BIO Web of Conferences **187**, 01004 (2025) https://doi.org/10.1051/bioconf/202518701004
ISPH-ISNPR 2025

African mushrooms as a preventative healthcare and nutrition intervention

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Abstract. In Africa, food insecurity remains a significant challenge, with millions struggling to access adequate and nutritious food, particularly in eastern, western, and central regions. Limited access to nutritious food, poor infrastructure, and non-existent service significantly impact healthcare and nutrition challenges like wasting, stunting, underweight, micronutrient and essential amino acids deficiencies. Promoting indigenous crops, including mushrooms, is one way to mitigate these effects while meeting dietary requirements. It is evident from the literature that Africa's health depends on improved nutrition. Mushrooms offer a range of nutritional benefits and can be a valuable addition to a healthy diet, providing vitamins, minerals, antioxidants, and other beneficial compounds that support overall well-being. Extensive studies focusing on the efficient health-promoting properties (nutraceuticals) and high nutritional value (protein sources) of mushrooms have increased over the past few decades. However, limited investigations have been done on African mushrooms. The focus of the study was to provide an overview and compile the latest information on the potential nutritional and health benefits of African mushrooms. From this study, it is concluded that screening more species is necessary, particularly with the addition of mushrooms to the diet, as a sustainable source of natural adjuvants for the prevention and treatment of various health diseases.

1 Introduction

Preventive healthcare and nutrition intervention involve a proactive approach to health by promoting healthy lifestyles and preventing disease through dietary choices and other preventative measures [1]. This includes strategies like promoting healthy eating habits, encouraging regular physical activity, and giving access to preventive healthcare services, including vaccinations and screenings. Food security and adequate nutrition are crucial for promoting overall well-being while reducing the risks of chronic diseases. Indigenous crops and mushrooms play a vital role in preventive healthcare and nutrition interventions by offering a diverse range of nutrients and potential health benefits, often overlooked in mainstream diets [2]. They can contribute to food security, address micronutrient deficiencies, and offer a sustainable approach to healthy eating, especially in regions where they are locally available and culturally relevant.

Mushrooms have several nutritional benefits, making them a valuable addition to a healthy diet, providing vitamins, minerals, antioxidants, and other beneficial compounds that support health and overall well-being [3]. Mushrooms will be included in the next-generation diets, providing health and wellness, while being prophylactic or therapeutic agents. For centuries, African mushrooms have contributed to food security [4] and income generation for the local community, while also being used to treat various ailments [5]. African mushrooms are increasingly recognized for their medicinal properties and potential in treating various diseases. Traditional healers have habitually used them for ailments like headaches, stomach pain, and even more serious conditions like cancer. However, they have been neglected and poorly understood, with minimal scientific studies done. Therefore, this mini-review aimed to provide a summary of the current knowledge on the nutritional value of edible wild mushrooms on the African continent.

2 Materials and Methods

For this mini-review, relevant studies published in peer-reviewed journals, book chapters, and non-academic reports were chosen. Publications were confined to those available since 2000, written in English and covering Africa, Madagascar and related islands. A comprehensive literature search was performed using the CAB index, Scopus, PubMed and Google Scholar. Specific keywords such as traditional use, edible wild fungi, Africa, health benefits, nutraceutical properties, and proximate analysis were used in various combinations.

3 Results and Discussion

Extensive studies on the efficient health-promoting properties (nutraceuticals) and high nutritional value (protein sources) of mushrooms worldwide, especially from Asia, have increased over the past few decades. However, limited investigations have been done on African mushrooms. From all the publications retrieved, one review in particular, Sileshi and co-authors in 2023 [6], highlights the significant potential of African mushrooms as a food source, medicine, and source of income, particularly for rural populations. Limited studies have previously been published on wild mushrooms in Africa.

