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Research Article

Edible and Medicinal Mushrooms Sold at Traditional Markets in Tanzania

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Abstract

Background and Objective: Mushrooms are non timber forest products that are sparingly studied. Ethnomycological studies are thus important to cut the need of knowledge on the consumption of medicinal mushrooms and their cultural values to people of different socio-economic levels. This study is conducted to present ethnomycological study on 31 traditional markets in Tanzania. Also to bestow a novel list of edible and medicinal mushrooms sold in these markets, highlighting the most sold and their tradition therapeutic applications. **Materials and Methods:** This study focused on ethnomycological information from vendors of both edible and medicinal mushrooms from 31 traditional markets in Tanzania. Semi-structured and face-to-face interviews were used to collect information from 151 individuals. The interviewees included rural harvesters (25%), renowned wholesale traders (10%), formal and informal vendors (43%), prominent consumers (16%) and some local traditional healers (6%). Agreement among vendors about the therapeutic uses of medicinal mushrooms was measured using the Factor of Informant Consensus (FIC) while the Fidelity Level (FL) was used to assess the most used medicinal mushroom species. **Results:** One hundred thirty three mushroom species were registered out of which 128 are edible whereas, 28 possessed health beneficial uses grouped into eight medical categories. The categories include ailments related to digestive, genitourinary, gynecologic, hormonal, circulatory, dermatological, respiratory system and general disorder. Vendor agreement for the ethno-medicinal uses varied (FIC = 0.95-0.82) with highest value reported in the digestive and circulatory systems medical categories. The highest FL values were observed in four species led by *Ganoderma tsugae* (FL = 0.85) while the least value was reported in *Armillaria mellea* (FL = 0.1). **Conclusion:** Studies in traditional markets are important for conserving ethnomycological knowledge transfer across generations. The four mushroom species which reported high FL values are recommended for further pharmacological and phytochemical studies into possible drug development.

Key words: Edible mushrooms, ethnomycological studies, medicinal mushrooms, Tanzania, traditional markets

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Markets are special meeting places to display diverse goods and products including manufactured goods, natural products from farms. Goods are sold locally from neighboring communities that generally differs culturally, ecologically and economically¹⁻². Unlike big markets, traditional markets around the world are renowned as places where people meet for trading different products including vegetables, mushrooms, plants and their derivative products as well as potential centers where cultures are expressed, exchanged and transformed across generations. It is in traditional markets where medicinal mushrooms and medicinal plants market value chain runs. In order for scientists to tap the ethnomycological information of these essential medicinal mushrooms, they need to do survey in these traditional markets. Such surveys are essential in ensuring the understanding of the networks of collectors, consumers, sellers and healers by the supply and demand of medicinal and edible mushroom and their imitative products³. Wild mushroom consumptions and traditional markets have been studied since ancient times as far back as 1930's as reported by Szulczewski⁴. A global overview of mushroom consumption and their use is reported by Boa⁵ while a more recent study on wild and native plants and mushrooms sold in the open-air markets of Southeastern Poland was reported by Kasper-Pakosz *et al.*⁶.

According to the World Health Organization (WHO), 80% of the population still relies on traditional medicine, spiritual therapies and ancestral healing practices as their primary healthcare^{7,8}. The practices are more evident in traditional communities living in rural areas and are of high demand. Traditional medicines healing and remedies play a very important role in the health of millions of people in Africa. Generally in African countries, the ratios of traditional practitioners and medical doctors in relation to the whole population shows that traditional practitioner has low ratios compared to medical doctors. For example in Swaziland, it is 110 people for every traditional healer versus 10,000 people for every medical doctor. In Ghana, it is 224 people for every traditional practitioner compared to nearly 21,000 people for one medical doctor. In Zambia, 60% of the population receives medical care from traditional practitioners while in Tanzania there are 75,000 traditional healers in comparison to 600 medical doctors^{9,10}. Traditional medicines are popularly preferred because they are generally cheaper than Western medicine. For those who live in rural villages, they are easier to access than city hospitals.

Studies on the role of traditional markets in ethnobotanical aspects have been carried out in different parts of the world including Bolivia, Venezuela, Peru and Colombia¹¹⁻¹⁵. In Tanzania, a few ethnobotanical studies based on vendor interviews have been also conducted for different markets¹⁶⁻¹⁹. However, these studies did not include collecting voucher material for further identification by a botanist, for comparison and matching the vernacular names to scientific names²⁰. For ethnomycological studies it is sparingly studied. So far the only ethnomycological study done is by Tibuhwa²¹ and the study was confined to the areas surrounding the Serengeti National Park with a dominance of two tribes, the Kuria and Maasai. Nevertheless the study revealed vast folk taxonomy knowledge and pointed out several mushroom traditional uses including medicinal and ritual applications. It further pointed the knowledge gap and gender dominance of the mushroom market chain²¹. Therefore, this research study was conducted to prepare and present a novel list of edible and medicinal mushrooms sold at 31 traditional markets from 12 regions in Tanzania and established the most sold and used medicinal mushroom species.

MATERIALS AND METHODS

Study area: The study was conducted since 2011-2016 in 31 traditional markets from 12 regions in Tanzania. The regions include Tabora, Morogoro, Tanga, Kigoma, Kagera, Mwanza, Geita, Shinyanga, Iringa, Morogoro, Mara and Coast (Fig. 1). The spoken languages, estimated population and other ethnic characteristics found in these regions are summarized in Table 1. The studied regions possess quite diversified hydrographic features, including mountains, natural forests, rivers and lakes which make them portray a very irregular topography and altitudes hence considerable variation in local climate, with conditions represented by hot to dry tropical, subtropical humid and cold humid. Their principal economic activities range from agriculture, cattle raising, fishing as well as hunting and collection of wild products, which is reflected in their diversified diets summarized in Table 1. Some of their languages have a very composite folk taxonomy of both local plants and mushrooms such that they can distinguish several taxa of mushrooms up to species level, which indicates how competent they are in the ecology and environment surrounding them. In their languages, most of the plants, animals and mushrooms have their names associated with myths, practical or ritual uses and original history. For example in Tanga region, people living near Eastern Usambara

