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Fungal Resources for Human Well-being: Implications for Poverty and Gender Inequality in Sub-Saharan Africa

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ABSTRACT

Wild Useful Fungi (WUF) offer substantial yet underexplored opportunities to enhance livelihoods, address gender disparities and alleviate poverty across Sub-Saharan Africa (SSA). This paper synthesizes the growing body of empirical literature on the socio-economic and ecological roles of WUF to examine their contribution to food security, healthcare and reducing the gender inequalities. A systematic literature review of 95 high-quality peer-reviewed studies published between January, 2000 and June 2025 was conducted using the PRISMA and Cadima methodology. The analysis highlights 396 WUF, 47 of which have documented medicinal uses. These fungi significantly contribute to the diversity of nutritional properties through their rich protein content, vitamins and minerals, and play a crucial role in local food preservation and fermentation practices. Medicinal properties, including antimicrobial and pharmacological benefits, position WUF as promising resources for healthcare innovation. Economically, WUF harvesting and trade serve as vital livelihood strategies, particularly for rural women. Women's involvement in WUF value chains fosters household income generation and food security. Based on the results of this study, it is recommended the cultivation of nutritious fungal species, strengthening value chains and implementation of gender-sensitive policies to maximize the sustainable management and utilization of WUF.

Keywords: Food security, Gender equality, Poverty alleviation, Sub-Saharan Africa, Wild useful fungi.

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SIGNIFICANCE STATEMENT

This manuscript presents the first comprehensive synthesis of empirical literature examining the socio-economic, nutritional and medicinal value of Wild Useful Fungi (WUF) in Sub-Saharan Africa. By systematically reviewing 95 peer-reviewed articles published between January, 2000 and June 2025, this study reveals the pivotal role of WUF in promoting food security, gender equity, and poverty alleviation. The originality of this work lies in its interdisciplinary approach that combines ecological, economic and gender-based insights. The findings emphasize the urgent need for inclusive policies and sustainable management strategies to harness the full potential of WUF for rural development and public health.

INTRODUCTION

Non-Timber Forest Products (NTFPs) represent crucial sources of income and subsistence for rural African people, with more than 80% of rural households relying on these products (Ahenkan and Boon 2011; Derebe and Alemu 2023; Sunderland et al. 2014). Among the NTFPs, fungi, a group of organisms often overshadowed by more visible life forms, play an important role in providing ecosystem services (Kewessa et al. 2024; Zedda 2015). Fungi, including moulds and yeasts, are essential components of ecosystems, playing a central role in nutrient cycling and pest control biodiversity conservation (Kewessa et al. 2023; Tahat et al. 2020). The ecological and socio-economical roles of fungi lead to tangible benefits as assets for food and nutritional security for millions of people in Sub-Saharan Africa (SSA) (Boa 2004; Bourdeaux et al. 2003; Yadav et al. 2020; De Kesel et al. 2024). Fungi are widely recognized as an important source of proteins, vitamins, minerals and other micronutrients essential for human well-being (Atikpo et al. 2008; Fernandes et al. 2021). Beyond their nutritional role, they also contribute significantly to healthcare through their valorisation in traditional medicines used by many rural and indigenous communities across Africa (Codjia and Yorou 2014; Fadeyi et al. 2017; Soro et al. 2019). Their potential as sources for the development of new pharmaceutical treatments further underscores their global relevance (El Enshasy et al. 2013). In Sub-Saharan Africa (SSA), wild useful fungi (WUF) are mainly harvested in natural habitats such as forests and savannas during the rainy season (Dejene et al. 2023; Milenge Kamalebo et al. 2018; Tibuhwa 2012). For centuries, local populations have developed close cultural and medicinal ties with fungi, with more than a thousand species attributed with therapeutic properties.

Moreover, some biotechnological innovations exploit WUF for the production of enzymes, biofuels and biodegradable plastics (Anusiya et al. 2021; Bhambri et al. 2022). Recent studies highlighted the antiviral, antibacterial and anticancer properties of certain WUF offering, therefore, promising avenues for pharmaceutical research in an near future (Adeleke and Babalola 2021; Omomowo et al. 2023).

In SSA, the commercial development of wild useful fungi is primarily carried out by local communities, especially women, who harvest, process and sell them in local and regional markets. This small-scale trade provides an accessible source of income and livelihood diversification for vulnerable households, thereby contributing directly to poverty reduction and food security (Adedokun et al. 2022; Tibuhwa 2013).

Recent years have witnessed an increase in global attention to gender, its role in socio-economic development processes such as poverty reduction and improved livelihoods, and the inequalities that exist between men and women (Arora-Jonsson et al. 2019; Rao and Pachauri 2017). The empowerment of rural women in Africa with regard to equitable access to forest resources remains crucial for food security, households well-being and poverty alleviation (Djondang and Gongnet 2025; Freddy et al. 2023). At the same time, women face numerous challenges at household level. In many SSA rural communities, women are in charge of clothing, schooling and healthcare of their offspring. This growing interest in gender issues is also reflected in the WUF uses in rural communities in Africa where women are the main actors in the harvest and informal trade of WUF (Boni and Yorou 2015; Codjia and Yorou 2014). Although crucial for household livelihoods, their contribution often remains invisible and undervalued. Nevertheless, the commercialization of WUF offers significant economic and social empowerment opportunities for rural African women (Degreef et al. 2016; Masika et al. 2022; Shackleton et al. 2011, Madamo Malasi et al. 2017).

In many SSA countries, the gathering of NTFPs, including WUF, is perceived as a simple extension of women's domestic tasks. In Nigeria for example, the income generated by women through the sale of mushrooms is rarely controlled by them, thus reducing their responsibility within the household and their ability to meet the needs for themselves and for their children (Ayodele 2009). Moreover, despite the crucial role of women in the collection and trade of WUF, gender dimensions are rarely taken into account (Buyck 1994). In habitats where these resources are available, picking mushrooms requires long hours of walking, which impacts their domestic responsibility (Andrew et al.

2013). The lack of transportation also limits their ability to access remote harvesting areas (Mabuza et al. 2014).

The documentation and valorisation of gender-based mycological knowledge is therefore essential for sustainable management of fungal resources in SSA (Shackleton et al. 2011). However, an in-depth analysis of the specific contribution of women in the fungal value chain would provide a better understanding of the overall importance of WUF for livelihoods and poverty alleviation on the African continent. Adopting an inclusive and participatory approach that considers the distinct responsibilities of men and women could promote the balance between preserving fungal diversity and supporting the livelihoods of dependent communities. Thus, this study aims to examine the multifaceted roles of WUF in promoting human well-being and reducing inequalities in SSA, through a synthesis of current knowledge from the scientific literature.

