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Domestication of Wild Edible Mushrooms in Eastern Africa: A Review of Research Advances and Future Prospects

Susan Njuguini KABACIA[1*], Mary Nyawira MUCHANE[2]

**Corresponding author:* *susannjuguini@gmail.com*

[1] National Museums of Kenya, Nairobi, Kenya / *susannjuguini@gmail.com*

[2] Nairobi, Kenya / *mmurethi@yahoo.com*

Abstract: Mushroom farming is an emerging industry in Africa with great potential to improve livelihoods. However, the industry is still dominated by a few exotic varieties faced with challenges of regional adaptability. Also, information concerning their domestication status, challenges and future prospects is scattered and unclear. The purpose of this paper was to review and detail the diversity of mushrooms occurring in Eastern Africa (EA), reveal the wild edible/medicinal species (WEMs) that have already been domesticated, their domestication status, the nutritional composition status of the edible species and availability of their germplasm (mother cultures). To achieve this, a detailed review of published research articles, books and reports from EA was conducted. Data was collected from articles focusing on the diversity of WEMs, nutritional composition analysis and domestication methods and status. From the review, 306 WEMs are shown to have desirable characteristics for utilization as food /medicine, with Tanzania documenting the highest number (147) followed by Malawi (90). Among these, 82 species are edible ectomycorrhizal species with great potential to support the mushroom industry if sustainably harvested and managed. The rest are saprophytic fungi species. Only 14 species among the saprobe group have been tissue cultured, tested for spawn production and cultivation. 51 species have been analyzed for nutritional composition. However, none of these have been commercially introduced to cultivation and the availability of their germplasm for research and propagation purpose is uncertain. The result from this study clearly shows research on the domestication of WEMS in Africa is still in its infancy stages.

Key words: Cultivation, Distribution, Species, Substrates, Symbiosis

Doğu Afrika'da Yenilebilir Yabani Mantarların Kültüre Alınması: Araştırmadaki İlerlemeler ve Gelecekteki Beklentiler Üzerine Bir İnceleme

Öz: Mantar yetiştiriciliği, geçim kaynaklarını iyileştirme konusunda büyük potansiyele sahip, Afrika'da gelişmekte olan bir endüstridir. Bununla birlikte, sektöre hala bölgesel uyum sağlamada zorluklarla karşı karşıya kalan birkaç egzotik tür hakimdir. Ayrıca, mantarların kültüre alma durumları, karşılaştıkları zorluklar ve gelecek beklentileri ile ilgili bilgiler dağınık ve belirsizdir. Bu makalenin amacı, Doğu Afrika'da bulunan mantarların çeşitliliğini incelemek ve detaylandırmak, halihazırda kültüre alınmış olan yabani yenilebilir/tıbbi mantar türlerinin (WEM'ler), kültüre alma durumlarını, yenilebilir türlerin beslenme kompozisyon durumunu ve anaç kültürlerinin (germplazmlarının) mevcudiyetini ortaya çıkarmaktır. Bunu başarmak için, yayınlanan araştırma makaleleri, kitaplar ve Doğu Afrika raporlarının ayrıntılı bir incelemesi yapılmıştır. Veriler, yabani yenilebilir/tıbbi türlerin çeşitliliğine, besin bileşimi analizine ve kültüre alma yöntemlerine ve statüsüne odaklanan makalelerden toplanmıştır. Araştırmada 306 yabani yenilebilir/tıbbi türün gıda/ilaç olarak kullanım için arzu edilen özelliklere sahip olduğu gösterilmiştir, en yüksek sayıyı ortaya koyan Tanzanya (147) ve onu Malavi (90) takip etmektedir. Bunların arasında 82 tür, sürdürülebilir bir şekilde hasat edilir ve yönetilirse mantar endüstrisini destekleme potansiyeli yüksek, yenilebilir ektomikorizal türlerdir. Geri kalanı saprofitik mantar türleridir. Saprofitik grubundan sadece 14 türün doku kültürü yapılmış ve tohumluk misel üretimi ve yetiştirme için test edilmiştir. 51 tür besin bileşimi açısından analiz edilmiştir. Bununla birlikte, bunların hiçbiri ticari olarak kültüre alınmaya çalışılmamıştır ve anaç kültürlerin araştırılması ve çoğaltılması amacıyla mevcut durum belirsizdir. Bu çalışmadan elde edilen sonuç, Afrika'da yabani yenilebilir/tıbbi türlerin kültüre alınmasına ilişkin araştırmaların henüz başlangıç aşamasında olduğunu açıkça göstermektedir.

