International Research Journal of Biological Sciences _____ ISSN 2278-3202
Vol. **9(1),** 33-39, February **(2020)** *Int. Res. J. Biological Sci.*

Review Paper

Edible mushrooms in Tanzania: enlightening human health and improved livelihood

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Available online at: www.isca.in, www.isca.me
Received 9th September 2019, revised 20th November 2019, accepted 25th December 2019

Abstract

Mushrooms have become more popular due to their nutraceuticals potential contributes to their antioxidant, antimicrobial, antitumor and antiviral potential. The emergence of drug-resistant has attracted more studies on the edible mushroom as an alternative source of antibiotics to overcome drug resistance challenges. Apart from their pharmacological significance, edible mushrooms have good taste and are nutritious with high protein and fibre contents. They contain all essential amino and fatty acids vital to humans. They are cholesterol-free, low in calories, and fat. Besides their nutritional potential, research describes them as therapeutic foods, with the ability to inhibit ailments such as high cholesterol, elevated blood pressure, and cancer. Mushroom extracts contain bioactive constituents such as phenolic compounds, terpenoids, alkaloids, lactones, sterols, glycoproteins and polysaccharides. Their biological effectiveness has been traditionally exploited to boost immunity, improve the health of long ill people, prescribed as a tonic for gastro-intestinal ailments, relieving stomach pains, constipation, stomach ulcers and used as skin ointment to treat skin diseases. Furthermore, they have been used to enhance the quick recovery of childbirth mothers and improve milk production to breastfeeding mothers. The present review is aimto appraise traditional uses, nutritional significance and the nutraceutical value of edible mushrooms of Tanzania for the improvement of human health and livelihood.

Keywords: Edible mushroom, functional food, nutraceutical, human health, Tanzania.

Introduction

Mushrooms are fleshy to leathery fruit bodies of fungi conspicuous by naked eyes that may sprout above or below substrate[1]. Mushroom edibility can be described as poisonous free mushrooms on humans with possession of appreciated taste and aroma. It was through trial and error, humans have accumulated information on mushroom edibility, avoid the poisonous species and this knowledge was passed to the next generation until today[2].

The difference between edible and medicinal species of mushrooms is not easy since several edible mushrooms have healing potential and numerous used for medicinal purposes are also palatable. Nonetheless, some of the medicinal mushrooms like *Ganoderma*, *Coriolus* and alike are inedible due to their fruit bodies toughness[3]. Often wild mushrooms are collected from forests, some of which are difficult to cultivate due to complex dependency to their partners for growing (mycorrhizae; termitomyces depend on living plants and termites respectively). Cultivated species have been grown on a dead organic matter, which provides the nutrients that enable their growth and ensure its availability throw-out a year[4]. Both wild and cultivated edible mushrooms are a source of income since they are sold in local markets. Seasonal mushroom collectors can earn between 400-900 USD per year by selling wild mushrooms to local communities[5].

Mushrooms are valuable for their dietetic properties and therapeutic abilities and thus regarded as a functional food. For a millennium they have been used as food and medicine; Chinese acknowledged them to be the restorative of life, the Romans believed them to be the foods of the Divinities while Greeks believed mushroom consumption provided strength to their warriors in battle. Its medicinal properties have been mentioned in some old religious scriptures such as the Vedas[6,7]. They were included in a daily diet and delicacy due to their preferred taste and the appealing smell. Currently, mushrooms have gain popularity as valuable foods since they are cholesterol-free, fewer calories, carbohydrates and fat. Increasing people's awareness of eating healthy foods also has attracted mushroom utilization since they provide important macro and micronutrients, multivitamins, proteins, fibre, essential amino acids including lysine, leucine and unsaturated fatty acids[8]. They possess phenolic compounds which are specialized metabolites with an aromatic ring bearing a single or many hydroxyl groups. Phenolic compounds include simple phenolic acids or complex derivatives like polymers. Mushrooms show immunomodulatory, chemopreventive, cardioprotective, cytostatic, antiatherogenic, antibacterial, anti-

fungal, antiallergenic, antioxidant and other therapeutic potential[9].