MATERIAL AND METHODS

Data collection

The methodology of this study is based on a systematic literature review, using the PRISMA approach to code and filter relevant articles. The articles were searched on three major electronic scientific databases for potentially relevant studies: Scopus, PubMed, and Google Scholar. To capture a broad range of relevant studies to answer the research questions, the search terms reflect the thematic focus of this article and are derived four guiding elements but only two 'wild edible mushrooms' and 'population welfare' are cited. Finally, using Boolean operators, the search terms were converted into a single search equation (Supplement material), which was systematically used across the three databases to search by keywords, title, and abstract for articles published from January 2000 to June 2025 onward in English or French. The initial search resulted in 3373 sources. Their references were transferred to Cadima, a software program designed to support the search process when conducting a systematic literature review. CADIMA identified 3,096 sources as unique records. The remaining 277 sources were classified as duplicates or potential duplicates, which had to be reviewed and compared using the Zotero tool. Out of this group, 149 sources were recognized as duplicates and removed, bringing the total to 3,224 sources, constituting the initial sample. Box 1 below illustrates the process of identifying and selecting relevant studies.

Box 1:

1) Content-related criteria:

a. The text must discuss the collection and the use of wild edible fungi by local communities.

b. The described utilisation should be directly/indirectly related to food source, medicine purpose, income activities, traditional use and other purpose related to human well-being.

c. The described utilisation must include a gender, poverty and well-being perspective and women empowerment

2) Formal criteria:

a. The study is located in Sub-Sahara Africa.

b. The study was carried out between January 2000 and June 2025.

c. The study is published in English or French.

d. The study has been peer-reviewed.

e. The study presents empirical research.

Eligibility criteria and exclusion of studies

The initial sample selection focused on reviewing the titles and, if available, keywords of the 3224 sources. Each source was tested against eight inclusion/exclusion criteria: three criteria related to the content of the studies and five reflecting more formal requirements (Box 1). The formal criteria included could be assessed against each criterion as 'yes' (criterion met), 'unclear' (criterion met uncertain), and 'no' (criterion not met). Only sources assessed as yes' or 'unclear' on each criterion were selected and moved on to the second screening. During this first screening, 2827 sources were excluded. From the group of 397 sources included through abstract reading, 179 were assessed as meeting all criteria, while the remaining 218 sources were assessed as "unclear" on at least one criterion. Regardless of this subcategorization, the 179 selected sources entered the retrieval stage. Of the 179 selected sources, the full-text versions of 77 articles were either inaccessible or published outside the Sub-Saharan African context. Thus, 102 full-text articles were obtained. In order to conduct an in-depth analysis of the 102 articles selected for the final evaluation, eight new criteria were defined (see Box 2). After reviewing these articles using these criteria, 7 sources were excluded, resulting in our final sample of 95 individual articles generally not addressed (Figure 1, Additional File 3).

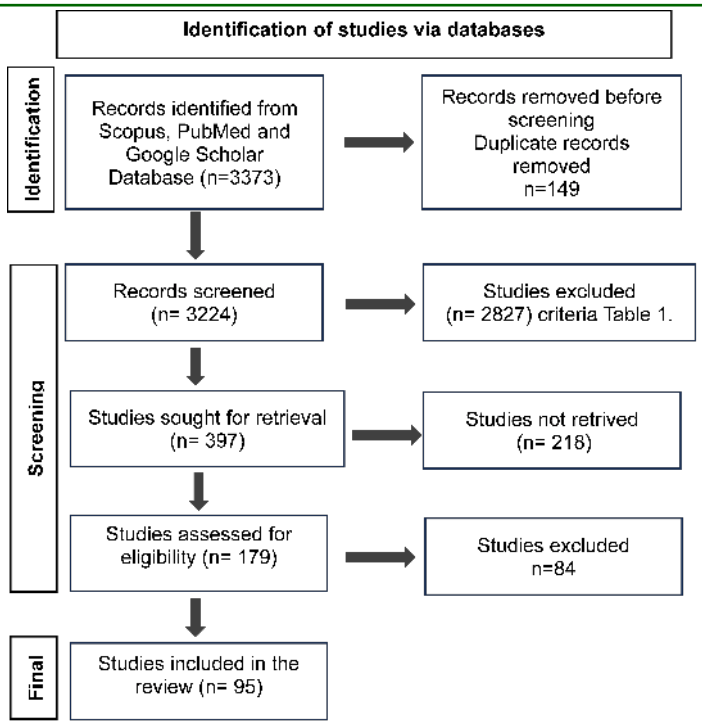

Figure 1. PRISMA Flow Diagram with selection relevant esturdies.

Box 2:

1. Content-related criteria:

a. The text must address the use of wild mushrooms (species, uses, access, dependence, and vulnerability).

b. It must establish a link between fungal resources, livelihoods, and gender, in relation to population well-being.

c. The study must exclude agroforestry systems, industrial mushroom cultivation, and purely commercial or agricultural uses. The food, medicinal, economic, and social aspects of wild mushrooms must be covered.

2. Formal criteria:

a. The study must formulate research questions or objectives on the role of wild mushrooms in livelihoods, poverty, and gender inequalities.

b. It must detail its data collection and analysis methods (databases used, article selection criteria, analytical approaches).

c. The results must be clearly presented, distinguishing research findings from existing literature.

Data analysis

To address the research question *How do mushrooms contribute to the well-being of rural communities in Sub-Saharan Africa?* we conducted a systematic literature review (SLR), framed around the theme *Contribution of fungal resources to human well-being and its implications for poverty alleviation and gender inequality in Sub-Saharan Africa.* In order to ensure transparency and reproducibility, our study adhered to the PRISMA 2020 guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) as outlined by Page et al. (2021). The selected articles were analysed based on several characteristics to respond to the primary research question. An analysis of publication trends by year and region was conducted to examine the evolution of research on this topic. Data extracted from the literature were coded using Microsoft Excel, and frequency analyses along with cross-tabulations were employed to evaluate the distribution of mushroom use across Sub-Saharan Africa. Graphs and tables were generated to visually represent the contribution of wild edible mushrooms to household income in various regions of Sub-Saharan Africa, as well as the types of mushrooms utilised. The review process included a taxonomic verification of fungal species names using reputable online databases Index Fungorum (`https://www.indexfungorum.org/names/names.asp`) to ensure they are correctly spelt and to use current names. In the case where a species

name cited in a published article has become a synonym of another name (refers to as a current name in Index Fungorum), we use in this paper that current name but not the name mentioned in that article. All information was organized logically, with appropriate citation of sources. The Zotero reference management software was used for organizing and managing the bibliographic data.

RESULTS

This review covers studies published between January, 2000 and June 2025. The distribution of publications over time is shown in Figure 2. The studies included in the final sample are not evenly distributed across years. Between 2000 and 2014, only 22 studies were recorded, representing an average of approximately 1.7 studies per year. In contrast, the period from 2015 to 2025 accounts for 67 studies, with an average of 6.7 studies per year, showing a notable increase in research activities over the last decade. The year 2021 stands out with the highest number of publications (10 studies), followed by 2018 (7 studies) and 2014, 2017, and 2022 (each with 6 studies). This sharp upward trend underscores the growing scholarly interest in the topic and the need to synthesize findings to provide a comprehensive overview of the field.