Anahtar kelimeler: Kültür mantarcılığı, Dağılım, Türler, Substratlar, Simbiyoz

Introduction

Wild edible mushrooms are valuable non-wood forest resources, cherished by many communities in the world (Boa, 2004; Dejene et al., 2017a; Degreef et al., 2016; Degreef et al., 2020; Ngom et al., 2022). In Africa, wild mushroom gathering and hunting is a common practice mostly among the rural populace, especially during the rainy season (Dejene et al., 2017b; Kashiki et al., 2021; Ngom et al., 2022), which is suitable fructification of fungi. They are the source of food, health promoting properties and economic value (Boa, 2004; Dejene et al., 2017a; Sande, 2019; Niazi and Ghafoor, 2021). Ethnomycological knowledge obtained from different parts of the world reveals the use of mushrooms in various ways including in traditional medicine (Atri and Chadha, 2018). In Tanzania for example, the wild mushroom collection is a socio-economic activity among the Hehe and Benna communities. It is estimated that the collectors earn approximately US $500 to 1000 for 750 - 1500 kg of mushrooms per season (Atri and Chadha, 2018). In other regions of Africa, wild edible mushrooms are collected to serve various nutritional needs, especially protein which in most cases is lacking or it is expensive (Atri and Chadha, 2018). Among the most cherished mushrooms in Africa are *Termitomycetes* which are preferred due to their unique taste, flavor and texture (Degreef et al., 2020). Despite the role mushrooms play to improve livelihoods and the well being of many communities in Africa, there is increasing unsustainable harvesting which raises concerns about their depletion from the wild which will consequently increase food insecurity among local communities in the near future (Waiganjo et al., 2008; Dejene et al., 2017a; Degreef et al., 2020). To protect the planet and its biodiversity while reducing food insecurity and maintaining peace and human prosperity in line with the 2015 Sustainable Development Goals (SDGs), local mushroom cultivation and expansion of the mushroom industry have been proposed as a viable way of sustaining mushroom supply and protecting WEMs in nature (Niazi and Ghafoor, 2021).

Mushroom cultivation has increased tremendously in many parts of the world. It is carried out in more than 100 countries with a growth rate of 6-7% annual production (Niazi and Ghafoor, 2021). China leads with over 80% in the production of edible and medicinal mushrooms. The mushroom industry is the second largest in China and has created over 25 million job opportunities (Willis, 2018). However, mushroom cultivation is low in Africa and the region contributes less than 1% of the annual worldwide production of mushrooms (Adejumo and Awosanya, 2005; Onyango et al., 2011; Dejene et al., 2017a). This is majorly attributed to over-reliance on wild harvesting and low uptake of mushroom cultivation when compared to the cultivation of other food crops such as maize and beans. Partly, it is dependent on imported exotic mushroom mother cultures which tend to be expensive and sometimes difficult to access making mushroom farming expensive and unattractive. In East Africa, only cultivated mushrooms of exotic origin (*Agaricus, Pleurotus, Lentinula* and *Ganoderma* sp) cultured from imported mother cultures (Musieba et al., 2012) dominates the mushroom industry. These imported strains are associated with low yields and susceptibility to pests and diseases, the assumption being that the species lack regional adaptability (Otieno et al., 2015). Over the past years, there has been increased interest to exploit and domesticate wild edible and medicinal saprophytic mushrooms with desirable characteristics such as good regional adaptability, ability to grow on readily available substrates, low susceptibility to pests and diseases and good flavor for sustainable nutritional source in Eastern Africa (EA) (Mdachi et al., 2004; Magingo et al., 2004; Oriyo et al., 2004; Mshadete and Cuff, 2008; Mwita et al., 2010; Musieba et al., 2012; Juma et al., 2015; Wendiro, Wacoo and Wise, 2019).