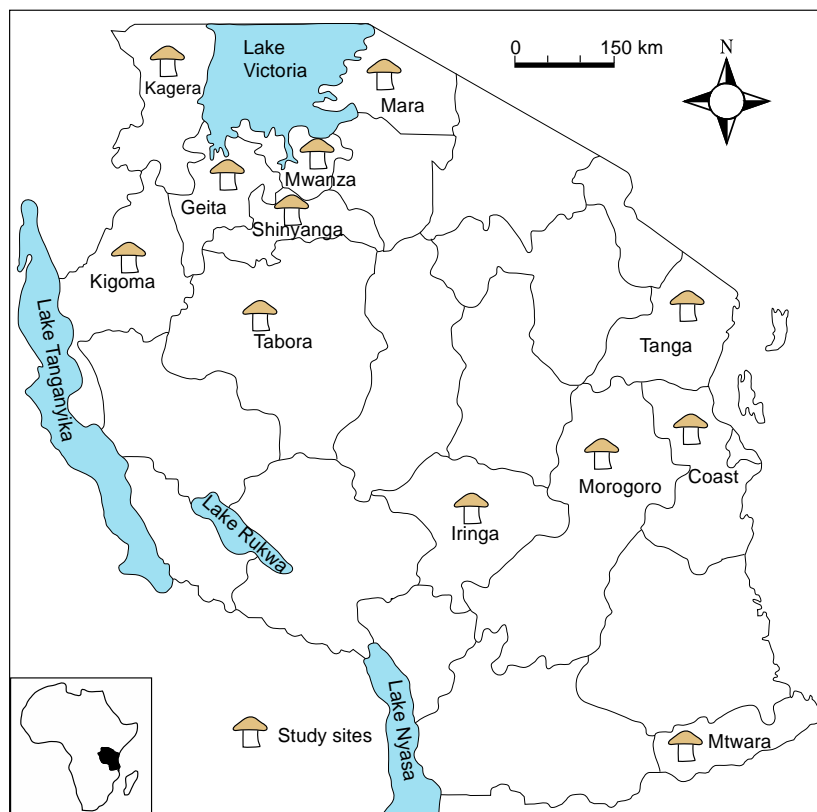


Fig. 1: Map of Tanzania showing the sampling sites in 12 regions

Table 1: Ethnic characteristics pertaining the studied regions

Region	Size (km ²)	Dominant tribes	Total population	Main diet	Sampled markets
Mwanza	9,467	Wasukuma, Wakerewe, Wakara and Wazinza	2,773,000	Rice, corn, beans, cassava and fish	3
Mtwara	16,707	Makonde, Mwela, Makua, Wayao	1,270,854	Corn, beans, cassava, millet and animals	2
Kigoma	37,040	Waha, Wamasanze and Wabembe	2,127,930	Potato, corn, beans, cassava and fish	3
Tanga	26,667	Wazigua, Wabondei, Wasambaa and Wadingo	2,045,000	Corn, beans and animals	3
Tabora	76,150	Wanyamwezi, Wanyantuzu	2,292,000	Corn, beans, rice and cassava	3
Mara	21,760	Wakurya, Wajita, Wazanaki and Wajaluo	1,744,000	Corn, rice, beans, millet, cassava, fish and animals	3
Kagera	25,265	Wahaya, Wanyambo, Wahangaza and Wasubi	2,458,023	Banana, corn, cassava, millet and fish	2
Geita	20,540	Wasukuma and Wazinza	1,740,000	Rice, corn, beans, cassava and fish	3
Shinyanga	18,901	Wasukuma, Wanyamwezi and Wasubwa	1,535,000	Rice, corn, beans, cassava and fish	2
Morogoro	70,624	Waluguru, Wapogoro, Wandamba	2,218,000	Rice, corn, beans, cassava and animals	2
Iringa	35,503	Hehe, Wabena	941,238	Corn, rice, beans, cassava and animals	3
Coast	32,547	Wazaramo, Wangindo, Wakwere	1,099,000	Corn, rice, beans, cassava and fish	2

mountains have their diets based on products obtained from corn and sisal plantations, direct hunting and collections from wild forests. Their main economic activities are agriculture and are generically characterized by having a profound knowledge in both wild plants, mushroom and have a strong dependence on them. However, in Mara region their economic activities are varied. For example, they are primarily extensive cattle raisers, farmers and partly practices fishing and hunting. Besides, they practice mixed agriculture and it is relatively intensive, reaping two crops a year.

Their diet is composed of agriculture products, wild products including wild mushrooms and fish from nearby water bodies, animals they keep and hunt from the nearby animal parks.

Fieldwork: The fieldwork involved visiting markets to determine the most sold mushroom species and their medicinal uses in 31 markets from 12 regions in Tanzania (Table 1). Markets were classified based on the modalities they operate as summarized in Table 2.

Table 2: Groups and characteristics of the studied market

Market type	Local name	Characteristics	Operating days in a week
Established market	Soko	Fixed infrastructure including building and fixed table tops. Sells mainly edible products from peasant farm fields as well as wild products and manufactured goods	Everyday
Mobile market	Gulio	Open space-not fixed and can operate all week or just 1 day in a week (day local market). Sells mainly edible products from peasant farm fields as well as wild products	All days/once
Peasant stand	Genge	Simple constructed shades equipped with simple table top. Sells mainly edible products from peasant farm fields as well as wild products serving the nearby households and capture passing trade	All days
Modern stand	Mnada	Open space. Sells any product and edible ones come from intermediary chains in specified days of the week	Few specified days
Roadside market	Kando ya Barabara	A stand set up on the side of the road - sells any product and edible ones, along side of the highways and operates throughout the week, capturing passing trade	All days