As the study focused on Sub-Saharan Africa, Cameroon and Kenya are the most frequently studied countries, each appearing in 7 articles, followed closely by Benin, Tanzania, and the Democratic Republic of Congo with 6 studies each. Côte d'Ivoire and Nigeria are each featured in 4 studies, while Ghana and Ethiopia appear in 3 studies. A number of countries are represented in 2 studies each, including Zimbabwe, Burundi, Rwanda, the Republic of the Congo, Uganda, Gabon, Malawi, Niger, and South Africa. Countries with a single occurrence include Zambia, Madagascar, Burkina Faso, Namibia, Angola, Eswatini, Togo, Senegal, and Botswana. In addition to country-specific studies, some papers focused on broader regions: Africa (3 studies), Central Africa (2), Sub-Saharan Africa (1), Middle East (1), Eastern Africa (1), and West Africa (1) (see Figure 3).

Diversity of edible mushrooms in Africa south of the Sahara

A total of 392 Wild Useful Fungi was recorded in SSA, according to the documents we consulted. A significant diversity of 246 species is recorded for eastern Africa followed by central Africa and southern Africa with respectively 161 and 158 species. On the other hand, the southern and western regions of Africa display a more modest diversity with 128 and 124 species recorded per region, respectively (Figure 4 and Additional File 1: Common edible mushrooms across different zones in Sub-Saharan Africa. See supplementary materials).

Regarding fungal diversity, the most documented WUF genera in SSA are *Cantharellus* Adans. ex Fr., *Russula* Pers., *Amanita* Pers., *Termitomyces* R. Heim, *Lactifluus* (Pers.) Roussel and *Lactarius* Pers. More specifically, in the Eastern and Central regions, the most frequently documented genera include *Cantharellus, Russula,* and *Termitomyces*. In contrast with Western and Southern regions, *Termitomyces*, *Lactifluus, Amanita* and *Russula* are more recorded (Figures 5 and 6).

Diversity of mushrooms used in traditional medicine in SSA

A total of 47 species is used in both traditional and modern medicine and folklore in SSA (Figures 7 and 8 and Additional File 2: Medicinal mushrooms and their therapeutic potential in Sub-Saharan Africa traditional medicine all regions together. See supplementary materials).

Women's role in the processing, and trade of wild edible mushrooms in SSA

Mushrooms are a longstanding food and economic resource in SSA, sold traditionally in local markets and roadside stalls (Figure 9). Women play a central role in this value chain, as they are primarily responsible for the collection, cleaning, and commercialization of mushrooms. There is considerable variation in the market value of mushrooms across different countries and from one species to another (Table 1).

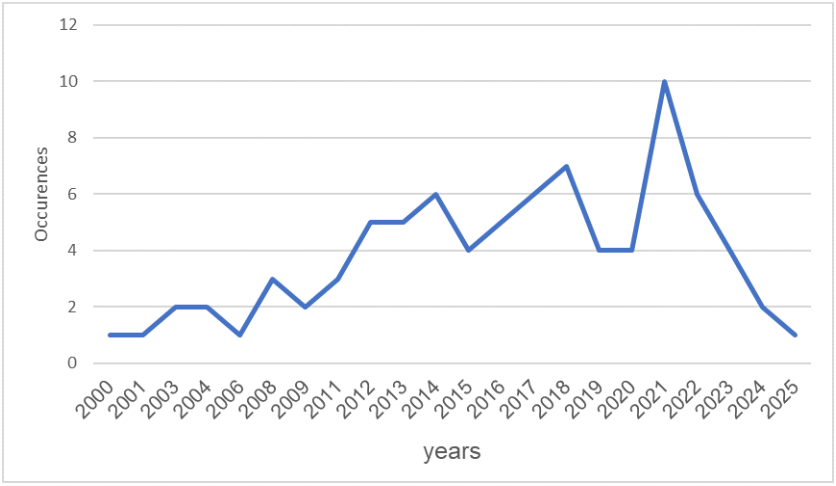

Figure 2. Temporal dynamic of reviewed ethnomycological studies (January 2000-June 2025), n = 95.

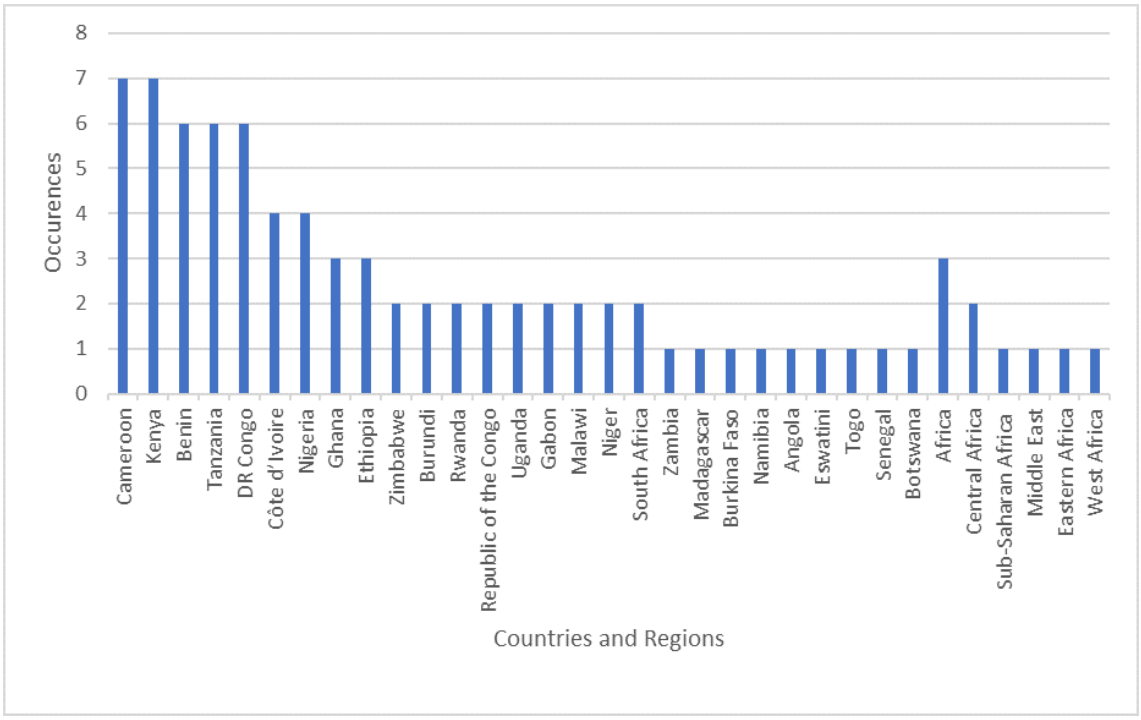

Figure 3. Number of reviewed studies per country, n = 95

DISCUSSION

Fungi as a source of food to sustain food security in SSA

The high fungal diversity documented in the Eastern zone is consistent with findings by Tibuhwa, (2012), who identified this area as a key hotspot for fungal diversity. Moreover, the Rift Valley and East African mountains also contain unique centers of diversity, with endemic species rates up to 50% (Williamson 1974 ; Assefa et al. 2007 ; Tibuhwa 2013). In Tanzania, for instance, at least 480 edible species have been documented (Tibuhwa 2012). In West Africa, countries such as Benin and Côte d'Ivoire stand out due to their extensive research efforts, resulting in relatively high species counts although many species remain undocumented (Fadeyi et al. 2017; Yian et al. 2020; Yorou et al. 2001). This contrast highlights the critical role that focused ethnomycological and taxonomic studies play in uncovering regional fungal diversity. Conversely, other countries such as Guinea-Bissau and Gambia show lower numbers, which are certainly due to a limited focus on fungal inventories rather than an actual scarcity of species (De Kesel et

