide a wide range of minerals and vitamins although the total nutrient

content varies significantly among species. Mushroom cultivation provides an opportunity to improve local farmers’ livelihoods and reduce dependence on natural resources (Allen et al., 1995).

Cameroon is located in Central-Western Africa. It is bordered by Nigeria to the west; Chad to the northeast; the Central Africa Republic to the east; and Equatorial Guinea, Gabon, and the Republic of the Congo to the south.

Cameroon has a population of approximately 22 million, with a growth rate of about 3.13%. 70% of the population lives in rural areas and about 40% of the entire population lives below the poverty line of US\$1 per day. Cameroon is endowed with diverse natural resources including the forest which harbours the timber and non-timber forest products. Mushrooms are one of the non timber forest products which people in the rural areas depend on as their protein source and to improve on their livelihoods.

The first known edible mushrooms from Cameroon were first described by Hennings in 1895 and included *Lepiota*, *Marasmius* and *Mycena* species. Heim (1855) also noted the consumption of *Lactarius gymnocarpus* in the South Region of Cameroon. This shows that there has been a long time tradition of mushroom utilization by the people of Cameroon. Mushroom production in Cameroon began in the early 1980s. As a result of economic crisis, many people could not more survive with their meager salaries. So many NGO's in mushroom cultivation created during that period began to supplement their incomes. The diversity of mushroom species in Cameroon has not been fully studied because the mycobiota for some biodiversity hotspots are not known. Common edible mushrooms species in Cameroon include the *Termitomyces*, *Pleurotus*, *Agaricus*, *Flammulina*, *Auricularia* and those used for medicinal purposes includes the *Termitomyces* and *Ganoderma* to name a few.

In Cameroon, there is an inadequate food supply in most rural areas, diminishing quality of health and increasing environmental deterioration. Many children and people in Cameroon are malnourished and most families cannot afford meat in their daily meal, there is also high prevalence rate of HIV/AIDS, malaria, and tuberculosis amongst others. Hence mushrooms can help to improve health and nutrition. When used as food, mushrooms promote good human health, being rich sources of protein and vitamins (including thiamine, riboflavin, niacin, biotin, cobalamin, ascorbic acid, etc.), unsaturated fatty acids and essential minerals (e.g., potassium, zinc, selenium, phosphorus, cobalt, copper), which play important physiological roles, e.g., as cofactors in enzyme systems Mshigeni et al., (2009).

Mushrooming in Cameroon rainforest zones is often possible only during the rainy season and is usually inefficient in terms of time spent to collect sufficient mushroom. Most edible species rot quickly and collector must be at the right time at the right place. Hence, there is a need for a cultivation center for lasting availability of mushroom. People usually boiled or fried mushrooms as meat substitute in various types of sauces and dishes. However, some people are afraid to consume many mushrooms for fear of been poisoned. The local people try to detect poisonous mushroom by dipping a silver spoon into the pot during mushroom cooking and if the spoon changes colour these mushrooms are assumed poisonous. If insects, rodents and snakes don't feed on the mushroom then it is assumed to be poisonous. Moreover, mushrooms that cause

itching if rubbed on the breast nipple or elbow or spew out if tasted are considered toxic. The people also think that if mushrooms have strange colours, then it is toxic. Despite the importance of mushroom in the ecosystems, health and nutrition, little research on mushroom, their production and marketing has been done in Cameroon. The aim of this study was to review literature on mushroom research, production and marketing in Cameroon.

### Mushroom research

Scientific research in Cameroon is carried out by state universities and research institutes. Most attention on research has been turn towards cash crops for exports such as cocoa, coffee, bananas, oil palm etc. Annual crop research activities in Cameroon were initially conducted by the then French tropical agronomic research institute (IRAT), at Bambui and Dschang.

In the mid-60s, after independence, when research was nationalized and a National Office for Scientific and Technical Research (ONAREST) was organized to cater for organized research in the country, nine research institutes were created and food crop activities were entrusted to the Institute of Food and Textile Crops (ICVT), with headquarters at Njombe. Later reorganization of scientific research led to the merging of all agriculture-related institutes into one, the Institute of Agricultural and Forestry Research (IRAF). IRAF gave way to the Institute of Agronomic Research (IRA), which later merged with the Institute of Animal and Veterinary Research (IRZV) to yield the present day Institute of Agricultural Research for Development (IRAD).