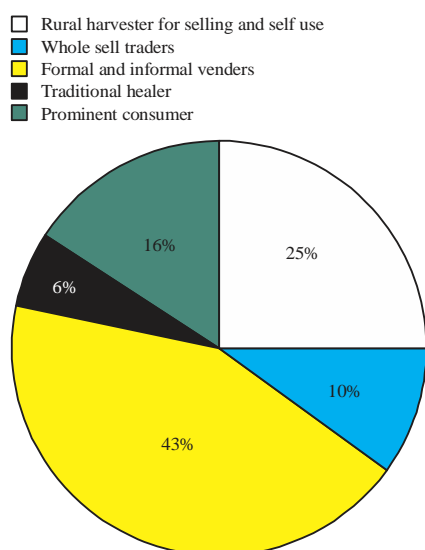


Fig. 2: Characteristics and number of the interviewees

The established market, known locally as “soko mjinga/soko la mkulima”, included mainly agricultural products such as legumes, fruits, vegetables, tubers, cooked food, personal use items, electronic equipments, groceries and dairy products. Vendors at these markets were many and not less than 50 sellers, with permanent specific selling table or points in the market facility. They buy mushrooms in wholesale and sell in retails to final consumers. Mobile market locally known as ‘gulio’ like in established markets usually included mainly agricultural products, cooked food, personal use items, electronic equipments, groceries, dairy products and forest products such as edible and medicinal mushrooms as well as medicinal plants. It was however not fixed and operated all week or just one day in a week (day local market). Vendors at mobile open markets were rural harvesters and/or small retailers who sold edible and medicinal mushrooms in fresh or dry forms. Peasant stand locally as ‘gengeni’ were

permanent like established market but in small scale, 1-10 sellers in one place. Modern stand known locally as “mnadani” traded manufactured product and agricultural edible products including mushrooms and vegetables. They were in large-scale usually more than 50 people but operated once or few specified days in a week. Roadside markets were selling any locally made product, poultry and agriculture products, including forest harvests such as edible and medicinal mushrooms, vegetables and medicinal plants. They sell their products along the highways and operated throughout the week.

Semi-structured questionnaires and face-to-face interviews were used to collect the information from 151 individuals who were main actors involved in the harvest, sales of edible and medicinal mushrooms at the studied markets. These actors mainly included rural harvester for selling and self-uses, renowned mushroom whole seller traders, formal and informal vendors, prominent consumers and some local traditional healers. Types of each actor in a market chain were recognized based on how they auto-recognized their own role as summarized in Fig. 2. From 151 interviewees, 91 were women and 60 were men. About 96% of the interviewees were able to speak Swahili national language while 4% spoke some indigenous language and thus the study employed the participant observation method and applied non-structured and semi-structured interviews according to Bernard²². Information of gathering process involved participatory techniques by carrying out field trips in the forest with informants whenever necessary especially to enable successful identification. Edibility of the studied mushrooms were conceptually distinguished by mainly the collectors on the basis of very few morphological characters such as Mushroom color, size of the basidiomata, shape and size of the pseudorhiza, habitat such as termite mounds associations and leaf litter as detailed in Tibuhwa²¹ while medicinal uses was revealed and recorded during the interviews.

Data analysis: The percentage of informants asserting the use of a certain medicinal mushroom for the same major purpose was calculated as the Fidelity level (FL) for the most frequently reported diseases or ailments as:

$$FL (\%) = \frac{N_p}{N} \times 100$$

where, N_p is the number of informants that claim a use of a medicinal mushroom species to treat a particular disease and N is the number of informants that use the medicinal mushroom as a medicine to treat any given disease according to Alexiades²³. Likewise factor of informant consensus was numerically determined using the equation:

$$FIC = \frac{Nur-Nt}{Nur-1}$$

where, Nur is the number of use citations in each category and Nt is the number of species reported in each category.

RESULTS AND DISCUSSION

The study enumerated 133 mushroom species all belonging to 19 families and 28 genera (Table 3). The edible and medicinal mushrooms were sold at 10 established markets, 5 mobile markets, 6 peasant stands, 4 modern stands and 6 roadside markets located in 12 regions (Fig. 1). Mushrooms are ephemeral in nature, thus usually fresh edible