3.1 Biodiversity

Africa is recognised for its rich biodiversity of plants and edible mushrooms. Over 480 species of mushrooms have been identified, belonging to more than 126 genera and 60 families [6] (Table 1). Despite this, a minimum of studies highlighted the wide variety of edible and medicinal mushrooms found in Central, East, and West Africa.

Fungal distribution is often underreported in tropical regions, including parts of Africa, due to limited sampling. Mostly harvested from the wild, the availability of these edible mushrooms often depends on the climate and suitable habitats, including forests, woodlands, and even termite mounds [7]. It is also important to note that the number of wild edible mushroom species varies between different regions of Africa, with only 300 species being documented in the literature.

For example, several wild mushrooms, like the South African Amakhowe, rely on sufficient rainfall for fruiting, with rainy summers yielding more mushrooms than dry ones. As reported by Sileshi et al. [6], the genus *Russula*, with 46 edible African species, is indeed the most species-rich among edible mycorrhizal mushroom clades in Africa, followed by *Cantharellus* with 38 species and *Lactarius* with 36 species reported to be edible. In 2023, a new species of Hericium mushroom, named *Hericium ophelieae* sp. nov., was reported in the southern Afrotemperate forests of South Africa and described in the journal Mycology [8]. This is the first endemic Hericium species to be described from Southern Africa. The mushroom was found in the Knysna and Amatole forests, growing on indigenous hardwoods. According to these researchers, there are likely more *Hericiaceae* species waiting to be found in Afrotemperate forests. From the literature survey, it is also evident that the *Entolomataceae* family of fungi is surprisingly diverse across Africa, with several countries contributing unique species to the global catalogue. For example, six new species of *Entoloma* were described in Cameroon, one new species, *Rhodophana flavipes*, and *Rhodocybe fibulata* were discovered in Niger**,** while more than 20 species of Entolomataceae have been reported in Kenya, Tanzania and Uganda [8].

3.2 Nutritional value

Mushrooms are globally recognized for their rich nutritional properties [6], due to their high content of minerals, vitamins, fiber, and essential amino acids [9]. They are a low-calorie food packed with essential nutrients, making them a healthy addition to any diet. Mushrooms are a good source of vitamin B, vitamin D, trace amounts of vitamin C, and minerals like selenium, copper, phosphorus, calcium, iron, zinc, and potassium.

They also contain antioxidants (glutathione and ergothioneine) [10] and are a good source of protein [11] and fiber, which is especially beneficial for those following a plant-based diet. The fruiting bodies contain carbohydrates such as glucose, chitin, glycogen, and glucan [12], along with varying amounts of nucleic acids, terpenoids, steroids, and lectins [13]. Combined with their other nutritional benefits, mushrooms' low-fat content makes them a valuable part of low-calorie diets [14].

Table 2 highlights the protein and carbohydrate content of selected edible mushrooms from Africa, Europe, Asia and South America. The carbohydrate content of African and Asian mushrooms varies by species. Both regions produce mushrooms with a relatively high carbohydrate content, often ranging from 30% to 70% on a dry weight basis. Some studies indicate that African mushrooms, particularly wild varieties, can have slightly higher carbohydrate levels than some cultivated Asian mushrooms [15].

Table 1. Major mycorrhizal edible wild mushroom genera and species in Africa [6]
(The data in this table is also based on global biodiversity databases like GBIF and regional fungal surveys)

Class	Family	No of genera	No of species	Most frequently reported (No of countries)
Agaricomycetes	*Amanitaceae*	2	32	*Amanita masasiensis* (11)
Agaricomycetes	*Boletaceae*	12	23	*Afroboletus luteolus* (6)
Agaricomycetes	*Boletinellaceae*	1	3	*Phlebopus colossus* (5)
Agaricomycetes	*Clavaraceae*	1	2	*Clavaria albiramea* (2)
Agaricomycetes	*Cortinariaceae*	1	1	*Mackintoshia persica* (2)
Agaricomycetes	*Entolomataceae*	2	2	*E. bisterigmatum*, (4) *E. djaense*, (2) *E. intricatum* (2) More than 20 species have been reported across the continent