Although, Cameroon boasts of a sprawling cache of junior academic institutions of excellence, higher institutions however are rather insufficient. Until date there are barely eight state run universities in (Bamenda, Buea, Douala, Yaounde I & II, Dschang, Maroua and Ngaoundere) and only a handful of thriving private universities like the Catholic Institute of the Diocese of Buea, Catholic Univeristy of Cameroon, Cameroon Christain University, Bamenda University of Science and Technology (BUST) and the Fotso Victor University in the West Region.

In Cameroon, mushroom research has been carried out in the areas of systematic, ecology, conservation, ethnomycological surveys, nutritional studies and cultivation. However just about 5% of the total tropical forest zone of 394.700km square has been studied. Some researchers who have contributed to the knowledge of edible and medicinal mushroom in Cameroon include:

Douanla-Meli (2007) studied the ecological diversity of mushrooms from the Mbalmayo forest reserves with emphasis on the taxonomy of non-gilled Hymenomycetes. 271 distinct species belonging to 110 genera in 58 families were recorded. Many new records and species new to science and important ethnomycological notes for people in and around the Mbalmayo forest reserves were documented.

Dijk et al, (2003) investigated the indigenous knowledge of edible mushrooms by local populations, relating folk taxonomy to scientific nomenclature, assessed the type and rate of mushroom utilization, investigated harvesting patterns and determining factors that affected mushroom use in the rain forest zone in the South Region of Cameroon. They found out that people had a well developed knowledge of native edible fungi and some species consumed as food included *Schizophyllum commune*, *Collybia aurea*, *Volvariella volvacea*, *Auricularia polytricha*, *Dacryopinax spathularia*, *Tremella fuciformis*, *Cantherellus* sp and *Sarcosom globosum*. They also found some species that are been used as cosmetics, dyes, fumigation of huts, to preserve jewelry and as medicines. *Lentinus squarrosulus* was believed in aiding the healing of the newborn's navel. *Pleurotus tuberregium* was reported to improve lactation of breast feeding women and its sclerotium may heal heart palpitations. *Cookeina sulcipes*, *C. tricholoma* and *Termitomyces* sp. may be used for ear inflammation.

Nunez and Daniels (1999), studied fungi from the Dja Biosphere reserve and found 23 species of polypores new to Cameroon. Species of *Amauroderma*, *Ganoderma*, *Phellinus*, *Antrodiella*, *Coriolopsis* were found among others.

Onguene (2000), researched on mycorrhizal association in the tropical rain forest of Campo in South Cameroon under various disturbance regimes and stages in order to provide essential information on the roles of mycorrhizas in tree establishment and forest recovery. It was revealed that the ectomycorrhizal fungi in the family Amanitaceae, Russulaceae, Boletaceae and Cantharellaceae were well represented, only few species of Cortinariaceae, Sclerodermataceae, Gomphaceae, Clavulinaceae and Hymenochaetaceae were found.

Roberts and Ryvardeen (2006), reported over 70 poroid species was from the Korup rainforest, Cameroon. Poroid bracket fungi are among the most prominent of forest fungi, often producing large, perennially visible fruiting bodies. They are ecologically important as the main decomposers of dead and fallen wood, forming an essential part of the forest nutrient recycling system and many medicinal mushrooms are found in this group. They described one genus and 16 species new to science.

Yongabi et al, (2004), carried out ethnomycological studies in Ndog plains, Baligham, Mbouda and Kumba, Cameroon for the purpose to identify mushroom diversity and traditional uses. A total of 22 mushroom species were identified by conventional taxonomy included *Termitomyces* spp, *Flammulina velutipes*, *Agaricus* spp, *Auricularia auricular* and *Pleurotus tuberregium*. They also found that mushrooms are used singly or in combination with other plants in treating diseases. For example *Ganoderma lucidium* is dried and mixed with palm oil and used as ointment for the treatment of skin diseases, boils, abscesses and tumors. *Termitomyces titanicus* is dried, ground and mixed with a pastry for consumption by children that are underweight and for diabetes.