Eastern Africa is a tropical region with 10 countries (Tanzania, Kenya, Uganda, Rwanda, Burundi, South Sudan, Djibouti, Eritrea, Ethiopia, and Somalia). The region is known for its unique forested ecosystems hosting valuable mycodiversity (Pegler and Rayner, 1969; Pegler, 1977; Boa, 2004). Although research on the diversity and taxonomy of mushroom resources in this region is increasing tremendously with new species being reported (Boa, 2004; Tibuhwa, 2011; Njuguini et al., 2018; Nteziryayo et al., 2019; Muchane et al., 2021;Ngom et al., 2022) information concerning domestication of these wild edible varieties is still scanty. Unlike many parts of the world where more than 100 species have been domesticated and 60% commercialized (Chang and Miles, 2004; Dejene et al., 2017a; Willis, 2018) in EA available information points only to the successful cultivation trials, but reports of adopted species by farmers for cultivation is lacking (Magingo et al., 2004, Mshadete and Cuff, 2008, Musieba et al., 2012, Juma et al., 2015). Additionally, the diversity of WEMs in EA is also poorly investigated. The potential of WEMs contribution to the mushroom industry remains less known and explored, with information concerning their domestication status, challenges and future prospects still scattered and not clear. There is still no clear distinction between edible and medical mushrooms.

Domestication of WEMs in EA provides a great opportunity of producing mushroom strains adapted to EA environmental and climate conditions as well as strains less susceptible to diseases. Since most of these WEMs are adapted to high temperatures and humid conditions, their production can be faster compared to exotic strains from temperate regions (Musieba et al., 2012). Optimization and simulation of growth conditions to match that of natural habitats is also possible since habitats and growth conditions of domesticated strains are known and accessible. Such information will enable spawn producers and mushroom farmers to use only strains ideal for conditions in the growing facility and use of right substrate. Domestication of WEMs will also increase the production of traditionally preferred and high-nutritional indigenous mushrooms. This will increase levels of mushroom farming adoption and production. This will also minimize losses, increase value for money, and lower the cost of production thus expanding the mushroom industry in EA. Although many of the common edible species have therapeutic properties and are used for medical purposes, information regarding their unique medicinal properties is also required for proper characterization.

The purpose of this paper is to review and detail the diversity of WEMs with special reference to EA, it's potential in the mushroom industry, domestication status, the nutritional value in comparison to introduced exotic species and availability of their germ-plasm (mother cultures).

Material and Metod

Literature was obtained through Internet-based scientific literature search engines (ISI web of Science, Research gate and Google scholar) and Libraries. Research materials that fulfilled the following criteria were selected; research materials and articles in eight selected countries focusing on the diversity of WEMs, nutritional composition analysis, articles detailing domestication, experimental methods and status. Data collected included; wild edible mushroom species (WEMs), nutrient content of WEMs, domesticated mushroom species, status of domestication (tissue culture, spawn or cultivated). Methods & materials used during domestication, and the yield of cultivated mushrooms was considered. Data were extracted from the results section and appendices with the list of WEMs, tables of means, graphs, and figures. Graphs and tables were used to summarize WEMs species in different countries.

Results

Diversity of edible (medicinal) mushrooms

This study has revealed a diverse community of wild edible mushroom (WEMs) species in East Africa with a total of 306 species of WEMs distributed within the division *Basidiomycota* (82 genera within 39 families) and *Ascomycota* (4 genera within 2 Phylum) (Table 1).