Besides, mushrooms are associated with health improvement through consumption directly as diet or as concoction herbal formulas in traditional medicine. They have been used as health tonics, tinctures, teas, soups, and healthful food dishes in different communities. Species such as *Tremella fuciformis* has been used to lubricate the lungs, *Cordyceps sinensis* tonify the kidneys, *Grifola umbellate* reduce excessive dampness and *Wolfiporiacocos* to revitalize the spleen[3]. The fruiting body of *Ganoderma lucidum* is famous in folk medicine to treat liver dysfunction, gastric ulcer, hypertension, arthritis, sleeplessness, bronchitis, asthma, liver and kidney inflammation in China and Japan[10]. Moreover, functional mushrooms are known for their potential to regulate the immune system, lower blood pressure and blood lipid, and prevent tumours, inflammation, and microbial activities[11,12]. Phenolic compounds in mushrooms help to minimize the risk of cardiovascular diseases, stroke and various forms of cancer due to the antioxidant potential of polyphenol[13,14].

Tanzania is gifted with diversified geographical features rich in natural forests which support the growth of various species of mushrooms. People living near these forests are well informed on mushroom folk taxonomy, biology and ecology. They participate in mushroom hunting during raining where they collect enough for consumption and even extra which they sell in local markets. Knowledge on mushrooms is acquired and imparted by practices and is customarily transferred through a family dissemination. At an early age children go with their parents in mushroom hunting, they learn about their identification, consumption and other beneficial uses like pharmacological applications[5]. Numerous studies have reported various edible and medicinal mushroom species available in Tanzania[15-25]. There is inadequacy documentation on health beneficial effects that come from the utilisation of edible mushrooms. This study aimed to assess the current knowledge of traditional uses, nutritional significance and the nutraceutical value of edible mushrooms in Tanzania for the improvement of human health and livelihood.

Results and Discussion

Traditional uses: Traditional utilization of the mushrooms varies in different communities in Tanzania which have more than 120 ethnic groups distributed across the country. The majority of communities are familiar with the consumption of mushrooms as foods, however, some communities particularly Maasai and Chagga are unaware of mushroom edibility, but former use as mushroom tonic and other pharmacological uses. Apart from mushroom consumption as cuisine, other pharmacological uses include improving the health of long ill people by using mushrooms (*Termitomyces*) that boost their immunity, prescribed as a tonic for gastro-intestinal ailments, relieving stomach pains, constipation, and stomach[26]. Furthermore, mushrooms have been used to enhance the quick recovery of childbirth mothers and improve milk production to breastfeeding mothers[17]. *Kusaghiporia usambarensis* locally known as the 'Kusaghizi', the Sambaa tribe has been exploited for a long time to treat hypertension, diabetes and haemorrhoids[22]. In south Pare species of *Termitomyces eurrhizus* is used in a concoction with other herbs as skin ointment[27]. The ingenious use of ascomycete spores (soot) as 'anaesthesia' in honey collecting has been testified. Matured dry ascospores are directly released into the beehives which come out like soot that causes bees unconsciousness for about 30 minutes allowing safe honey harvesting[26].

The knowledge of mushroom utilisation is associated with the accurate identification of desired mushrooms. Folk taxonomy has been used for characterizing mushrooms based on colour, the size and shape of the basidiocarp, the size of the pseudorrhiza and habitats. For instance, the term 'maghwede' in the Sambaa tribe which means ear has been used to describe mushrooms of genus *Auricularia*, 'Kiyogamchwalaini' which means soft mushroom of termitesin Swahili, refers to *Termitomyces tylerianus*. 'Uyogamkonge' from Swahili means sisal mushroom refers to *Coprinus disseminates*, 'Kusaghizi' in the Sambaa tribe which means collector or accumulator which describe how the mushroom grows by collecting anything that come in contact with basidiocarp, it refers to *Kusaghiporia usambarensis*[21,25].