Table 3: Studied mushroom species their edibility and medicinal applications

Family	Species	Collection number and herbarium	Edibility/ medicinal uses	
Agaricaceae	<i>Agaricus arvensis</i> Schaeff.	Zuhura 15.2013 (DSM)	E	
	<i>Agaricus augustus</i> Fr.	Zuhura 23. 2014 (DSM)	E	
	<i>Agaricus bisporus</i> (J.E. Lange) Imbach	Zuhura 22. 2014 (DSM)	E	
	<i>Agaricus bitorquis</i> (Qu.Žl.) Sacc.	Zuhura 17. 2014 (DSM)	E	
	<i>Agaricus campestris</i> L.:Fr.	Zuhura 19. 2014 (DSM)	E	
	<i>Agaricus silvicola</i> (Vitt.) Lev.	Zuhura 21. 2014 (DSM)	E	
	<i>Chlorophyllum brunneum</i> (Farl. and Burt) Vellinga	DDT 1075.2011 (DSM)	E	
	<i>Chlorophyllum rachodes</i> (Vittad.) Vellinga	DDT 1067.2012 (DSM)	E	
	<i>Coprinus disseminatus</i> (Pers.) Gray	DDT 1049.2010 (DSM)	E	
	<i>Coprinus cinereus</i> (Schaeff.) Gray	DDT 1045.2010 (DSM)	E	
	<i>Coprinus comatus</i> (O.F. Mu"ll.) Pers	DDT 1035.2010 (DSM)	E	
	<i>Leucocoprinus fragilissimus</i> (Berk. and M.A. Curtis) Pat	DDT 1093 (DSM)	E	
	Amanitaceae	<i>Amanita loosi</i> Beeli	DDT 1082 (DSM)	E and M
		<i>Amanita mafingaensis</i> Härk. and Saarim.	DDT 1087 (DSM)	E
		<i>Amanita masasiensis</i> Härk. and Saarim.	DDT 1088 (DSM)	E
<i>Amanita pudica</i> (Beeli) Walley		DDT 1092 (DSM)	E	
<i>Amanita rubescens</i> Pers.		DDT 1094 (DSM)	E	
<i>Amanita tanzanica</i> Härk. and Saarim.		DDT 1061 (DSM)	E	
<i>Amanita vaginata</i> (Fries) Vittadini		DT 20012-67 (DSM)	E	
Lyophyllaceae	<i>Termitomyces albuminosus</i> (Berk.) R. Heim	DT 20011-19 (DSM)	E	
	<i>Termitomyces aurantiacus</i> (R. Heim) R. Heim	DT 20011-14 (DSM)	E	
	<i>Termitomyces badius</i> Otieno	DDT 1015 (DSM)	E	
	<i>Termitomyces clypeatus</i> R. Heim	DT2000-12 (DSM)	E	
	<i>Termitomyces eurhizus</i> (Berk.) R. Heim	DT 2010-18 (DSM)	E and M	
	<i>Termitomyces heimii</i> Natarajan Natarajan	DDT 1017 (DSM)	E	
	<i>Termitomyces le-testui</i> (Pat.) R. Heim	DT 2010-20 (DSM)	E and M	
	<i>Termitomyces mammiformis</i> R. Heim	DT 2009-34 (DSM)	E	
	<i>Termitomyces microcarpus</i> (Berk. And Broome) R. Heim	D2004-19 (DSM)	E and M	
	<i>Termitomyces robustus</i> (Beli) Heim	DDT 1026 (DSM)	E and M	
	<i>Termitomyces saggitiformis</i> (Kalchbr. and Cooke) D.A. Reid	DT 2010-48 (DSM)	E	
	<i>Termitomyces schimperi</i> (Pat.) R. Heim	DT 2010-54 (DSM)	E	
	<i>Termitomyces singidensis</i> Saarim. and Härk.	DT 20010-57 (DSM)	E	
	<i>Termitomyces striatus</i> (Beeli) R. Heim	DT 20010-49 (DSM)	E	
	<i>Termitomyces titanicus</i> Pegler and Pearce	DT 20011-12 (DSM)	E and M	
<i>Termitomyces tyleranus</i> var. macrocarpa Art A. Kaur and Kour	DT 2015-22 (DSM)	E		
<i>Termitomyces umkowaan</i> (Cooke and Masee) D.A. Reid	D2000-6 (DSM)	E and M		
Physalacriaceae	<i>Armillaria borealis</i> Marxmuller and Korhonen	DDT 1028(DSM)	E	
	<i>Armillaria cepistipes</i> Velen	DDT 1022 (DSM)	E	
	<i>Armillaria heimii</i> Pegler	DDT 1031(DSM)	E	
	<i>Armillaria heimii</i> Pegler	DDT 1034 (DSM)	E	
	<i>Armillaria lutea</i> Gillet	#	E	
	<i>Armillaria mellea</i> (Vahl) P. Kummer	#	E and M	

Table 3: Continue

Family	Species	Collection number and herbarium	Edibility/ medicinal uses	
Pleurotaceae	<i>Pleurotus cystidiosus</i> O.K. Mill.,	IJV51 (DSM)	E	
	<i>Pleurotus djamor</i> (Rumph. ex Fr.)	IJV35 (DSM)	E	
	<i>Pleurotus eryngii</i> (DC.) Quél.	IJV38 (DSM)	E and M	
	<i>Pleurotus flabellatus</i> (Sacc.)	DT 2015-24 (DSM)	E	
	<i>Pleurotus ostreatus</i> (Jacq.)P.Kumm.	DT 2015-29 (DSM)	E	
	<i>Pleurotus sajor-caju</i> Fr.	Hussein 36.2013 (DSM)	E	
	<i>Pleurotus tuber-regium</i> (Rumph. Ex Fr.) Singer	IJV57 (DSM)	E and M	
Macrolepiota	<i>Macrolepiota africana</i> (R.Heim) Heinem.	Hussein 49.2014 (DSM)	E	
	<i>Macrolepiota albuminosa</i> (Berk.) Pegler	#	E	
	<i>Macrolepiota dolichaula</i> (Berk. and Broome) Pegler and R.W. Rayner	Hussein 44.2013 (DSM)	E	
	<i>Macrolepiota procera</i> (Scop.) Singer	Hussein 42.2013 (DSM)	E	
Pluteaceae	<i>Volvariella volvacea</i> (Bull.) Singer	#	E	
Clavulinaceae	<i>Clavulina wisoli</i> R.H. Peterson,	DT 20012-42 (DSM)	E	
	<i>Panaeolus antillarum</i> (Fr.) Dennis	DT 20012-44 (DSM)	E	
Tricholomataceae	<i>Lepista sordida</i> (Schumach.)Singer	DDT 1027(DSM)	E	
Russulaceae	<i>Russula cellulata</i> Buyck	DT 20011-32 (DSM)	E	
	<i>Russula ciliata</i> Buyck	#	E	
	<i>Russula compressa</i> Buyck	DT 20011-33 (DSM)	E	
	<i>Russula congoana</i> Pat	DT 20011-42 (DSM)	E	
	<i>Russula hiemisilvae</i> Buyck	DT 20011-36 (DSM)	E	
	<i>Russula cephalata</i> Buyck	DT 20012-57 (DSM)	E	
	<i>Russula roseovelata</i> Buyck	DT 20012-53 (DSM)	E	
	<i>Russula roseoviolacea</i> Quél.	DT 20012-51 (DSM)	E	
	<i>Russula sejuncta</i> Buyck	#	E	
	<i>Lactarius densifolius</i> Verbeken and Karhula	EDC 11-1001 (DSM)	E	
	<i>Lactarius edulis</i> Verbeken and Buyck	EDC 11-1002(DSM)	E	
	<i>Lactarius heimii</i> Verbeken	EDC 11-1003 (DSM)	E	
	<i>Lactarius kabansus</i> Pegler	EDC 11-1004 (DSM)	E	
	<i>Lactarius luteopus</i> Verbeken	EDC 11-1005 (DSM)	E	
	<i>Lactarius medusae</i> Verbeken	EDC 11-1006 (BR, DSM)	E	
	<i>Lactarius pumilus</i> Verbeken	EDC 11-1007 (DSM)	E	
	<i>Lactarius tanzanicus</i> Karhula and Verbeken	EDC 11-1008 (DSM)	E	
	<i>Lactarius volemoides</i> (Fr.)	EDC 11-1009 (DSM)	E	
	<i>Lactarius xerampelinus</i> Karhula andVerbeken	EDC 11-10010 (DSM)	E	
	<i>Lactifluus aureifolius</i> (Verbeken) Verbeken	EDC 11-10011 (DSM)	E	
	<i>Lactifluus densifolius</i> Verbeken and Karhula	EDC 11-10012 (DSM)	E	
	<i>Lactifluus gymnocarpoides</i> (Verbeken) Verbeken	EDC 11-100 13(DSM)	E	
	<i>Lactifluus kigomaensis</i> De Crop and Verbeken	AV 11-006 (BR, DSM)	E	
	<i>Lactifluus longisporus</i> (Verbeken) Verbeken	EDC 11-100 14 (DSM)	E	
	<i>Lactifluus luteopus</i> (Verbeken) Verbeken	EDC 11-100 15 (DSM)	E	
	Cantharellaceae	<i>Cantharellus congolensis</i> Beeli	Tibuhwa 1077.2007 (UPS, DSM)	E
		<i>Cantharellus cyanoxanthus</i> R. Heim ex Heinem	DDT 1032 (DSM)	E
		<i>Cantharellus defibulatus</i> (Heinem.) Eyssart. and Buyck	(UPS, DSM)	E
		<i>Cantharellus densifolius</i> Heinem	Tibuhwa 1040.2006 (UPS, DSM)	E
		<i>Cantharellus fistulosus</i> Tibuhwa and Buyck	D 59.2007 (UPS, DSM)	E
<i>Cantharellus flabellatus</i> Berk.		(UPS, DSM)	E	
<i>Cantharellus floridulus</i> Heinem.		Tibuhwa 1033.2006 (UPS, DSM)	E	
<i>Cantharellus isabellinus</i> var. <i>Parvisporus</i> Eyssart. and Buyck		Tibuhwa 1022.2005 (UPS, DSM)	E	
<i>Cantharellus isabellinus</i> var. <i>Isabellinus</i> Heinem. Heinem.		Tibuhwa 1030.2006 (UPS, DSM)	E	
<i>Cantharellus luteopunctatus</i> (Beeli) Heinem.		Tibuhwa 1068.2010 (DSM)	E	
<i>Cantharellus miomboensis</i> Buyck and V. Hofst		Tibuhwa 1079.2007 (UPS, DSM)	E and M	
<i>Cantharellus platyphyllus</i> Heinem.		Tibuhwa 1063.2007 (UPS, DSM)	E	
<i>Cantharellus pseudocibarius</i> Henn.		Tibuhwa 1002.2004 (UPS, DSM)	E	
<i>Cantharellus pseudocibarius</i> Henn.		Tibuhwa 1005.2004 (UPS, DSM)	E	
<i>Cantharellus rhodophyllus</i> Heinem			E	
<i>Cantharellus ruber</i> Heinem	Tibuhwa 1045.2007 (UPS, DSM)			
<i>Cantharellus rufopunctatus</i> Heim	Tibuhwa 1010.2004 (UPS, DSM)	E		
<i>Cantharellus splendens</i> Buyck	Tibuhwa 1057.2007 (UPS, DSM)	E		
<i>Cantharellus subincarnatus</i> Eyssart. and Buyck	DDT 1042/2013 (DSM)	E		