Table 1: list of wild edible / Medicinal mushrooms in East Africa Region

Species	Habitat association	Country	Reference
Afloboletus luteolus **(Heinem.) Pegler & T.W.K. Young**	**Ectomycorrhizal**	**Tanzania, Burundi, Malawi**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Afroboletus costatisporus **(Beeli) Watling.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
Afrocantharellus fistulosus **Tibuhwa & Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Afrocantharellus splendens **Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**

Afrocantharellus symoensii (Heinemann) Tibuhwa	Ectomycorrhizal	Tanzania	Tibuhwa, 2013
Agaricus campestris (L. ex Fr.)	Saprobe	Tanzania, Kenya, Somalia, Malawi , Ethiopia	Pegler, 1977; Rammeloo and Wallyne, 1993; Boa, 2004; Mdachi *et al*., 2004; Tibuhwa, 2011; Woldegiorgis, 2015;Dejene *et al*., 2017a; Dejene *et al*., 2017b ; Njugini *et al*., 2018
Agaricus campestroides (Heinem & Gooss. -Font	Saprobe	Ethiopia	Dejene *et al*., 2017b
Agaricus amboensis (Fayod) Sacc.	Saprobe	Somalia, Uganda	Boa, 2004
Agaricus arvensis Schaeff.	Saprobe	Ethiopia ,Tanzania, Uganda	Harkonen *et al*., 2003; Degreef *et al*., 2016; Dejene *et al*., 2017a; Dejene *et al*., 2017b; Ngom *et al*., 2022
Agaricus augustus Fr.	Saprobe	Kenya, Tanzania	Pegler, 1977; Tibuhwa, 2011; Njuguini *et al*., 2018
Agaricus bimbaumii (Corda)Singer	Saprobe	Tanzania	Tibuhwa, 2013
Agaricus bingensis Heinem.	Saprobe	Malawi, Uganda	Rammeloo and Wallyne 1993; Boa, 2004
Agaricus bisporus (Lange) Imbach	Saprobe	Tanzania, Ethiopia, Kenya, Malawi	Rammeloo and Wallyne, 1993; Tibuhwa, 2011; Tibuhwa, 2013; Woldegiorgis, 2015
Agaricus croceolutescens (Heinemann & Gooss.-Font)	Saprobe	Malawi	Rammeloo and Wallyne, 1993; Boa, 2004
Agaricus placomyces Perk.	Saprobe	Tanzania	Tibuhwa 2013
Agaricus silvaticus Schaeff.	Saprobe	Kenya	Pegler, 1977; Njuguini *et al*., 2018
Agaricus sp. L.: Fr. Emend. Karst	Saprobe	Tanzania, Uganda, Malawi	Nakalembe *et al*., 2009
Agaricus subedulis Heinem.	Saprobe	Ethiopia	Dejene *et al*., 2017a.
Agaricus sylvicola (Vitt.) Lév.	Saprobe	Rwanda	Degreef *et al*., 2016
Agaricus volvatulus Heinem. & Gooss.	Saprobe	Kenya	Tibuhwa 2011; Njuguini *et al*., 2018
Agrocybe pediades (Fr.) Fayod	Saprobe	Ethiopia	Dejene *et al*., 2017a
Amanita aff. calopus (Beeli)	Ectomycorrhizal	Malawi	Rammeloo and Wallyne, 1993; Boa, 2004
Amanita aurea (Beeli) E.J. Gilbert	Ectomycorrhizal	Tanzania	Harkonen *et al*., 2003
Amanita bingensis (Beeli) Heinem.	Ectomycorrhizal	Malawi	Rammeloo and Wallyne, 1993; Boa, 2004
Amanita cf. robusta (Beeli)	Ectomycorrhizal	Malawi	Rammeloo and Wallyne 1993
Amanita flammeola (Pegler & Piearce)	Ectomycorrhizal	Malawi	Rammeloo and Wallyne, 1993; Boa 2004
Amanita fulva (Schaeff) Fr.	Ectomycorrhizal	Malawi	Boa, 2004; Rammeloo and Wallyne, 1993
Amanita goossensiae (Beeli)	Ectomycorrhizal	Malawi	Boa, 2004; Rammeloo and Wallyne, 1993
Amanita hemibapha (Berk. & Br.)	Ectomycorrhizal	Malawi	Boa, 2004; Rammeloo and Wallyne 1993
Amanita loosii Beeli	Ectomycorrhizal	Burundi, Tanzania	Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016
Amanita mafingensis Härk. & Saarim.	Ectomycorrhizal	Burundi	Harkonen *et al*., 2003; Tibuhwa, 2013; Degreef *et al*., 2016