Nutritional significance: Edible mushrooms are considered as a functional food, their consumption helps to improve human health. The nutritional significance of edible mushrooms is supported by their low fat and high protein content that has been reported to be more than many kinds of cereal, fruits and vegetables and they are good sources of dietary fibre[18]. They are well known for their use as sources of essential amino acids[28]. Mdachi et al.[17] reported six-teen amino acids from edible mushrooms of Tanzania with some species like *Boletinuscavipes* containing seven essential amino acids. The high amount of Vitamin C content in edible the mushrooms have been reported in various studies[29-31]. Vitamin C is a valuable food component in mushroom due to its antioxidant and therapeutic properties. Inclusion of edible mushrooms in daily diet has great potential for enhancing nutrient supply shortages that are prevalent in many developing countries, including Tanzania.

Nutraceutical importance of Mushrooms

Antioxidant Activity: Human bodies generate free radicals during oxidative metabolism and energy production. These free radicals are detrimental to our DNA and essential enzymes and have the potential to stimulate lipid peroxidation and auto-oxidation reactions. Luckily enough, our bodies have self-protection mechanisms against oxidative damage caused by free radicals[32]. However, natural self-protection against free radical may lead to oxidative stress, as consequence free radicals may

damage cellular DNA which results in various diseases like myocardial infarction and cancer[33]. Dietary consumption of edible and medicinal mushrooms that have reported to have antioxidant properties that prevent our cells from the impairment caused by oxidative stress[34]. Edible mushrooms from Tanzania have been reported to contain significant antioxidant activities. For example, a study by Hussein et al.[35] reported antioxidant activity from wild edible mushrooms from Tanzania. This study included mushroom species: *Auricularia auricular-judae, Lentinussajor-caju*, *Lentinus squarrosulus, Macrolepiota procera, Panusconchatus,* and *Polyporus tenuiculus*. Another study is by Tibuhwa[20] where by qualitative and quantitative values of antiradical and antioxidant of crude methanolic extracts of *Termitomyces* species (*T. titanicus, T. aurantiacus, T. letestui, T. clypeatus, T. microcarpus* and *T. eurhizus*) were investigated. Tibuhwa[31] also studied the comparison of antioxidant potential amongst fresh and dry *Cantharellus* and *Afrocantharellus* mushrooms where generally consumption of these mushrooms in both forms dry and fresh was found to be advantageous to health since they are ability to offer antioxidant protection against oxidative damage. Muruke[23] have assessed antioxidant potential of flavonoids, lycopene and β-carotenes from isolated from a wild Edible *Pleurotus cystidiosus* from Tanzania. Juma et al.[24] studied antioxidant activities in seven edible mushrooms where methanol extracts from the mushroom *Polyporus tenuiculus* exhibited strong antioxidant activity in 1,1-diphenyl-2-picryhydrazyl (DPPH) radical scavenging activity assays. Also, Tibuhwa et al.[36] compared post-harvest treatments on nutritive contents of *Coprinus cinereus* where the studied mushroom was reported to be good sources of antioxidants. Antioxidants found in studied edible mushrooms of Tanzania are associated with phenolic compounds and vitamin C. Similarly, Ferreira et al.[7] have reported phenolic acids and flavonoids in edible mushrooms to have significant antioxidant activity. Phenolic compounds have portrayed positive correlations with antioxidant activities of edible mushroom extracts[38]. *Lentinussajor-caju* has shown a strong antioxidant property and metal chelating activities[39]. These studies confirm beyond doubt that Tanzanian edible mushrooms are a good source of antioxidant and consumption of these mushrooms will have health beneficial effects to consumers. Since few wild edible mushrooms studied so far have revealed high nutraceutical potential, further studies are needed to domesticate and upscale their production.