Kansci et al, (2003), revealed the nutritional contents of some mushroom species of the genus *Termitomyces* consumed in Cameroon and found high water content of 83.3-94.3g/100g wet matter, and contained more lipids of 2.5-5.4g/100 dry weight with high proportions of polyunsaturated fatty acids of 45.1-65.1% of total fatty acid, methyl esters and remarkable proportions of crude fibres (17.5-24.7g/dry weight). Their protein content varied between 15.1 and 19.1g/100g dry weight and ash content between 5.2 and 14.4.

Kinge and Mih (2011), described a new species of *Ganoderma*, which could not be identified with any known species during a survey of fungi associated with basal stem rot disease of oil palm in the Littoral and South West Regions of Cameroon. Morphological and molecular characterization showed that it was closely related to *G. steyaertanum* and *G. boninense*, but distinct from these in having ellipsoidal basidiospores with slightly truncated apices. Elucidation of the phylogenetic relationship with other species of *Ganoderma*, using internally transcribed rDNA sequences (ITS1, 5.8S and ITS2) showed that it was a distinct species, in the oil palm clade that is new to science. This species was named *Ganoderma ryvardense* R.K. Tonjock & A.M. Mih, with the specific epithet in honor of Lief Ryvardeen, a renowned mycologist who has contributed immensely to the African mycobiota and to the genus *Ganoderma*.

Kinge and Mih (2011), identified three lanostane-type triterpenoids ; lanosta-7,9 (11), 24-trien-3-one 15, 26-dihydroxy, lanosta-7,9(11), 24-trien-26-oic, 3-hydroxy and ganoderic acid y, four steroids ; (22E, 24R)-ergosta-7, 22-dien-3  $\beta$ , 5  $\alpha$  8  $\alpha$ -epidiory, (22E,24R)-ergosta-6,22-dien-3 $\beta$ -ol, ergosta-5,7,22-trien-3 $\beta$ -ol,7 (ergosterol) and ergosta-7,22-dien-3 $\beta$ -ol,6] and a benzene derivative (dimethyl phthalate) isolated from ethyl acetate crude extract of *Ganoderma zonatum* Murill of oil palm from Cameroon. Their structures were elucidated by nuclear magnetic resonance (NMR), electron impact ionization mass spectrum experiments (EI-MS) and by comparing with the data reported in literature. The highly oxygenated lanostane triterpenoid - ganoderic acid y was found to show moderate cytotoxicity against two human tumour cell lines, SMMC-7721 (liver cancer) and A549 (lung cancer) with IC 50 values of 33.5 and 29.9  $\mu$ M, respectively and no activity on HL-60, MCF-7 and SW480, while lanosta-7,9(11),24-trien-3-one,15;26-dihydroxy and lanosta- 7,9(11),24-trien-26-oic,3-hydroxy, showed no activity.

Kinge et al. (2011), carried out an ethnomycological survey in the Mount Cameroon Region with the aim of documenting the indigenous knowledge of mushrooms as a prelude to conservation efforts. They also sought to assess the mycophilic and mycophobic tendencies of the inhabitants. It was revealed that traditionally, mushrooms were used as food, medicine, for mythological purposes, for aesthetics, and some poisonous species were also recorded. Fifteen different species were identified to be edible among

the Bakweri people. In that region species used for ethnomedicine among the Bakweris belonged to several genera, including *Termitomyces*, *Auricularia*, *Agaricus*, *Daldinia*, *Dictyophora*, *Pleurotus*, *Russula*, *Trametes*, *Chlorophyllum*, and *Ganoderma*. Mushrooms were used as love charms, for dispelling evil spirits, and as part of cultural festivals.