Amanita masasiensis **Hark. & Saarim.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003;Tibuhwa, 2013**
Amanita **Pers.**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995; Dejene *et al*., 2017a**
Amanita pudica **(Beeli) Walleyn**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Amanita rhodophylla **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Amanita robusta **(Beeli)**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
Amanita rubescens **(Pers.: Fr.)**	**Ectomycorrhizal**	**Burundi, Malawi**	**Rammeloo and Wallyne, 1993; Buyck and Nzigidahera, 1995; Boa, 2004; Degreef *et al*., 2016**
Amanita tanzanica **Hark. Saarim.**	**Ectomycorrhizal**	**Tanzania, Burundi**	**Harkonen *et al*., 2003; Tibuhwa, 2013; Degreef *et al*., 2016**
Amanita vaginata **(Bull.: Fr)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Amanita verna **(Bull.) Lam.**	**Ectomycorrhizal**	**Burundi**	**Nteziryayo, *et al*,. 2019**
Amanita zambiana **(Pegler & Pierce)**	**Ectomycorrhizal**	**Kenya, Malawi, Burundi**	**Rammeloo and Wallyne, 1993; Boa, 2004; Wandati *et al*., 2013; Nteziryayo *et al*., 2019**
Amylosporus **IJ-2014**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2016**
Armillaria borealis **Marxmüller & Korhonen**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Armillaria cepistipes **Velen.**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Armillaria heimii **Pegler**	**Saprobe**	**Tanzania, Rwanda, Ethiopia**	**Tibuhwa, 2013; Degreef *et al*., 2016; Dejene *et al*., 2017a**
Armillaria lutea **Gillet**	**Saprobe**		**Degreef *et al*., 2016**
Armillaria mellea **(Vahl) P. Kumm.**	**Saprobe**	**Kenya, Tanzania, Uganda**	**Pegler, 1977; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Njuguini *et al*., 2018**
Armillaria ostoyae **(Romagn.) Herink**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Armillaria tabescens **(Scop.) Emel**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Auricularia auricula - judae **(Bull.: Fr.) Wettst.**	**Saprobe**	**Kenya, Malawi, Rwanda, Uganda**	**Rammeloo and Wallyne, 1993; Boa, 2004; Onyango *et al.,* 2012; Degreef *et al*., 2016; Hussein *et al*., 2016; Njuguini *et al*., 2018**
Auricularia **Bull.ex Juss**	**Saprobe**	**Ethiopia; Kenya**	**Wandati *et al*., 2014; Dejene *et al*., 2017; Njuguini *et al*., 2018**
Auricularia cornea **Ehrenb.**	**Saprobe**	**Tanzania, Burundi, Rwanda**	**Tibuhwa *et al*., 2013; Degreef *et al*., 2016**
Auricularia delicata **(Mont. ex Fr.) Henn.**	**Saprobe**	**Kenya , Tanzania,Uganda Malawi**	**Rammeloo and Wallyne,1993; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2011; Tibuhwa, 2013; Degreef *et al*., 2016; Njuguini *et al*., 2018; Ngom , *et al*., 2022**
Auricularia fuscosuccinea **(Mont.) Henn.**	**Saprobe**	**Tanzania**	**Boa, 2004**
Auricularia polytrica **(Mont.) Sacc.**	**Saprobe**	**Tanzania, Kenya**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2011; Hussein *et al*., 2016; Njuguini *et al*., 2018;**
Bolbitius vitellinus **(Pers.:Fr.)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993**
Boletus clavipes **(Perk) Pilat & Dermek**	**Ectomycorrhizal**	**Tanzania**	**Mdachi *et al*., 2004**
Boletus loosii **Heinem.**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Boletus pallidissimus **Watling**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Boletus pruinatus/ xerocomellus	**Ectomycorrhizal**	**Tanzania**	**Mdachi *et al*., 2004**