Antiradical activity: Reactive oxygen species (ROS) are constantly produced metabolic processes in our bodies which have numerous detrimental effects include DNA damage, carcinogenesis and cellular deterioration contributes to aging[40]. Mushroom extracts have shown effectiveness to free radical scavenging activity[41]. Free radical scavenging and ferrous ion chelating activities of edible mushroom extracts are well known[23,24,31,35]. Antiradical activities portrayed by mushroom extracts in above-mentioned studies have been associated with flavonoids, lycopene and β-carotene contents that were isolated from edible mushroom extracts. Portrayed free radical foraging significant of the polyphenol constituents of mushroom extracts inferring protective roles of these compounds and mushroom consumption can prevent deleterious effects of free radicals generated during cellular metabolic processes[42].

Antimicrobial Activity: Extract from edible and medicinal mushrooms have been proven to have potent antibiotic properties against pathogens since long time[43]. Exploratory for new drugs of pharmacological value has been vastly increased due to the emergence of drug-resistant. As results, edible and medicinal mushrooms have been studied as an alternative source of antibiotics to overcome drug resistance challenge[44,45]. Several studies have testified antibiotic activity from mushroom species such as *Auricularia auricular-judae*[46,47], *Lentinus sajor-caju*[48], *Macrolepiota procera*[49], species of *Lentinus squarrosulus, Termitomyces microcarpus,* and *Volvariella volvacea*[50], all these mushroom species grow naturally in Tanzanian forests[22]. Additionally, Tibuhwa[51] investigated *Boletus bicolor* which traditionally used to treat several human diseases in Tanzania and found it to have antimicrobial activity against a human pathogen *Bacillus subtilis.* Also, Baraza et al.[52] reported antimicrobial activity of three wild edible mushrooms *Termitomyces letestui, Agaricus sp. aff. Arvensis* and *Lactarius edulis*. Likewise crude extracts of some wild edible mushrooms have shown antibacterial and antifungal activities against human pathogens *Shigella flexneri*, *Klebsiella oxytoca* and *Candida albicans*[53]. Extract from edible mushroom *Coprinus cinereus* portrayed antimicrobial activity[54]. The study findings also portrayed an interesting observation of the positive correlation of antimicrobial activity with increasing chicken manure supplements. These findings show that chicken fertilizer is potential supplements in mushroom farming and improve secondary metabolites from cultivated mushrooms[54,55]. Edible mushroom of Tanzania not only contain antimicrobial activity, but there is a possibility of cultivating them for ensuring their availability all year round with improving its nutraceutical capability.

Antiviral activity: Nutraceutical value of edible mushrooms is attributed with their ability to exert its potent over a wide range of diseases that affects human. Studies to explore antiviral effect from edible mushroom have shown potential to inhibit viruses' proliferation. Extract from mushroom has shown inhibitory activity against HIV-1 reverse transcriptase[56]. Chemically modified glucomannan polysaccharides isolated from *Agaricus brasiliensis* mycelium portrayed inhibition of Herpes Simplex Virus (HSV)[57]. Different mechanisms have been proposed for their antiviral activity that ranges from small molecules like peptides, lectins to Glycoprotein, polysaccharide and various complex molecules[58]. In Tanzania Kidukuli et al.[59] assessed antiviral effects of wild edible mushrooms reported *Cantharellus isabellinus* and *Pleurotus djamour* extracts exert antiviral potent against Infectious Bursal Disease Virus (IBDV)

and pox virus. Similarly, *Ganoderma lucidum* from Tanzania studied by Mdachi et al.[17] has been reported to possess anti-HIV activity[60]. Antiviral potentials of edible mushrooms from Tanzania are poorly studied, thus more studies are needed to explore their potentiality against various infectious viruses.

Anti-tumour potential: Apart from numerous nutritional value reported in edible mushrooms, significant amounts of bioactive compounds with anti-tumour potential were reported in edible mushrooms including Tanzania. Ma et al.[61] has found β-d-glucan isolated from *Auricularia auricula-judae* that portrayed strong inhibition against the tumor growth of Acinar cell carcinoma. In another study polysaccharides (L-rhamnose, L-arabinose, D-xylose, D-mannose, D-glucose, and D-galactose) extracted from *A. judae* prevents oxidative stress in an ageing mouse[62]. Extracts from *Ganoderma lucidum* and *Volvariella volvacea* have shown anti-tumor effect[2]. Antitumor active polysaccharides have been found in the extract from some edible and medicinal mushrooms[63,64].