Kinge et al., (2012), identified different species of *Ganoderma* as an important genus of the Polyporales in the tropics. Identification of tropical species has mainly been based on morphology, which has led to misidentification. Their study aimed at elucidating the diversity and phylogenetic relationships of *Ganoderma* isolates from different hosts in Cameroon using morphological and molecular techniques. Analyses of basidiocarp morphology, internal transcribed spacer and mitochondria small subunit were undertaken for 28 isolates from five plant species. The results showed that the isolates belonged to eight species. Three of the species were identified to species level; of these only *G. ryvardense* has been previously described from Cameroon with *G. cupreum* and *G. weberianum* being new records. The five remaining species did not match with any previously described species and have been designated as *Ganoderma* with different species affinities.

Ajoninia and Tatah (2012), evaluated the growth performance of oyster mushroom (*Pleurotus ostreatus*) on different locally available substrate compositions to find out the best substrate for mushroom cultivation. Bags were sterilised in 1000 litres iron containers for 5h at 100°C, cooled for 6h and then inoculated with actively growing mushroom mother culture on rice grains obtained from Mushroom Cameroon, Bamenda. The bags were incubated until mycelium had fully colonized the substrate and then taken to the cropping house. The highest mycelium running rate was found on corn cobs and palm cones (1:1) but the lowest in control. Completion of mycelium running time was lowest in (1:3, 3:1 and palm cones). Number of total primordia and effective primordia, found highest in control but the highest pileus thickness was measured from corn cobs. Highest biological yield (146.1 g and 172.1 g) was obtained from corn cones which was much higher than control.

Kinge et al., (2013), researched in the Mount Cameroon Region between 2010 and 2012 to produce a check-list of macrofungi. Reported 520 samples of macrofungi collected in the region. A checklist of 177 species of fungi belonging to 83 genera was recorded. A new record for the area encompasses 163 species of Basidiomycetes and 14 species of the Ascomycetes.

Egbe et al., (2013), carried out an altitudinal research on the diversity and distribution of macrofungi in the Mount Cameroon Region, which resulted in a total of 177 macrofungal species belonging to 83 genera and 38 families recorded. Species richness was higher in the rainy seasons (134 species) than in the early dry seasons (89 species) and tended to decrease with altitude, with 116 and 112 species

for low and high altitudes, respectively. Eighty-eight species were recorded only in the rainy seasons, 43 species in the early dry seasons only, and 46 species were common to both seasons. Sixty-five species were found only in the low altitude, 61 species only in the high altitude, and 51 species were common to both altitudes. *Auricularia auricular* was the most abundant species during the rainy seasons, while *Coltricia cinnamomea* was rare during the rainy seasons, and the most abundant during the dry seasons. Six of the 12 morpho-groups identified occurred across the sites, with the gilled fungi being the most frequent. *Cyathus striatus* was found only in Buea Town during the rainy seasons. The study established that macrofungal diversity is threatened in the Mount Cameroon Region and there is a need for conservation measures especially for edible and medicinal species.

### Mushroom production

Mushroom play important social, economic and ecological roles in Cameroon. About 70% of people live in rural areas and most of them on poor diets. Cameroonians are familiar with the sayings that *rain follows the sun*, and *mushrooms follow the rain*. So immediately after the rain, children and women go out early in the morning to gather mushrooms especially the *Termitomyces*, *Agaricus*, *Pleurotus*, *Flammulina* and *Auricularia* amongst others. They normally gather this species in moist shady soils, dry or smoke their harvests and then keep them for several months. Alternatively, it is taken to the market to be sold.

With the economic crisis in 1982, and the subsequent devaluation of the CFA salaries of workers were reduced drastically, and a high rate of unemployment. Hence, many Cameroonians grouped themselves in development associations known as NGO's (Non Governmental Organizations) to supplement their incomes and assure their survival. Many of these NGO's are involved in mushroom cultivation e.g., OCACAM, CERUT, GOOD FRAM, WACOMAC and MUPTAREC etc. Pensioners are also actively involved in mushroom production to supplement their incomes.

The substrate, used by most cultivators includes corn husk, and then the other ingredients like urea, whitewash fungicides and the plastic bags bought from the market or agricultural waste, be it palm bunch waste, maize husks that is found everywhere, even saw-dust are needed. According to research, maize cobs and the palm bunch waste common in oil palm plantations such as CDC, PAMOL, and SOCAPALM are considered the most important and are relatively cheap and abundant. If the tram of about 250 kg of mushroom substrate in bags were used it will take about three months to harvest their mushrooms.