Table 3: Continue

Family	Species	Collection number and herbarium	Edibility/ medicinal uses
	<i>Cantharellus symoensii</i> (Heinem) Heim	Tibuhwa 1036.2005 (UPS, DSM)	E
	<i>Cantharellus tomentosus</i> Eyssart. And Buyck	Tibuhwa 1069.2007 (UPS, DSM)	E
	<i>Craterellus cornucopioides</i> (L.) Pers.	DDT 1042/2011 (DSM)	E
	<i>Craterellus odoratus</i> (Schwein.) Fr.	DDT 1057/2011 (DSM)	E
	<i>Craterellus</i> species	DDT 1056/2011 (DSM)	E
Auriculariaceae	<i>Auricularia auricula</i> (L. ex Hook.) Underw.	DDT 1069.2013 (DSM)	E
	<i>Auricularia auricula-judae</i> (Bull.) J.Schröt.	Hussein 45.2013 (DSM)	E and M
	<i>Auricularia cornea</i> Ehrenb	IJV46 (DSM)	E and M
	<i>Auricularia delicata</i> (Mont.) Henn.	E	E
	<i>Auricularia polytricha</i> (Mont.) Sacc.	Hussein 43.2013 (DSM)	E and M
Tremellaceae	<i>Tremella fuciformis</i> Berk	Tibuhwa 1061.2012 (DSM)	E
Boletaceae	<i>Boletus pallidissimus</i> Watling	Tibuhwa 1053.2012 (DSM)	E and M
	<i>Boletus spectabilissimus</i> Waltling	Tibuhwa 1052.2012 (DSM)	E and M
	<i>Boletus loosii</i> Heinem	Tibuhwa 1051.2012 (DSM)	E
	<i>Boletus bicolor</i> Massee	DDT 1066.2011 (DSM)	E and M
	<i>Afroboletus luteolus</i> (Heinem.) Pegler and T.W.K. Young	Tibuhwa 1056.2012 (DSM)	E and M
Suillaceae	<i>Suillus granulatus</i> (Linnaeus) Roussel	Tibuhwa 1058.2014 (DSM)	E and M
	<i>Suillus luteus</i> (L.) Roussel	Tibuhwa 1063.2014 (DSM)	E
Polyporaceae	<i>Polyporus moluccensis</i> (Mont.) Ryvardeen,	IJV34 (DSM)	E and M
	<i>Polyporus tenuiculus</i> (P. Beauvois) Fries	Hussein 33.2013 (DSM)	E and M
	Unidentified <i>Polyporus</i> species	JMH02 (UPS, UDSM)	E and M
Schizophyllaceae	<i>Panaeolus antillarum</i> (Fr.) Dennis	DDT 1099 (DSM)	E
	<i>Schizophyllum commune</i> Fr.	DDT 10101 (DSM)	E and M
	<i>Coriolopsis polyzona</i>		M
Ganodermataceae	<i>Ganoderma applanatum</i> (Pers.) Pat.	DDT 1037 (DSM)	M
	<i>Ganoderma lucidum</i> (Curtis) P. Karst.	DDT 10103 (DSM)	M
	<i>Ganoderma tsugae</i> Murrill	DDT 10102 (DSM)	M
	<i>Laetiporus sulphureus</i> (Bull.) Murrill	IJ-2014 (DSM)	E
	<i>Lentinus cladopus</i> Lev.	Hussein 41.2013 (DSM)	E
	<i>Lentinus retinervis</i> Pegler	DDT 1051 (DSM)	E
	<i>Lentinus sajor-caju</i> (Fr.) Fr.,	Hussein 36.2013 (DSM)	E
	<i>Phellinus rimosus</i> (Berk.) Pilát	DDT 10127 (DSM)	M