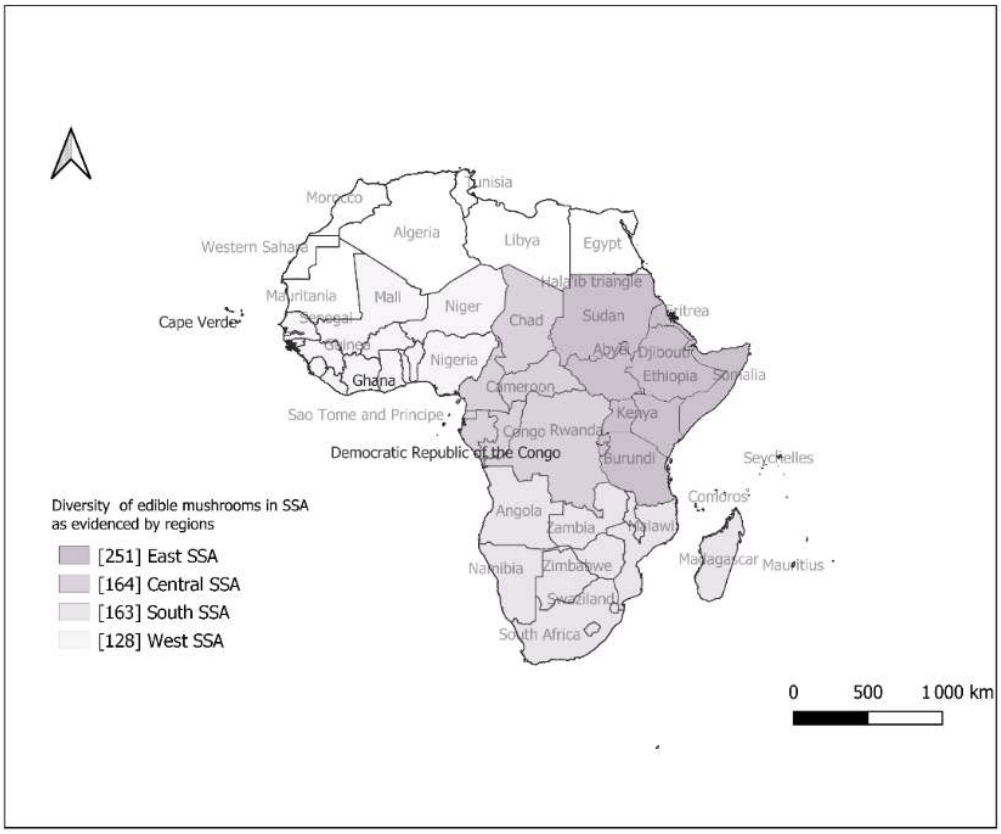

Figure 4. Diversity of recorded edible mushrooms in Africa south of the Sahara by regions.

al. 2024). When compared with other world regions, the 392 WUF species recorded for SSA appears modest. For instance, over 600 wild edible fungi have been described in China alone (Yu et al. 2020). In North America, particularly in Mexico, there are about 371 documented species, depending on the region and the intensity of ethnomycological studies (Garibay-Orijel et al. 2020). Several factors may explain the observed pattern within SSA and between SSA and other world regions. Uneven research intensity plays a decisive role: areas with established mycological schools and strong research groups (e.g., Tanzania, Benin, South Africa) report higher numbers, while countries with limited scientific infrastructure and funding appear underrepresented. Economic and institutional priorities often favour staple crops over non-timber forest products, leading to a lack of investment in fungal biodiversity studies. Third, ecological and biogeographic factors are also important. The heterogeneity of African ecosystems from tropical rainforests to dry savannahs and high-altitude grasslands provides conditions for a rich mycobiota, but these ecosystems remain insufficiently sampled (Adeniyi et al. 2018; Boa 2004). Finally, the COVID-19 pandemic triggered a surge in research on fungal pharmacology starting in 2021, as fungi were investigated both as sources of novel antiviral compounds and in relation to secondary fungal infections associated with SARS-CoV-2 patients (Alhumaid et al. 2021; Soni et al. 2022).

Overall, Sub-Sahara Africa has a wide variety of habitats that support a rich mycobiota, from tropical rainforests to dry savannas and high-altitude grasslands. African ecosystems are hotspots to a multitude of fungi with very diverse lifestyles (Adeniyi et al. 2018; Boa 2004). Among this fungal diversity inventory, there are many edible species which represent important sources of food for local people (Mjaika 2023). It is believed that the African continent hosts the richest but also most threatened mycobiota in the world, due to deforestation, climate change and the lack of conservation of natural habitats (Immanuel and Oyedeji 2023; Mueller et al. 2007). Sub-Sahara Africa abounds with a wide diversity of Wild Edible Fungi (WEF), constituting major traditional foods for many rural communities. Species belonging to *Auricularia, Cantharellus, Ganoderma, Pleurotus, Lactarius, Lactifluus, Russula*, and *Termitomyces* genera are among the most harvested and consumed in many parts of