pruinatus **Fr.& Hok Sutara**			
Boletus spectabilissimus **Watling**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa, 2013**
Buntarantara Buntarantara	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009**
Bunyabikandaigo	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2003**
Calvatia rubroflava **(Cragin) Lloyd**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Calvatia urtiliformis **(Bull.:Pers)**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993**
Cantharellus rufopunctatus **(Beeli) Heinem.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Cantharellus **Adans. ex Fr**	**Ectomycorrhizal**	**Malawi, Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Mdachi *et al*., 2004; Tibuhwa, 2013; Gateri *et al*., 2014;**
Cantharellus cibarius **Fr.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cantharellus cibarius var. defibulatus **Heinem.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Cantharellus congolensis **Beeli**	**Ectomycorrhizal**	**Burundi, Tanzania, Malwi**	**Rammeloo and Wallyne, 1993; Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016**
Cantharellus cyanescens **Buyck.**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995; Boa, 2004**
Cantharellus cyanoxanthus **R. Heim ex Heinem.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Tibuhwa, 2013; Degreef *et al*., 2016**
Cantharellus defibulatus **(Heinem.) Eyssart. & Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Cantharellus densifolius **Heinem.**	**Ectomycorrhizal**	**Burundi , Tanzania , Malawi**	**Rammeloo and Wallyne, 1993; Buyck and Nzigidahera 1995; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Cantharellus floridula **(Pegler) Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2004; Tibuhwa, 2013**
Cantharellus **Fr. var. *latifolius*** **Heinem.**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995**
Cantharellus isabellinus **Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013**
Cantharellus longisporus **Heinem.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cantharellus luteopunctatus **(Beeli) Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus miomboensis **Buyck & V. Hofst.**	**Ectomycorrhizal**		**Degreef *et al*., 2016**
Cantharellus parvisporus **(Eyssart. & Buyck)**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus platyphyllus **Heinem. var. cyanescens (Buyck) Eyssart. & Buyck**	**Ectomycorrhizal**	**Tanzania, Burundi**	**Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016**
Cantharellus pseudocibarius **Henn.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**

Cantharellus rhodophyllus **Heinem.**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus ruber **Heinem.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Cantharellus rufopunctatus **(Beeli) Heneim.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera, 1995; Tibuhwa, 2013**
Cantharellus splendens **Buyck**	**Ectomycorrhizal**	**Burundi**	**Buyck and Nzigidahera, 1995; Degreef *et al*., 2016**
Cantharellus subincarnatus **Eyssart. & Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Cantharellus symoensii **Heinem.**	**Ectomycorrhizal**	**Burundi , Tanzania**	**Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016**
Cantharellus tenuis **Heinem.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Cantharellus tomentosus **Eyssart. & Buyck**	**Ectomycorrhizal**	**Tanzania**	**Tibuhwa, 2013**
Clavaria albiramea **(Corner) Buyck & Duhem**	**Saprobe**	**Malawi**	**Boa, 2004**
Clavatia rubroflava **(Cragin) Lloyd**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Clavulina wisoli **R.H. Petersen**	**Saprobe**	**Tanzania**	**Harkonen *et al*., 2003**
Collybia aurea **(Beeli) Pegler**	**Saprobe**	**Burundi, Rwanda**	**Buyck and Nzigidahera 1995; Degreef *et al*., 2016**
Collybia confluens **(Pers) Kumm.**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Collybia dryophila **(Bull.) Kumm.**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Coprinellus domesticus **(Bolton)Vilgalys, Hopple & Jacq. Johnson**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Coprinellus niveus **Fr.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Coprinus cf. molestus **Bouriquet**	**Saprobe**	**Burundi**	**Buyck and Nzigidahera, 1995**
Coprinus cinereus **(Schaeff.)**	**Saprobe**	**Tanzania**	**Harkonen *et al*. 2003; Boa, 2004, Mshandete and Cuff 2007 and 2008, Raymond *et al*., 2012**
Coprinus comatus **(O.F Murill.) Pers**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Tibuhwa, 2013**
Coprinus disseminatus **(Pers.)J. E Lange**	**Saprobe**	**Tanzania, Malawi, Uganda , Kenya**	**Pegler, 1977; Boa, 2004; Tibuhwa, 2013; Njuguini *et al*. 2018**
Coprinus micaceus **(Bull.) Fr.**	**Saprobe**	**Kenya , Tanzania**	**Pegler 1977; Njuguini *et al*., 2018**
Coprinus **sp Pers.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Coprinus pseudoplicatilis **Voglina**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**