https://doi.org/10.1051/bioconf/202518701004

Class	Family	No of genera	No of species	Most frequently reported (No of countries)
Agaricomycetes	*Gomphaceae*	4	2	*Ramiaria africana* (5) *Ramaria madagascarensis* (3) *Ramaria kisantuensis* (3) *Ramaria largentii* (2) *Ramaria aurea* (4)
Agaricomycetes	*Gyroporaceae*	1	1	*Gyroporus castaneus* (2)
Agaricomycetes	*Hericiaceae*	1	3	*Hericium ophelieae* (1) *Hericium bembedjaense* (1)
Agaricomycetes	*Hydnaceae*	5	48	*Cantharellus congolensis* (12)
Agaricomycetes				
Agaricomycetes	*Inocybaceae*	1	2	N
Agaricomycetes	*Melanogastraceae*	1	1	N
Agaricomycetes	*Meruliaceae*	2	2	N
Agaricomycetes	*Omphalotaceae*	1	2	N
Agaricomycetes	*Paxillaceae*	1	1	N
Agaricomycetes	*Phallaceae*	1	1	N
Agaricomycetes	*Russulaceae*	3	100	*Russula celluata* (10)
Agaricomycetes	*Sclerodermatacea e*	1	1	N
Agaricomycetes	*Strophariaceae*	1	2	N
Agaricomycetes	*Suillaceae*	1	2	*Suillus granulatus* (6)
Pezizomycetes	*Helvellaceae*	1	2	N
Pezizomycetes	*Morchellaceae*	2	3	N
Pezizomycetes	*Pezizaceae*	5	6	*Tirmania nivea* (5)
Pezizomycetes	*Pyronemataceae*	1	2	*Picoa juniperi* (2)
Pezizomycetes	*Terfeziaceae*	1	5	*Terfezia boudieri* (6)
Pezizomycetes	*Tuberaceae*	1	5	*Tuber africanum* (4) (e.g. Nigeria) *Tuber borchii* (3) (e.g. Morocco) *Tuber aestivum* (3) (e.g. Tunisia) *Tuber oligospermum* (5) (e.g. Kenya) *Tuber rufum* (North and East Africa)

[a]N indicates that none of the species were reported in more than one country.

Table 2. Protein**,** carbohydrate content and nutritional benefits of selected edible mushrooms from Africa, Europe, Asia and South America [6, 9-15, 32-38]

Continent	Mushroom Species	Carbohydrate (% Dry weight)	Protein (% Dry weight)	Nutritional benefits
Africa	*Ganoderma lucidum*	1855-65	13.3–36.5	Rich in polysaccharides, triterpenoids, and phenolic compounds, as well as vitamins, minerals, and 18 amino acids (riboflavin, niacin, thiamin, vitamin B6, vitamin C, vitamin