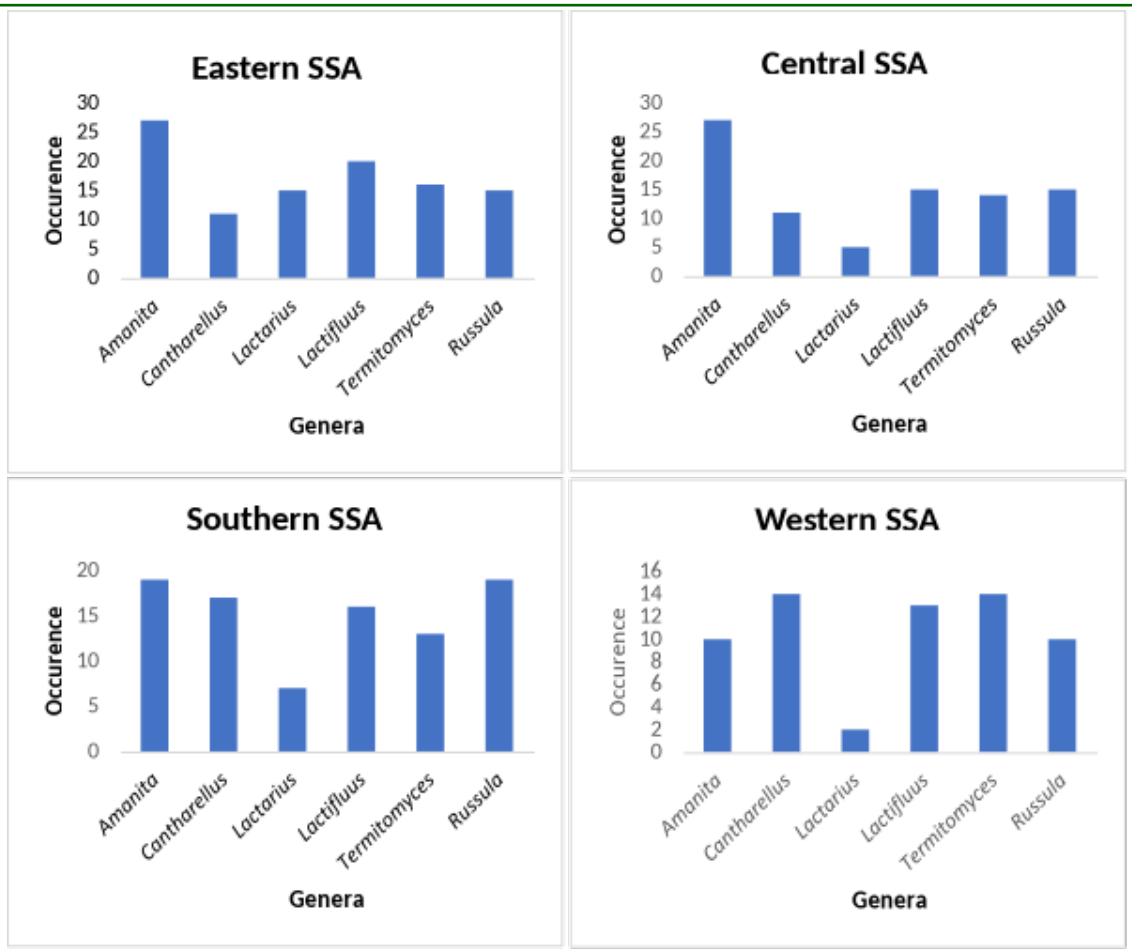

Figure 5. Diversity of genera of Wild Useful Fungi documented for Sub-Saharan Africa, across each zone.

the SSA (Dijk et al. 2003; Njouonkou et al. 2016; Nnorom et al. 2020). In particular, in the Southern zone of SSA, where climatic variations can cause disruptions in traditional agricultural cycles, the incorporation of WEF such as *Favolus tenuiculus, Pleurotus cystidiosus* and *Auricularia auricula-judae* represents a promising strategy to ensure food stability (Awana et al. 2018; Ndolo Ebika et al. 2018). While specific species may vary according to biogeographical contexts, the same genera (e.g., *Pleurotus*, *Polyporus*, *Auricularia*) are widely distributed and consumed across tropical regions. For instance, *Favolus tenuiculus* is highly valued not only in SSA but also in the Americas, highlighting its global relevance as a food and nutritional resource (Omarini et al. 2009).The rainforests of East Africa are teeming with a wide variety of WEF, that constitute long-valued culinary ingredients for many rural communities in this region (Awana et al. 2018; Woldegiorgis 2015). Traditionally, the seasonal collection of WEF and their consumption have been anchored in local food traditions for centuries. Fungi are generally eaten cooked, often in a sauce or stew accompanying the main course made from tubers, cereals or vegetables (Yongabi et al. 2014). Furthermore, many initiatives are emerging to domesticate wild species and produce them locally on a large scale to make them staple foods in the area (Boukary et al. 2024; Dzomeku et al. 2023; Nteziryayo et al. 2019; Osemwegie et al. 2014). In line with this, in Gabon, various species of mushrooms from forests, such as *Lentinus squarrosulus*, are intensively cultivated in modern facilities (Eyi Ndong et al. 2021). Such traditions explain the high levels of consumption observed in certain countries. In Nigeria, the annual per capita consumption of *Volvariella volvacea* and *Lentinus squarrosulus* (the most consumed species in the country), has been estimated at 0.5 kg in rural areas (Nnorom et al. 2020; Osuafor et al. 2023). In the Democratic Republic of Congo, the annual average reaches 30 kg per person in rural areas against 15 kg annually in the cities (Degreef and De Kesel 2017), while in Zimbabwe a family composed of 3 persons consumes up to 20 kg of fresh WEF per year, a figure which increases significantly in Mozambique, where around 160 kg are con-

Figure 6. Common mushrooms use as food in SSA. A, *Amanita masasiensis;* B, *Cantharellus platyphyllus;* C, *Lactifluus gymnocarpus*; D, *Lentinus squarrosulus;* E, *Russula congoana;* F, *Termitomyces schimperi.* Photos by Nourou SY.

sumed per person in each family (Degreef and De Kesel 2017). Likewise, the average mushrooms quantities per meal per household was 1.4 kg in Dumbwe, 1.3 kg in Donga and 1.5 kg in Simandala (Dube et al. 2021). Beyond their culinary role, collective consumption of WEF can promote social cohesion by sharing a common food culture, strengthening community ties and contributing to collective well-being. Frequent family meals may have a protective effect on the mental health of adolescents, particularly for depressive symptoms in girls (Utter et al. 2017).The relevance of WEF to sustain food security do not lie in the amount consumed each year, but rather in their nutritional composition. Several studies have shown that the amino acids content, coupled with their vitamins and mineral elements makes them an invaluable source of nutrition for consumers (Alofe et al. 1996; Osuafor et al. 2023; Rasalanavho et al. 2019; Rzymski et al. 2016). Reportedly, certain species have a high level of protein per 100 g meal, surpassing that of meat and fish, such as *Termitomyces robustus* (13.3 g/100 g) and *Volvariella volvacea* (42.63 g/100 g) (Adejumo et al. 2015; Beluhan and Ranogajec 2011; Obodai et al. 2014; Ouzouni and Riganakos 2007). This evidence clearly supports the crucial role played of wild edible fungi in food security in Africa. Several species have gained significant attention for their remarkable composition of microelements and vitamin C. *Pleu-*

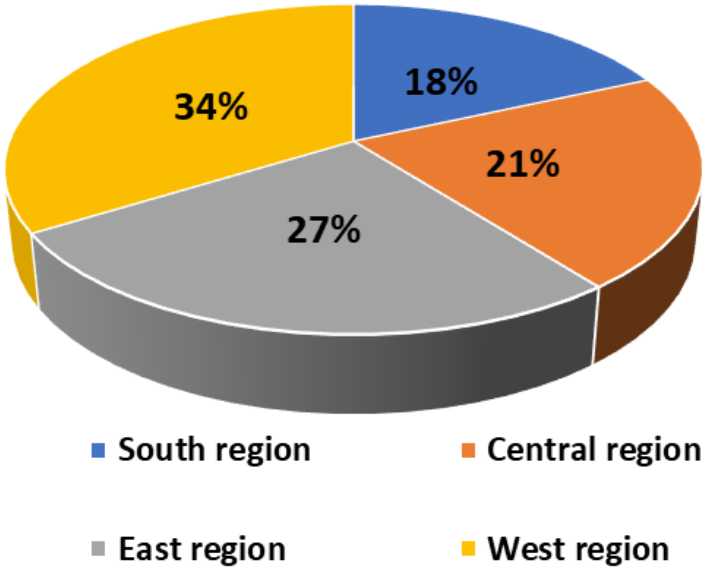

Figure 7. Use of mushrooms in traditional medicine in Sub-Saharan Africa..