Coprinus sterquilinus (Fries) Fries	Saprobe	Kenya	Boa, 2004
Coprinopsis nivea (Pers.) Redhead, Vilgalays & Moncalvo	Saprobe	Ethiopia	Dejene *et al*., 2017
Cotylidia aurantiaca (Pat.) A.L. Welden	Saprobe	Burundi , Rwanda	Degreef *et al*., 2016
Craterellus Pers.	Ectomycorrhizal	Ethiopia	Dejene *et al*., 2017a
Cymatoderma dendriticum (Pers) D.A Raid	Saprobe	Malawi	Rammeloo and Wallyne, 1993; Boa, 2004
Cystodermella elegans (Beeli) Harmaja	Saprobe	Rwanda	Degreef *et al*., 2016
Dacryopinax spathularia (Schwein.) G.W. Martin	Saprobe	Rwanda	Degreef *et al*., 2016
Entoloma argypus P. Karst	Saprobe	Tanzania	Rammeloo and Wallyne, 1993; Boa, 2004
Favolus brasiliensis (Fr) Fr.	Saprobe	Malawi	Rammeloo and Wallyne, 1993
Ganoderma applanatum (Pers.) Pat.	Saprobe	Ethiopia, Uganda	Dejene *et al*., 2017b; Ngom *et al*., 2022
Ganoderma lucidum (Curtis) P. Karst	Saprobe	Tanzania	Mdachi *et al*., 2004
Ganoderma sp P. Karst sp	Saprophytic	Kenya	Njuguini *et al*., 2018
Gyroporus castaneus (Bull Quel.	Saprobe	Malawi	Rammeloo and Wallyne, 1993
Hygrophoropsis aurantiaca (Wurfen) Maire	Saprobe	Ethiopia	Dejene *et al*., 2017a
Hymenagaricus sp Heinem.	Saprobe	Ethiopia	Dejene *et al*., 2017a
Hypholoma fasciculare (Huds: Fr.) P.Kumm.	Saprobe	Burundi	Nteziryayo *et al*., 2019
Hypholoma subviride (Berk. & M.A. Curtis) Dennis	Saprobe		Boa, 2004; Degreef *et al*., 2016
Inonotus P.Karst.	Saprobe	Tanzania	Mdachi *et al*., 2004
Joga kadzonzo	Ectomycorrhizal	Kenya	Wandati *et al*., 2013
Joga muhama	Ectomycorrhizal	Kenya	Wandati *et al*., 2013
Kuehneromyces mutabilis Schaeff. Singer & A.H.Sm	Saprobe	Tanzania	Rammeloo and Wallyne, 1993; Boa, 2004
Lactarius aff. gymnocarpus R. Heim ex Singer	Ectomycorrhizal	Burundi	Buyck and Nzigidahera, 1995
Lactarius deliciosus (L.ex Fr.) Gray	Ectomycorrhizal	Malawi, Tanzania , Burundi	Rammeloo and Wallyne, 1993; Harkonen *et al*., 2003; Tibuhwa, 2013
Lactarius edulis (Verbeken & Buyck)	Ectomycorrhizal	Burundi , Tanzania	Buyck and Nzigidahera, 1995
Lactarius gymnocarpoides Verbeken	Ectomycorrhizal	Tanzania, Malawi	Harkonen *et al*., 2003; Boa, 2004