				D, vitamin E, phosphorus, sulfur, copper, magnesium, and iron).
	Pleurotus ostreatus	30-35	29-58	Low in calories and fat, and a good source of protein, fiber, vitamins, and minerals
	Pleurotus tuber-regium	40-50	15-25	Protein, essential amino acids (methionine, Lysine and tryptophan), essential fatty acids, dietary fiber, minerals (selenium, iron, zinc) and vitamins (Vit C)
	Auricularia polytricha	66-81	7.2	Fiber, B vitamins (Riboflavins, niacin, pantothenic acid), minerals (iron, potassium, phosphorus)
Europe	*Boletus edulis*	45-55	25-35	Low in calories, fat, and carbohydrates but high in protein and fiber. Provides essential vitamins and minerals (thiamine, riboflavin, niacin, vitamin B6, folate, vitamin C, calcium, copper, iron, phosphorus, and potassium).
	Cantharellus cibarius	35-70	20–25	Good source of vitamin D, B (niacin and pantothenic acid), copper, iron, and potassium. Contains beneficial compounds like polysaccharides (chitin, chitosan) and ergothioneine.
	Agaricus bisporus	50-60	30-39	Rich in essential nutrients (Potassium, selenium), Vitamin B (riboflavin, niacin, pantothenic) and beta-glucans. Rich in fiber and antioxidants (ergothioneine).
Asia	*Lentinula edodes (Shiitake)*	60-70	20-35	Rich in protein, fiber, vitamin C and B (riboflavin, biotin, thiamine). Contains all essential amino acids. Rich in fiber, including chitin and beta-glucans. Contains essential minerals (potassium, sodium, phosphorus, iron, zinc, copper)
	Volvariella volvacea	35-70	26.3	Rich in protein, fiber, vitamins C and B (riboflavin, biotin, thiamine). Contains essential amino acids, unsaturated fatty acids, carbohydrates (chitin, glucans, mannans, xylans, galactans and cellulose).
	*Pleurotus eryngii (*King oyster)	5-7	25-30	Rich in vitamin B (Niacin and riboflavin) and D. Rich in potassium, phosphorus, and selenium.
	Auricularia auricula (Wood Ear)	65-83	10-18	Good source of protein, fiber, vitamin B and beta-carotene, minerals (calcium, iron, potassium, magnesium, phosphorus, silicon).
	Calocybes sp. (MK-white)	80	10-14	Vitamin B, E, A and C. Rich in potassium, phosphorus and

				selenium. Good source of beta-glucans.
South America	*Pleurotus sajor-caju*	63.4	19.2	Good source of vitamins, minerals (Calcium, iron, Magnesium, sodium), and dietary fiber. Rich in glucose, mannitol, α-trehalose, chitin and glycogen. It also contains hemicelluloses and pectic substances.
	Volvariella volvacea	54.8	37.5	Rich in protein, fiber, vitamins C and B (riboflavin, biotin, thiamine). Contains essential amino acids, unsaturated fatty acids, carbohydrates (chitin, glucans, mannans, xylans, galactans and cellulose)
	Calocybe indica	64.3	17.7	Rich in protein, fiber, vitamins (B12, folic acid and vitamin D), and minerals like potassium, phosphorus, and selenium.
	Flammulina velutipes (enoki)	73.1	17.6	Rich in vitamin B1, C and E. It contains a large amount of zinc, selenium and dietary fiber. Good source of mycosterols.

An interesting study by Teke et al. (2021) [16] reports on the nutrient and mineral components of eight wild mushroom species (*Polyporus tenuiculus, Termitomyces striatus, Termitomyces macrocarus, Auricularia polytricha, Laetiporus sulphurous, Termitomyces sp1, Termitomyces sp2* and *Polyporus disctyopus*) from the North West region of Cameroon.

The study demonstrates the richness of the wild mushrooms in nutrients and minerals, with a dried weight content of crude protein (%) ranging from 6.60 to 30.69, 43.49 to 64.88 for carbohydrates, and 2.17 to 3.22% for crude fibres. Studies on the nutritional qualities of African edible wild mushrooms have been limited. However, it is suggested that all species can serve as valuable sources of nutrients. Nonetheless, our understanding of these mushrooms remains insufficient, highlighting the need for the development of a comprehensive nutritional database. Furthermore, the identified mushroom species could be cultivated by rural communities to meet their nutritional needs and generate income.

3.3 Medicinal properties

In recent years, wild mushrooms have attracted considerable interest in medicine and food processing due to their remarkable nutritional and medicinal properties [17, 18] (Table 3).

Today, mushrooms are widely used in medical applications, pharmacology, food processing, and fermentation. The discovery or synthesis of new biologically active compounds has become increasingly challenging in recent years.

As a result, there has been growing interest in mushrooms as a potential source of bioactive compounds, leading to extensive research on their biological activity over the past two decades.