Table 1. Wild Edible Fungi price across Sub-Saharan Africa.

Country	Price	Unity of weight	References
Benin	0.8 to1.23 USD	kg	(Yorou et al. 2001)
Burundi	0.2 to 0.68 USD	kg	(Nikuze et al. 2020)
Cameroun	42 USD	baskets of 3 kg to 4 kg	(Yongabi et al. 2014)
Democratic Republic of Congo	3.9 to 5.5 USD	kg	(De Kesel et al. 2017)
Ethiopia	0.3 to 1.5 USD	kg	(Sitotaw et al. 2020)
Ghana	0.67 to 02USD	kg	(Owusu and Dekagbey 2020)
Kenya	3.1 to 3.8 USD	kg	(Nelima et al. 2021)
Malawi	2.04 to 5.10 USD	kg	(Chioza and Ohga 2014)
Republic of Congo	2.31 USD	kg	(Ndolo Ebika et al. 2024)
Rwanda	1.5 USD	kg	(Imanishimwe 2018)
Tanzania	10 to 15 USD	per bucket (capacity 20 liters)	(Tibuhwa 2013)
Togo	0.2 to 0.4 USD	kg	(Kamou et al. 2015)
Zimbabwe	3.5 to 5 USD	kg	(Mutema et al. 2009)

rotus flabellatus (34 mg/100 g); *Termitomyces robustus* (10.30 mg/100 g) and *Volvariella volvacea* (6.70 mg/100 g) are good example of species with high content of microelements (Adejumo et al. 2015; Mshandete and Cuff 2007; Munishi et al. 2008; Rasalanavho et al. 2019). This foundational role of wild edible fungi in local diets and nutrition paves the way for a deeper examination of their contribution to food transformation systems in Sub-Saharan Africa.

Figure 8. Common mushrooms used in traditional medicine in Sub-Saharan Africa. A, *Daldinia eschscholtzii*; B, *Ganoderma boninense*; C, *Pleurotus tuber-regium* and D, *Podaxis pistillaris*. Photo by Nourou SY.

Fungi in food processing systems in SSA

WUF play a vital role in food processing in SSA, contributing to both traditional culinary practices and modern food industries (Fernandes et al. 2021; Muyonga et al. 2020). Particularly in Sub-Sahara Africa, traditional fermentation processes often involve the use of fungi. *Rhizopus* and *Aspergillus* species, for example, are involved in the fermentation of cassava, a major staple crop in Africa, by reducing cyanogenic compounds present in cassava and making it more suitable for consumption (Akinyele et al. 2017). The fermented cassava is then used to produce foods like gari and fufu (Obadina et al. 2009; Ray and Sivakumar 2009), thus providing and healthy, compared with chemical additives to nutritional fortification compared to costly chemical additives. In addition, fermentation imparts desirable flavours and improves the

Figure 9. Selling of wild edible mushrooms. A and B *Termitomyces striatus* processing before cooking, C, *Termitomyces aurantiacus* sold at Dragage market, Republic of Congo; D, *Termitomyces letestui* sold at a market in Côte d'Ivoire. © Photos should be: A-C by Ndolo Ebika ST; D by Koné AN.

preservation of these products.

Furthermore, traditional drinks and porridges, such as *ogi* (a fermented grain porridge) and *pito tchapalo* (a fermented sorghum beer), rely on *Saccharomyces cerevisiae*, *Candida tropicalis* and *Lactobacillus* sp. for fermentation (Coulibaly et al. 2014). These fungi, along with various lactic acid bacteria collaborate to ferment grains, resulting in products rich in probiotics and with improved nutritional profiles (Adebo and Gabriela Medina-Meza 2020). The modernization of food processing in SSA has seen an increase in industrial applications of fungi, particularly in the production of enzymes, bioactive compounds and food additives. Fungi such as *Aspergillus niger* and *Rhizopus oryzae* are used in the industrial production of enzymes necessary for bread making. Notably, these fermented foods and beverages are particularly important in rural areas, where they contribute to food security and dietary diversity (Fusco et al. 2023). Overall, the use of fungi in food processing is deeply rooted in traditional practices, yet also offers potential for modern industrial applications to improve food and nutrition security (Barzee et al. 2021).

Medicinal Fungi from SSA: traditional uses and well-being of populations

Ancestral knowledge regarding fungi is of considerable importance, revealing the connections with humans in a specific environment (Molares et al. 2020; Oso 1975; Sitotaw et al. 2020). Over the past few decades, interest in the pharmaceutical and traditional therapeutic potential of fungi has greatly increased worldwide. Research has revealed that certain fungi can produce organic compounds with exceptional properties, thus prompting in-depth studies in this field (Ferreira et al. 2007; Nkadimeng et al. 2021; Patel and Goyal 2012). Many African fungi possess antioxidant and antimicrobial properties, making them promising candidates for the treatment of infections and contributing to the population well-being

(Adebo and Gabriela Medina-Meza, 2020; Fadeyi et al. 2019).