Table 4: Therapeutic uses of medicinal mushrooms used to treat local ailments in 12 regions from Tanzania grouped in medical categories adapted from the World Health Organization²⁷

Medical categories	Local illnesses and diseases recognized by market vendors
Digestive system	Diarrhea, constipation, sickness, hangover, flatulence, liver disorder (included inflammation), stomach
General disorders	Inflammation, cancer, fever, headache and sunstroke
Gynecological system	Vaginal disorders, abdominal pain, menstrual cramps and related disorders, ovary inflammation and promoting labor and childbirth recovery
Genitourinary system	Kidney ailments (included inflammation and infection) and prostate and urinary tract disorders
Hormonal system	Diabetes and galactagogues
Dermatological system	Acne, fungus infection, gangrene, rash, wounds, nosebleed, hair loss and dandruff
Circulatory system	Anemia, bad blood circulation, high cholesterol and high or low blood pressure
Respiratory system	Cold, cough, flu, sore throat and measles

mushrooms are sold in these markets during the rain season and in places not far away from the forest where they were harvested^{5,24-26}. Nevertheless, dry mushrooms for food and medicinal uses were found throughout the year in some markets including, Tabora, Geita, Coast, Iringa and Kigoma. The vendors usually collected or bought them in large stock and sun dry or smoke those to increase their shelf life hence make them available for selling throughout the year.

Medicinal mushroom and factor of informant consensus

(FIC): In this study, 28 medicinal mushrooms were found sold in different 31 traditional markets and were claimed to treat different ailments classified into 8 medical categories adapted from the catalogue of International Classification of Diseases made by the WHO²⁷ summarized in Table 4. In this study, 'illness' refers to being ill as conceived from a sociocultural personal perception, while 'disease' was considered from the

biomedical perspective adopted from Tinitana *et al.*². For the used medical category, WHO²⁷ recognizes them in relation to the health practice systems of traditional population. The most popular medicinal mushrooms that were found sold in different markets are *Ganoderma applanatum*, *Ganoderma tsugae*, *Ganoderma lucidum* and *Termitomyces microcarpus*. However, the species which were recorded to have many medicinal applications, were all the *Ganoderma* and unidentified *Polyporus* species. For example, the number of usage for these species: *Ganoderma tsugae*, *Ganoderma applanatum* and *Ganoderma lucidum* were 6 different uses categorized into 4 medical categories while unidentified *Polyporus* species recorded 5 different uses categorized into 5 medical categories. Further analysis on the family level taxa showed that family Lyophyllaceae was represented by the highest number of species (6 species) followed by Polyporaceae and Ganodermataceae both represented by 4 species. The least were in families Amanitaceae, Cantharellaceae, Physalacriaceae, Schizophyllaceae and Suillaceae all represented by one species each (Table 5). Factor of Informant Consensus (FIC) has been largely used in studies related to medicinal plants to represent a measure of reliability for specific statement of evidence regarding agreement amongst human groups^{1,28-33}. It is for the first time is applied for the studied 28 medicinal mushrooms. Analysis of the information recorded in the structured ethnomycological questionnaires revealed two medicinal uses to possess the highest level of agreement amongst the interviewees; Improving the health of long ill people or boosting immunity and helping in digestion disorder. The medicinal mushrooms responsible are three *Ganoderma* species (*G. tsugae*, *G. applanatum* and *G. lucidum*) and one *Termitomyces* species (*T. microcarpus*) with FL value of 0.85, 0.82, 0.83 and 0.81, respectively. The two *Ganoderma* species which were also confirmed by participative observation are believed by local communities to be efficient in the treatment of 6 local ailments belonging to the four medical categories which includes general disorders, genitourinary system, dermatological system as well as respiratory system (Table 5). There was a variation on the agreement among the vendors for the 8 medical categories pertaining to the 28 medicinal mushrooms studied with Factor of Informants Consensus values ranging from 0.95-0.82 with an average value of 0.87 to treat ailments related to digestive system, genitourinary system, gynecologic system, hormonal system, circulatory system, dermatological system, respiratory system and general disorder (Table 6).

The FIC reflects homogeneity of information provided by different informants regarding medicinal mushroom species used to treat a specific category of ailments. This therefore, imply that the observed medicinal mushroom species with high FIC could be efficient in treating a particular ailment as it has been also noted in medicinal plant studies^{34,35}.

For the assessment of the most used medicinal mushroom species in this study, four mushroom species were revealed to possess high FL values. It was interesting to note that, the highest FL value were in the three *Ganoderma* species with values 0.85-0.82 while the least value was observed in *Armillaria mellea* with FL value of 0.12 (Table 5). The low FL values shows a low agreement amongst medicinal mushroom market vendors with respect to the treatment of the symptoms related to the claimed ailments or to the fact that they do not know it as it is also observed in medicinal plants³⁶. The four medicinal mushroom species found with high FL values are thus recommended to be given priorities for further pharmacological and phytochemical studies into possible drug development. Beside this study, results shows that edible and medicinal mushrooms are very important resources especially for local people practicing auto-medication thus country polices should allow beneficial utilization of these resources for the betterment of the benefiting societies.