To date, various bioactive compounds, including lectins, polysaccharides, polysaccharide-protein complexes, polysaccharide-peptides, lanostane-type triterpenoids, phenolic compounds, and flavonoids, have been isolated from different mushroom species.

These compounds demonstrate anticancer, antioxidant, antitumor, antiviral, antibacterial, antifungal, anti-inflammatory, and immunomodulatory properties. Medicinal mushrooms are rich in polysaccharides that not only enhance immune system function but also play a role in cancer prevention.

Given the challenges associated with treating various types of cancer, mushrooms could serve as a valuable source of novel drugs for modern medicine, offering potential breakthroughs in cancer treatment. For example, *Ganoderma lucidum* is a mushroom found in various parts of Africa, including South Africa, Namibia, Ghana, Kenya, and Tanzania. However, while it's widely recognized for its medicinal properties in Asia, its potential in Africa, particularly in developing countries, is largely untapped.

Nonetheless, research is underway to identify and cultivate different Ganoderma species in Africa, including *G. lucidum*, to explore their potential for health and economic benefits. Nevertheless, most knowledge on the therapeutic properties of wild mushrooms in Africa remains limited and confined to oral accounts passed down for generations. This indigenous knowledge encompasses a wide range of uses, beliefs, and practices related to wild mushrooms [19-21].

While all four continents offer mushrooms with overlapping benefits such as immune support and antioxidant activity, Asian species tend to be more extensively studied for therapeutic applications, especially in traditional medicine.

Table 3. Summary of therapeutic benefits of African mushrooms compared to European, Asian and South American species [17- 21, 39- 41]

Continent & Common species	Antioxidant	Therapeutic Benefits
Africa *Pleurotus tuber-regium*, *Termitomyces spp.*, *Ganoderma spp.*, *Calvatia cyathiformis*	Phenolics, flavonoids, vitamin C & D Polyphenols, flavonoids, ergothioneine. Tannins	*Pleurotus tuber-regium* for headache and stomach pain, - *Lentinus squarullosus* for mumps and heart issues, - *Termitomyces microcarpus* for gonorrhea. - *Ganoderma lucidum* and *G. resinaceum* are used for arthritis, neoplasia, hyperglycemia, and liver diseases. - Schizophyllum commune is used for diabetes and has antitumor and immunomodulatory properties
Europe *Agaricus bisporus* (white button), *Boletus edulis* (porcini), *Cantharellus cibarius* (chanterelle), *Pleurotus ostreatus* (oyster)	Ergothioneine, selenium, polyphenols Carotenoids, flavonoids β-glucans	- Supports immune and cardiovascular health - Anti-aging and anti-cancer potential - Chanterelles may aid in wound healing and liver protection
Asia *Lentinula edodes* (shiitake), *Ganoderma lucidum* (reishi), *Cordyceps sinensis*, *Hericium erinaceus* (lion's mane), *Auricularia polytricha* (black fungus)	Polysaccharides (β-glucans), melanin Flavonoids, Vitamin C and E, Lentinan, carotenoids Ergothioneine and ergosterol	- Immune modulation and anti-viral effects - Neuroprotective (lion's mane), anti-cancer (reishi, turkey tail), and energy-boosting (cordyceps) - Used in Traditional Chinese Medicine for balancing Qi and organ health, including kidney and lung support, and fatigue relief

Nonetheless, African mushrooms, though less commercialized, show promising potential for biopharmaceutical development.

3.4 Potential use in preventative healthcare

From the body of publications since 2000, it is evident that mushrooms can play a preventative role in healthcare due to their rich content of vitamins, minerals, and antioxidants, which can help protect against various health conditions. Incorporating mushrooms into diet, whether through cooking or supplementation, can potentially lower the risk of cancer, boost the immune system, improve cardiovascular health, and aid in cognitive function [22].