In SSA, local fungi are often traditionally prescribed by healers to boost the immune system (Oyetayo 2011). In Togo, for example, *Pleurotus tuber-regium* is used to fight diseases such as asthma, heart disease and hypertension (Kamou et al. 2015). Similarly, in Benin, *Collybia* sp. and *Candolleomyces tuberculatus* are used by Nagot and Holli people to treat epilepsy, bilharzia, head lice and scabies as well as a disease that results in loss of skin on the soles of the feet, locally called "itankpa" (Codjia and Yorou 2014). In the same case, fungi are used to treat various conditions such as malnutrition in infants, diabetes, obesity or hyperlipidemia, infertility, anaemia, mumps, fever, and protein deficiencies in Nigeria (Akpaja et al. 2005). In Ivory Coast, *Auricularia delicata, Candolleomyces tuberculatus* and *Schizophyllum commune* have been identified as having therapeutic properties capable of treating bilharzia, inflammation, epilepsy, boils, hemorrhoids, hypertension, and malignant tumors (Yian et al. 2020). Furthermore, in Burkina Faso, certain species such as *Daldinia eschscholzii, Ganoderma* sp.*, Ochrosporellus pachyphloeus, Podaxis pistillaris, Lentinus squarrosulus, Lycoperdon* sp. and *Scleroderma* sp. provide important medicinal resources for the treatment of hemorrhoids, small wounds and skin rashes (Guissou et al. 2014). The use of these locally available natural remedies could result in potential savings for the healthcare system, particularly in the treatment costs. The consumption of *Volvariella volvacea* and *Termitomyces robustus* is associated with tonic properties for the blood, while *T. globulus* and *T. clypeatus* could reduce hypertension (Apetorgbor et al. 2005, 2006; Kadhila-Muandingi and Chimwamurombe 2012). *Ganoderma* sp., *Phellinus allardii* and *Podaxis pistillaris* are part of the traditional pharmacopoeia of Africa for the treatment of wounds and intestinal worms (Dejene et al. 2017; Hama et al. 2012). In a similar way, *Pleurotus tuber-regium* and *Ganoderma lucidum* are used to treat heartaches, sexual weaknesses, stomach-aches, anaemia, and asthma (Kamou et al. 2015). In Cameroon, a mixture of dried *Ganoderma* sp. and palm oil is commonly used to treat skin infections, chronic stomach aches, hemorrhoids, rheumatism, arthritis, neoplasms, to reduce the large navels of newborns and to stimulate renal activity (Yongabi et al. 2014). In the Selous-Niassa corridor in the Ruvuma region of Tanzania, *Amanita masasiensis, Auricularia delicata, Auricularia nigricans, Boletus spectabilissimus, Cantharellus isabellinus, Clavulina* sp1., *Clavulina* sp.2, *Clavulina wisoli, Lactarius densifolius* and *Royoporus spatulatus* are part of traditional potions to treat rheumatic pains, injuries, skin inflammation, hemorrhoids and hemoptysis (Qwarse et al. 2021). The use of locally available medicinal fungi remedies limit expenses on imported and expensive allopathic drugs, thereby freeing up resources to address other essential needs of disadvantaged communities (Reid et al. 2016). It is demonstrated that extracts from fungi species produced in the woodlands of Zimbabwe (*Cantharellus symoensii, C. miomboensis, C. heinemannianus* and *Ganoderma lucidum*) have good antibacterial effects. Polysaccharides contained in certain African fungi, such as *Ganoderma lucidum, Pleurotus ostreatus*, *Daldinia concentrica, Ganoderma applanatum* and *Royoporus spatulatus* have immuno-modulatory effects and can support the immune system (Muthangya et al. 2019; Osemwegie et al. 2020).

The traditional division of labor within many SSA societies has played a crucial role in the preservation and dissemination of ethnomycological wisdom. Women, often the primary collectors and cookers of wild foods, have been the custodians of extensive knowledge pertaining to edible and medicinal fungi (Härkönen 2001; Kinge et al. 2011; Garibay-Orijel et al. 2012; Fadeyi et al. 2024, 2025). This gender-based specialization not only ensures the intergenerational transmission of knowledge (Fadeyi et al. 2017) but also highlights the central role of women in sustaining food security and biodiversity practices in rural communities (Qwarse et al. 2021). This knowledge is passed on from generation to generation (Fadeyi et al. 2017), ensuring its continuity and enrichment (Qwarse et al. 2021). The impact of medicinal mushrooms goes beyond the treatment by physical ailments as it is also facilitating connection with the spiritual world or enhancing emotional resilience. The Igbo people of Nigeria use mushrooms symbolically and distribute them to adversaries as a form of warning, while the Yoruba use selected fungi (such as *Daldinia childiae* and *Calvatia* sp.) with psychoactive and hallucinogenic effects for idol worship and spiritualism (Akpaja et al. 2005; Oso 1975). The low use of mushrooms in traditional therapy in certain SSA regions could be linked to the insufficient transfer of traditional knowledge from the elders to the young (Teketay et al. 2018; Fadeyi et al. 2025) or simply because communities do not have sufficient knowledge about the therapeutic virtues of mushrooms (Mikobi et al. 2023). These features and properties given to fungi have drawn upon experience and observation that evolve with the growing development of modern medicine, focusing on the uncertainties of traditional medicine practices (Humbe 2024; Sullivan et al. 2006).

Monetary value of mushrooms and their potential for women's empowerment and poverty alleviation in SSA

The selling of WUF in local markets in SSA is emerging as a promising economic activity, offering a significant alternative for poverty reduction and the empowerment of women within their households. It is estimated that between 70% and 90% of people involved in collecting WUF fungi are women (Ayodele 2009; Guissou et al. 2008; Masika et al. 2022; Nikuze et al. 2020; Soro et al. 2019; Tibuhwa 2013). In Central and East Africa, the harvest and trade of WUF (e.g. *Amanita, Termitomyces* and *Cantharellus*) are widely observed in rural areas and local markets and are of significant economic importance in several countries, including Tanzania (Härkönen 2001) and Democratic Republic of Congo (Degreef et al. 1997). Moreover, studies revealed that in certain regions, such as among the Mossi in Burkina faso monthly revenue reaches 72.20 USD, while in Kenyan market it is recorded at 58.58 USD (Swedi et al. 2023). This socioeconomic transformation, often underestimated, could generate complex dynamics affecting various feminine aspects of societies. Access to markets and the opportunity to participate in income-generating activities can be an important factor in promoting gender equality and reducing economic disparities between men and women. Additionally, trading fungi in local markets can stimulate economic activity in rural areas, potentially creating other employment and trade opportunities, including in processing, transport and retail (Mlambo and Maphosa 2022; Swedi et al. 2023). This contributes to the diversification of the rural economy and the creation of opportunities for a greater number of people, particularly women in this sector, thus strengthening their economic resilience. In Kenya, for example, a training program on mushroom cultivation enabled groups of women to significantly increase their production and income (Kimole 2012). Additionally, research has shown that when women have greater control over household resources, they tend to invest more in their children's education and health, which helps break the intergenerational cycle of poverty (Duflo 2012). In some countries where prices are higher, such as the Democratic Republic of Congo (De Kesel et al. 2017), Kenya (Nelima et al. 2021), Republic of Congo (Ndolo Ebika et al. 2024) or Zimbabwe (Mutema et al. 2019), it could be potential for export to other regions, which could generate even greater income for local communities. This improved income not only contributes to the reduction of poverty at the household level, but has also strengthened the social status of women in their communities. In the Katanga region of the Democratic Republic of Congo, the trade of WUF by women supplies local markets and generates significant gains during the rainy season (Kashiki et al. 2021; Saado 2018). In Malawi, harvesting and selling wild mushrooms involve several women and generate approximately Mk 67,500 (USD 40) per year (Mahonya et al. 2019). Furthermore, the marketing of WUF can have a multiplier effect on the local women's economy. The income generated by this activity is often reinvested locally, stimulating other economic sectors and creating a virtuous circle of economic development (Oyetayo 2011). According to Yourou and De Kesel (2002), WUF are sold at almost double the price, reaching up to 750 FCFA/kg (1.24 USD/ kg) compared to the price of charcoal (at 425 FCFA/kg (0.70 USD/ kg). The same authors demonstrated that the economic values of WUF trade largely surpasses the one time clear-off of the forest for timber exploitation. Despite the significant annual quantities harvested for self-consumption or trade, the natural production of wild edible fungi (WEF) in sub-Saharan Africa (SSA) remains largely underutilized. For instance, the Sudanian woodlands of West Africa yield at least 300 kg/ha of fresh biomass of WUF each year. *Lactifluus gymnocarpoides* and *Amanita masasiensis* rank as the top two WEF species in terms of natural production in the region (Boukary et al. 2024; Yorou et al. 2002). Similarly, in the Zambezian woodlands of the Democratic Republic of Congo annual WEF production reaches 148 kg/ha (Milenge Kamalebo and De Kesel 2020).