Medicinal mushroom and associated medical categories:

The medicinal mushrooms were found used in treating somatic and psychosomatic health afflictions. For example, In the case of respiratory system and other medical categories including digestive system, dermatological and hormonal systems do not usually possess definite therapeutical prescriptions. Furthermore, the clear distinction between illnesses and diseases and its associated therapeutic administration and treatment is also lacking. For example, unrelated taxa of *Ganoderma* species and unidentified *Polypore* (Table 5) were all recorded to improve health of long ill people, boost immunity, aphrodisiac in men, anti tumor and general unwell of the body. The agreement among 151 market vendors in the use of four specific most sold medicinal mushroom species for the 8 medical categories were generally high. It should be understood that for the case of the three *Ganoderma* species (*G. tsugae*, *G. lucidum* and *G. applanatum*) they were generally undistinguished by most of the vendors and they referred to them as one folk species. The 4 most sold medicinal mushrooms have been well evaluated for their medicinal potentials in other studies. For

Table 5: Mushrooms with medical applications and their associated medical category and Fidelity level among the informants

Species	Educibility and or medicinal uses	Therapeutic administration	Medical category	Fidelity level (FL)
<i>Afroboletus luteolus</i>	Edible and medicinal	Oral and powder swallowing	Digestive system	0.36
<i>Amanita loosi</i>	Edible and medicinal	Oral	Digestive system	0.17
<i>Armillaria mellea</i>	Edible	Oral	Digestive system	0.12
<i>Auricularia auricula-judae</i>	Edible and medicinal	Oral	Digestive system	0.30
<i>Auricularia cornea</i>	Edible and medicinal	Oral	Digestive system	0.30
<i>Auricularia polytricha</i>	Edible and medicinal	Oral and powder swallowing	Digestive system and hormonal systems	0.30
<i>Boletus bicolor</i>	Edible and medicinal	Oral, topical application and powder swallowing	Dermatological system	0.45
<i>Boletus pallidissimus</i>	Edible and medicinal	Oral, topical application and powder swallowing	Dermatological system	0.35
<i>Boletus spectabilissimus</i>	Edible and medicinal	Oral, topical application and powder swallowing	Dermatological system	0.34
<i>Cantharellus miomboensis</i>	Edible and medicinal	Oral eating for long illness, diabetes and cancer treatment	Digestive, hormonal, dermatological and circulatory systems	0.23
<i>Coriolopsis polyzona</i>	Medicinal	Extracted drink like tea and topical application	Dermatological system	0.17
<i>Ganoderma applanatum</i>	Medicinal	Oral, topical application and powder swallowing, cleaning wounds, tea extract for long illness and cancer treatment	Genitourinary, dermatological and respiratory systems	0.82
<i>Ganoderma lucidum</i>	Medicinal	Oral, topical application and powder swallowing, cleaning wounds, tea extract for long illness and cancer treatment	General disorders, genitourinary, Dermatological and respiratory systems	0.83
<i>Ganoderma tsugae</i>	Medicinal	Oral, topical application and powder swallowing, cleaning wounds, tea extract for long illness and cancer treatment	General disorders, genitourinary, Dermatological and respiratory system	0.85
<i>Phellinus rimosus</i>	Medicinal	Oral, topical application and powder swallowing, cleaning wounds, tea extract for long illness and cancer treatment	Dermatological and respiratory system	0.68
<i>Pleurotus eryngii</i>	Edible and medicinal	Oral, powder	Digestive and hormonal systems	0.13
<i>Pleurotus tuber-regium</i>	Edible and medicinal	Oral and topical application	Digestive and dermatological systems	0.52
<i>Polyporus moluccensis</i>	Edible and medicinal	Oral	Digestive system	0.31
<i>Polyporus tenuiculus</i>	Edible and medicinal	Oral	Digestive system	0.31
<i>Schizophyllum commune</i>	Edible and medicinal	Oral	Digestive system	0.42
<i>Suillus granulatus</i>	Edible and medicinal	Oral	Digestive system	0.34
<i>Termitomyces titanicus</i>	Edible and medicinal	Oral, soup after child birth and long illness	Digestive and gynecological systems	0.68
<i>Termitomyces umkoiwaan</i>	Edible and medicinal	Oral	Digestive system	0.30
<i>Termitomyces eurhizus</i>	Edible and medicinal	Oral	Digestive system	0.50
<i>Termitomyces le-testui</i>	Edible and medicinal	Oral	Digestive system	0.36
<i>Termitomyces microcarpus</i>	Edible and medicinal	Oral, soup after child birth and long illness	Digestive, gynecological and hormonal systems	0.81
<i>Termitomyces robustus</i>	Edible and medicinal	Oral	Digestive system	0.50
Unidentified <i>Polyporus</i> species	Edible and medicinal	Oral, topical application and powder swallowing and tea extract for long illness, diabetes and cancer treatment	Digestive, genitourinary, dermatological, respiratory and hormonal systems	0.37

example Tibuhwa³⁷ established that *T. microcarpus* possessed high content of phenols, flavonoid as well as highest antiradical activity unit (EAU515) compared with other studied termiterian mushrooms. Likewise a study by Mshandete³⁸ on *Ganoderma tsugae* found it to possess high antioxidants and portrayed good radical scavenging ability. It is important to note that, although the species *Cantharellus miomboensis* possessed less agreement among the interviewees in this study and found to be used in digestive system illness and general disorder, it has been clearly established that its crude extract is able to induce apoptosis in human cervical cancer cell line (HeLa) and the resistance to small cell lung carcinoma (H157)³⁹. This medicinal mushroom thus is recommended for further investigations especially in its unique antitumor properties.

Mushroom market dynamics: This study visited a total of 31 markets out of which 10 were established markets and 21 were either mobile or semi permanent markets (peasant and modern stand, roadside) characterized by small-scale sellers. It was interesting to note a variety of actors involved in the sale of edible and medicinal mushrooms chain at the studied markets. The majority of these actors included rural harvester for selling and self-uses (25%), renowned whole seller traders

(10%), formal and informal vendors (43%), prominent consumers (16%) and some local traditional healers (6%) (Fig. 2, Table 7). Good numbers of wild edible mushrooms were found sold in six established markets in Geita, Morogoro, Iringa, Tabora, Coast and Kigoma where the mushrooms sold mainly coming from nearby forests (Fig. 3, 4). This is contrary to what was observed in Mexico by Ruan-Soto *et al.*⁴⁰, who did not observe any wild mushroom being sold in established markets. However, those collected from nearby cultivated fields and close patches of bushes and open grassland mainly dominated sold mushrooms in the mobile markets as it has been also noted by Ruan-Soto *et al.*⁴⁰. On mobile markets vendors sell mushrooms one day after they were gathered. Selling is throughout depending on the catch thus there no specific day or period for selling the mushrooms. This is different from temperate areas where mushroom-gatherer undertake very long trips to collect mushrooms⁴⁰⁻⁴². Depending on the season, some mobile markets were found with no sold mushrooms although informers testified them being intermittently sold during rain seasons. In the mobile markets of Ilula in Iringa, Rwamgasa Geita and Newala Mtwara in fact, mushroom selling was completely not observed and even the renowned indigenous mushroom sellers were not present.