Sodium and high blood pressure are often linked, as sodium plays a crucial role in the body in retaining excess fluid. Therefore, incorporating mushrooms into the diet while offering a savoury umami flavour will reduce the need for salt. Numerous studies have demonstrated the mitigation of neurodegenerative diseases *via* an edible and medicinal mushrooms diet [23- 25]. In a study, Feng et al. [26] studied the cross-sectional association between mushroom-based diet and mild cognitive impairment and their research supported the role of mushrooms in delaying neurodegeneration.

3.5 Challenges and opportunities

Wild mushrooms offer both challenges and opportunities in the realm of food production and ecosystem management. While they represent a valuable source of food and potential income, overharvesting can disrupt delicate ecosystems, leading to biodiversity loss and possible threats to endangered species. Furthermore, several species harbor toxins that often lead to serious (gastrointestinal distress, neurotoxic, hepatotoxic) or even fatal poisonings when misidentified or improperly processed. In addition, wild mushrooms can compete with cultivated varieties, impacting commercial farms as well as small-scale farmers [27]. The challenges that face the potential use of African wild mushroom cultivation include the current absence of quality spawn and limited research on upscaling production [28]. Nevertheless, there are opportunities, since they can be a sustainable food source, a source of income for small farmers (marginal and landless farmers), especially for rural communities.

As reported in Nepal, they could provide employment opportunities in rural and peri-urban areas [29]. Due to their health benefits, wild mushrooms could provide a low-cost solution to reduce chronic diseases. Agricultural waste products like straw, banana peel, and corbs can be used as substrates for mushroom cultivation, promoting circular economy principles[30].

As mushrooms are a nutritious food source, they contribute to food security and address malnutrition. African wild mushrooms can be used in innovative food products like meat substitutes and functional beverages, offering a potential for expanding the market [31]. Their unique properties, such as fibrous texture and umami flavour, make them suitable for creating plant-based meat alternatives, while their potential health benefits can be leveraged in functional beverages. While wild African mushrooms are often used in traditional diets and medicines, several can pose health risks [42-45]. For example, *Amanita phalloides* (Death cap), *Amanita pantherina* (Panther cap), *Amanita muscaria* (Fly agaric), *Chlorophyllum molybdites* (False parasol) and *Agaricus xanthodermus* (yellow stainer) have been reported to be associated with human and animal poisoning incidents.

Sustainable cultivation practices can help conserve threatened and endangered mushroom species by replicating their natural habitat [46]. Controlled cultivation environments can produce higher-quality mushrooms with consistent growth and reduced risk of contamination [47]. Optimized growing conditions can enhance the nutritional content of cultivated mushrooms. Finally, the cultivation of African wild mushrooms can contribute to the economic development of both developed and developing countries [47]. Still, before implementing and promoting the use of these wild mushrooms, responsible harvesting, thorough research, training, sustainable cultivation practices, and regulations are crucial [6,7, 47, 48]. These factors will secure a successful production and consumption of these valuable mushrooms.

4 Conclusions

This study demonstrates that Africa, due to its incredible diversity of underutilized edible wild mushrooms, provides nutritious food for the people and plays a significant functional and operational role in the ecosystems. However, even if African mushrooms hold immense potential for nutrition and health care, several critical knowledge gaps are limiting their full utilization. These gaps include limited comprehensive data on their macro- and micronutrient content, the absence of dietary guidelines across Sub-Saharan Africa, and limited consumer awareness.

This study emphasizes that the poor identification and classification of mushroom species lead to confusion and hinder research and commercialization. The limited clinical research, lack of toxicology studies, and minimal integration into health systems, despite traditional usage, are concerning. Additionally, mushroom studies in Africa are fragmented, with few cross-country or interdisciplinary initiatives. Although African wild mushrooms hold immense potential for nutrition, medicine and sustainable agriculture, rigorous clinical studies, bioactive compound profiling and preclinical trials should be conducted. To shift traditional harvesting toward sustainable farming, it is crucial that research focusing on domestication trials, substrate optimization and spawn production should be done.

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