Challenges in mushroom harvesting and commercialization in SSA

Although the increasing role of mushrooms in women's income generation represents an opportunity for their empowerment, some challenges, however, remain (Beetz and Kustudia 2004). Alongside these dynamics, widespread forest and woodland degradation in the region over the decades constitute an actual threat for the supply of mushrooms, particularly the mycorrhizal species, which are a crucial resource for millions of people (Sileshi et al. 2023). Deforestation, fuelled by the increasing population and excessive firewood collection, not only reduces mushroom habitat but also impacts women who must travel longer distances, carrying heavier loads of wood (Sileshi et al. 2023). The consequence of this deforestation is a decline in natural fungal production due to the drastic change in the habitat and the intricate micro-climate becoming hotter and drier. A subsequent increase in grass cover encourages bush-fires which cause further damage to the fragile ecosystem. These ecological changes not only endanger the livelihoods of populations who depend on wild useful fungi (WUF), but also highlight the urgent need to regenerate native forests and counter large-scale agroindustrial expansion by

promoting sustainable alternatives to which the empowerment of NTFP such as WUF may contribute. Additionally, increasing competition for access to the diminishing mushroom harvesting areas, exacerbated by growing demand from urban consumers, adds another level of complexity to this situation (Kinge et al. 2014; Tibuhwa et al. 2011). Finally, fungal poisoning also represents a major challenge due to the similarity between some edible and toxic species (Tibuhwa 2013). Another significant but often overlooked challenge is mushroom poisoning. Tavassoli et al. (2019) explain that the morphological similarities between toxic and non-toxic mushrooms (including *Amanita phalloides*) often mislead gatherers, leading to frequent cases of poisoning. These incidents have clear gender-specific dimensions: women, as primary gatherers and food preparers, are more exposed to the risks of misidentification. When poisoning occurs, they may also bear the social blame for providing unsafe food to households (Mauree et al. 2019). Mitigation measures include community sensitization programs on mushroom identification, incorporation of indigenous classification systems into extension materials, and collaboration with mycologists to produce illustrated field guides in local languages. Additionally, integrating mushroom safety education into rural health campaigns and supporting local women's groups in training others can significantly reduce risks. Combining these interventions with improved access to healthcare facilities for timely treatment of poisoning would enhance resilience and safeguard livelihoods that depend heavily on wild and cultivated mushrooms.

Potential value chain development of useful fungi and implications for women empowerment and poverty alleviation

Mushroom production is an accessible activity to small-scale farmers with few resources, because it requires limited investment in facilities and inputs (Boukary et al. 2024; Chelela et al. 2014). Furthermore, the implications of mushroom value chain development extend far beyond mere economic considerations. Indeed this exploration contemplates the intricate interplay between mushroom cultivation and human well-being, encompassing aspects such as food security, nutritional enrichment (Adedokun et al. 2016, 2022), poverty alleviation and environmental sustainability (Birhanu et al. 2018; Fernandes et al. 2021). Moreover, cultivation techniques on different substrates (straw, sawdust, agricultural waste) are also within the reach of family farmers (Kumar et al. 2020; Subedi et al. 2023). Processing fresh mushrooms into value-added edible products (dried, powdered, canned, pickled mushrooms, etc.) at the local level (Kissanga et al. 2022) would also generate additional income and employment. Likewise, the extraction of bioactive compounds from some species (*Ganoderma* sp., *Psilocybe* sp., etc.) in traditional medicine in SSA (Kamou et al. 2015, 2017) would offer opportunities for the development and export of high-end pharmaceutical and nutraceutical products. Achieving this potential requires the countries involvement to exhibit political dedication through the adoption of a national strategy (Codjia and Yorou 2014; Gryzenhout et al. 2012). This means that public investments should be made in research in order to select high-performance strains of fungi adapted to local conditions (Mayanja and Tipi 2017). In Eastern and Western regions of Africa, the domestication and controlled cultivation of mushrooms with high nutritional value have enabled the generation of significant income for farmers while simultaneously diversifying their diet (Boukary et al. 2024; Dzomeku et al. 2023; Hussein et al. 2016; Kabacia and Muchane 2023; Nteziryayo et al. 2019). Strengthening the technical capacities of producers through agricultural advice and training would also contribute to the adoption of good practices thereby increasing productivity and the quality of production (Anchang 2014). Indeed, in some SSA countries such as Uganda, government efforts to boost mushroom cultivation and the district-wide value chain, have enabled the distribution of different varieties of high-yielding species as well as the training of farmers in innovative approaches to value addition (Newman et al. 2019). This inclusive development vision could be part of a holistic perspective, taking into account social, economic and environmental dimensions. In addition, financial, material and entrepreneurial support for private production and processing initiatives would be crucial for enhancing human well-being (Atikpo et al. 2008). Moreover, the development of secure local and export markets would also be necessary to ensure the sale of products and guarantee stable income. This implies the development of suitable transport, storage and cold chain infrastructure as well as the facilitation of trade at national and international levels (Pandey et al. 2018).

CONCLUSION

This review underscores the multifaceted significance of Wild Useful Fungi (WUF) in Sub-Saharan Africa, highlighting their vital contributions to food security, healthcare, poverty alleviation, and women's empowerment. Beyond their nutritional and medicinal values, WUF represent important socio-economic assets, with women playing central roles in their collection, processing, and trade. However, challenges such as habitat loss, under documentation of species, gender inequities, and risks of misidentification limit their potential. Future research should prioritize biocultural

studies that integrate local knowledge with scientific inquiry, while developing gender-sensitive strategies to strengthen value chains and ensure sustainable management. Expanding domestication, fostering innovation in processing, and addressing policy gaps are crucial steps toward harnessing fungi for resilient livelihoods and inclusive rural development in Africa.

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DATA AVAILABILITY

The data used to support the findings of this study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

CONTRIBUTION STATEMENT

WKA conducted data collection from various scientific databases and wrote the initial draft of the manuscript. OGF contributed to the definition of inclusion and exclusion criteria for the papers and reviewed and edited the manuscript. STNE, CS, DM, and NSY read and revised the manuscript. NSY supervised the entire research process.

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DISCLOSURE OF AI USE

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