Table 6: FIC for studied 28 medicinal mushrooms

Ailment category	Nur	Nt	FIC
Circulatory system	39	3	0.95
Dermatological system	18	4	0.82
Digestive system	135	16	0.89
General disorders	123	7	0.95
Genitourinary system	19	4	0.83
Gynecological system	25	5	0.83
Hormonal system	25	5	0.83
Respiratory system	113	8	0.94
Average			0.87

Nur: Number of use citations in each category, Nt: Number of species reported in each category

Biodata and gender patterns in relation to edible and medicinal mushroom market dynamics:

Throughout the mushroom market survey, it was interesting to note that women comprised the majority of the sellers up to 90% especially in the category of mushroom gathering from forests and formal and informal vendors. This trend has been also noted in other studies showing women dominating in Mushroom value chains. For example Tibuhwa⁴³ found that mushroom gathering is gender oriented, dominated by women (76.25%) in Tanzania, while Ruan-Soto *et al.*⁴⁰ noted

Table 7: Types of mushroom vendors of edible and medicinal mushrooms and their role in the studied traditional markets

Vendors	Played role
Rural harvesters and seller	Individuals who come from the rural areas surrounding the forest with vast knowledge in folk taxonomy and clearly demarcate edible mushrooms from inedible, bringing fresh mushrooms they collect in natural environment and/or their farms. They always trade them in large quantities
Small retailers	Individuals who come from rural areas surrounding the forest, bringing and selling fresh mushroom they gather. They occasionally go to nearby towns and cities to trade mushrooms to the customers and/or to formal vendors in small quantities at open markets
Formal vendors	Individuals who legally hold an operating license from the local government authorities to rent a stall in the established market for trading agricultural products such as legumes, fruits, vegetables, bunches of dry or fresh medicinal plants and fresh and dry mushrooms
Informal vendors	These are on foot market vendors. They usually come from rural areas and are resellers of fresh edible and medicinal mushrooms in small quantities at established and/or open markets or along the roadsides
Traditional healers	Individual who usually diagnoses common illnesses, selling and dispense remedies for medical complaints and divining the cause and providing solutions to spiritually or socially centered complaints mainly using medicinal plants and mushrooms
Prominent customer/consumer	Individuals who are in fond of mushrooms, usually buy them from local markets and are well equipped with folk taxonomies of the type of mushroom they buy



Fig. 3(a-g): Medicinal and edible mushrooms sold in different traditional markets in Tanzania

Photo plates: a, e and f source from Tibuhwa⁴³. The rest taken by the author during this study

that women represented 81.82% of mushroom sellers in his study done in Mexico. Interestingly, the traditional healer category was dominated by male (represented by 90%) while those who collect for home consumption were almost gender balanced (represented by 50% each) but was skewed toward old age and children who usually accompany their grandparents in the field for mushroom hunting. Other reports showing the predominance of women in mushroom gathering and selling are reported in Nigeria and the Brazilian Amazon⁴⁴⁻⁴⁵. In this study, the majority of the observed men engaged in mushroom gathering and selling were occasional except for traditional healers found in established markets with permanent desks/tables where they sell their medicinal

mushrooms together with other medicinal plants. The dominance of males in the traditional healer category may be attributed to the fact that traditional healers usually refuse to share their knowledge, because of cultural implications⁹. The knowledge is usually passed by a father to one of the selected son, the one liked most, described as one with good character and shows interest whilst young in his father's work.

Knowledge conservation, marketing and value added products:

The study results reveal an erosion of indigenous folk medical knowledge with 95% of the interviewed traditional health practitioners being old. It was interesting to note that all traditional health practitioners interviewed in this



Fig. 4(a-d): Rural mushroom vendors holding different *Termitomyces* species along the road sides in Mara region for sell and for a meal

Photo plates: b, source from Tibuhwa²¹. The rest taken by the author during this study

study were old above 65 years. Based on the general life expectancy in Tanzania given by the World Bank, Macroeconomics and Fiscal Management Global Practice and Poverty Global Practice⁴⁶, this is a generically a near dying age, while the expected youths to inherit the practice showed no interest or shy away from the practices although they confessed to often use it. This tremendous loss of indigenous knowledge has also been noted in other studies including^{47,48}. Likewise the study done in Ecuador by Tinitana *et al.*² also established large gaps between knowledge on medicinal plants trades. Unfortunately, this traditional medical knowledge is so diverse, varying from one community to another and deeply rooted in a specific socio-cultural context of the respective community. Due to its pluralistic nature, general cultural dependence and traditional inheritance across generations set up, it is important to document this knowledge for future generation references and possible uses.

More studies should focus on folk knowledge inventories and establishment of the common medicinal species and how they are related to local health ailments as well as their resources and products.

CONCLUSION

In this study, 128 mushroom species were reported to be edible and 28 species used by different ethnic groups in the treatment of eight different categories of human ailments. Four medicinal mushrooms possessed high Fidelity level values (FL) which were also associated with the obtained high values on the agreement among vendors about the therapeutic uses of these medicinal mushrooms (FIC). These high values call for further pharmacological and phytochemical studies on these medicinal mushrooms into possible drug development.

SIGNIFICANCE STATEMENT

This study established four medicinal mushrooms with high reliability for specific statement of evidence regarding therapeutic agreement amongst people who uses them portrayed by high values of Factor of Informant Consensus (FIC). This together with the established high Fidelity level values for the same mushrooms strongly support the need for further pharmacological and phytochemical studies for possible drug development.

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