From the substrate inoculation, it takes three to four weeks in the incubation room that is in the dark room where the mycelium is left to colonize the substrate. After this, it is put under white light for one to two weeks for the

caps to be fully formed and they might be harvested for three months before they are finally discarded off if they wish to or alternatively, they are bury in the soil and mushrooms start coming out again. The remains of the substrate are also used in feeding animals or in the farm as manure.

The spawn (inoculums on corn) production requires appropriate aseptic conditions, which local mushroom farmers cannot afford. Therefore, they used spawn supplied in the market by specialized services. Spawn of 1000 to 1500 CFA francs (2-3USD) can be used for spawning about ten kilogram of substrate which can yield about 7 to 8 kg (fresh Weight) of mushroom harvest. In the market presently the spawn is sold for (2USD) 1000 francs per kg. It cost about (15USD) 7000 FCFA for one bottle. Some cultivators grow spawn of *Pleurotus* but many people in the Southwest Region have to travel to Yaoundé in the Center to collect spawn from the Obala mushroom project and there is generally a scarcity of mushroom in this region and many other regions because many people don't still believe that mushroom can be cultivated. Most people in NGO's believe that there is much benefit in growing mushrooms for little work done.

### **Mushroom marketing**

Mushrooms are gathered in raffia baskets, taken to regional markets to be sold. Baskets containing about 3-4kg of fresh mushrooms, depending on bargaining, can reach a market price of 21000 FCFA (42USD) (Yongabi et al., 2004).

There is a ready market in Douala, Littoral region for processed and unprocessed mushrooms. Many people like to consume mushrooms on regular bases. Most NGO's are not able to satisfy the local farmers not to talk of looking for market outlets in restaurants, hotels and international. Mushrooms are not always available in the markets. Medical doctors prescribe mushroom consumption to vegetarians, pregnant and lactating women as well as patients with diabetes, hypertension, high cholesterol level, kidney disease etc.

Mushroom nutraceuticals and supplement are already been sold in Douala, Cameroon, but these are imported from China, Japan and the USA by business men and women, but are too expensive for most Cameroonians to afford. Also the distribution centers are limited and most people need to be sensitized on mushroom products.

### **Constraints on the development of Cameroon mushroom resources**

1. Need of Government financial support for mushroom research, production and marketing.
2. Lack of genuine mushroom taxonomy program and mushroom biomedical and biotechnology research centre.
3. Cameroon lacks a critical mass of scientists to undertake serious research on the commercialization of the affluent

mushroom biodiversity. The government must aggressively recruit, train, and retain a critical mass of scientists, to lead the process towards a vibrant mushroom farming and processing industry in the country. Also most laboratories are without the necessary equipment to carryout good research work hence many scientists cannot do research.

4. Lack of effective communication channels on mushroom marketing: there should be effective communication through the media, seminars, sensitization of the local population, workshops and conferences on mushroom and mushroom product, formation of mushroom groups and clubs in schools.

5. Outdated school curricula; mushroom science should be integrated in the Cameroonian school curriculum.

6. Mycophobia ; there is the need for mycotaxonomists to provide a check list of edible, medicinal and poisonous mushroom in Cameroon and also to carry out a toxicity test on mushrooms to encourage the population to be more engaged in mushroom utilization.

7. Loss of mushroom biodiversity; there is need to collect and maintain strains of Cameroonian mushrooms in a culture collection center hence with the increase of climate change, habitat change and destruction due to deforestation etc, our mushroom may become extinct forever.

8. Lack of post harvest facilities to preserve mushroom harvested for long term.

### **Conclusion**

Mushroom biodiversity in Cameroon is rich and remains poorly explored. It is proposed that mushroom research should focus on all aspects including taxonomy, ecology, biodiversity, pharmacological properties and mushroom cultivation amongst others. It is evident that the people of Cameroon have a long tradition of mushroom utilization hence there is a possibility for large scale production and a ready market, but this has to go hand in hand with research. Let's all join our hands to improve human health and nutrition and to discover the mycobiota of Cameroon, a country blessed with abundant natural resources.

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