Although ergosterol and peroxyergosterol which was isolated from wild Tanzanian mushrooms[52] have not been tested for its antitumor effects, Rhee et al.[65] reported ergosterol peroxide isolated from edible mushroom has suppressed phosphorylation, DNA binding activity and nuclear trans-localization of Signal Transducer and Activator of Transcription 3 (STAT3) in Multiple myeloma cell line U266. These findings imply that ergosterol peroxide possesses antitumor activity against several cancer cells. Likewise, a study by Masalu et al.[66] on in vitro screening for cytotoxicity, has revealed extract from *Cantharellus miombo ensis* has the potential to induce apoptosis of different human cancer cell lines, including Hepatocellular carcinoma (HepG2), Human non-small cell lung carcinoma (H157) and Human colon adenocarcinoma (HT.29). These interesting findings need further attention for validation and up-scaling for potential pharmaceutical applications.

Hypolipidemic Activity: Hyperlipidemia is un-usual increased lipids or lipoprotein levels in the blood which is a major contributing cause in the development of cardiovascular disease[67]. Mushroom extracts have shown the ability to decrease plasma cholesterol (hypolipidemic activity) on experimented rats[68]. Hypolipidemic effects of edible mushrooms *Auricularia polytricha*, *Agaricus bisporus, Ganoderma lucidum* and *Auricularia auricular- judae* have been reported in various studies[69,70].

The ability of edible mushrooms to the prevention of atherosclerosis (deposition of fatty materials in the inner walls of arteries that led to heart diseases) is due to their high content of fibre, proteins, microelements, and their low-fat content[71]. Although the hypolipidemic effect of Tanzanian edible mushroom has not been well studied, edible mushrooms with potential activities reported by Boh et al.[72] and Chen et al.[73] are available in Tanzania forests[17,22] hence studies are needed to ascertain their hypolipidemic activities.

Mushrooms improve livelihood

Apart from being desired food mushrooms are a source of income, contributing to improve livelihood of mushroom collectors, the majority are women and children who participate in mushroom hunting in the forests during the rainy season. It has been estimated that, gathered wild edible mushrooms sold in the local market generate up to 900USD annually per person[74]. Empowering mushroom collector with entrepreneur skills and mushroom cultivation technics, will increase their income as mushroom cultivation does not need arable land since one-meter square can produce up to 116kg/year for the Oyster mushrooms which is equivalent to 500 USD[20]. Readily available agricultural wastes located nationwide subsidize the cost for mushroom cultivation, as a result, more profitable and environmentally friendly disposal system. The presence of tourist hotels and an increase in social awareness on health benefits from mushroom, consumption has assured a reliable market. As nutritious food and source of income, edible mushrooms have prospective to improve people's livelihood.

Conclusion

Studies confirm wealthy of products with potent and unique health-enhancing prospective from an edible mushroom of Tanzania. Traditional uses of edible mushroom by various tribes in Tanzania to health maintenance, prevention and treatment of diseases has proven their appreciation in society. Despite the great potential for edible mushrooms, their utilization is mostly seasonal. The introduction of cultivation technics, processing and preservation of wild and cultivated mushroom will improve the mushroom value chain hence increase income generation and improved livelihood. Bioactivity and potential of Tanzanian mushroom are poorly studied. The paucity of detailed information on antimicrobial, antitumor, antiviral, hypolipidemic and their mechanism of Tanzanian edible mushrooms can be reduced by doing more research related to the missing information.

Acknowledgement

We are grateful to the Department of Molecular Biology and Biotechnology and to the anonymous reviewers who have spent their valuable time to review this manuscript.

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