Lactarius Pers.	Ectomycorrhizal	Tanzania	Harkonen *et al*., 2003; Boa, 2004; Mdachi *et al*. 2004; Tibuhwa, 2013
Lactarius inversus (Gooss.-Font &r. Heim.) Verbeken	Ectomycorrhizal	Burundi	Buyck and Nzigidahera, 1995
Lactarius kabansus Pegler & Piearce	Ectomycorrhizal	Burundi , Tanzania	Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016; Nteziryayo *et al*., 2019
Lactarius luteolus Peck.	Ectomycorrhizal	Tanzania	Tibuhwa, 2013
Lactarius medusae Verbeken	Ectomycorrhizal	Tanzania	Harkonen *et al*., 2003; Tibuhwa, 2013
Lactarius pelliculatus (Beeli) Buyck.	Ectomycorrhizal	Tanzania	Boa, 2004
Lactarius phlebophyllus Heim.	Ectomycorrhizal	Tanzania	Boa, 2004
Lactarius piperatus L. Roussel	Ectomycorrhizal	Malawi	Boa, 2004
Lactarius pumilus Verbeken	Ectomycorrhizal	Tanzania	Harkonen *et al*., 2003; Tibuhwa, 2013
Lactarius rubroviolascens R. Heim.	Ectomycorrhizal	Tanzania	Boa, 2004
Lactarius tanzanicus Karhula & Verbeken	Ectomycorrhizal	Tanzania	Tibuhwa, 2013
Lactarius vellereus (Fr.) Fr.	Ectomycorrhizal	Malawi	Boa, 2004
Lactarius volemoides Kurhula	Ectomycorrhizal	Tanzania	Harkonen *et al*., 2003; Tibuhwa, 2013
Lactifluus densifolius Verbeken & Karhula	Ectomycorrhizal	Burundi	Degreef *et al*., 2016
Lactifluus edulis (Verbeken & Buyck) Buyck	Ectomycorrhizal	Burundi	Degreef *et al*., 2016
Lactifluus gymnocarpoides (Verbeken) Verbeken	Ectomycorrhizal	Burundi	Degreef *et al*., 2016
Lactifluus kigomaensis sp. nov. De Crop & Verbeken	Ectomycorrhizal	Tanzania	Decrop *et al*., 2012
Lactifluus longisporus (Verbeken) Verbeken	Ectomycorrhizal	Burundi	Degreef *et al*., 2016
Lactifluus luteopus Verbeken	Ectomycorrhizal	Burundi	Degreef *et al*., 2016
Laetioporus Murr. (IJ- 2014)	Saprobe	Tanzania	Juma *et al*., 2016
Laetioporus sulphureus (Bull.) Murill	Saprobe	Burundi , Ethiopia, Tanzania	Boa, 2004;Tibuhwa, 2011; Woldegiorgis *et al*., 2015; Dejene *et al*. 2017a; Nteziryayo *et al*., 2019
Langermannia gigantea (Batsch) Rostk.	Saprobe	Burundi	Boa, 2004
Lentinus cladopus (Lev.)	Saprobe	Malawi	Rammeloo and Wallyne, 1993; Boa, 2004; Degreef *et al.,* 2016
Lentinus edodes (Berk.) Pegler	Saprobe	Ethiopia	Woldegiorgis, 2015
Lentinus Fr.	Saprobe	Ethiopia	Dejene *et al*., 2017
Lentinus prolifer (Pat. & Har.) Pegler	Saprobe	Uganda	Boa, 2004

Lentinus sajor caju **(Fr.; Fr.)**	**Saprobe**	**Tanzania**	**Boa, 2004; Rammeloo and Wallyne, 1993; Hussein *et al*., 2015; Degreef *et al*., 2016**
Lentinus squarrosulus **Mont.**	**Saprobe**	**Tanzania**	**Rammeloo and Wallyne, 1993, Boa, 2004; Hussein, *et al*., 2015, Nteziryayo *et al*. 2019**
Lenzite elegance **(Spreng.) Pat.**	**Saprobe**	**Tanzania**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Lepista cafrorum **(Kalchbr. & Mc Owan)**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Lepista nuda **(Bull.) Cooke**	**Saprobe**	**Burundi**	**Boa, 2004**
Lepista sordida **(Schumach.) Singer**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Leucoagaricus holosericeus **(Gillet) M.M Moser**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Leucoagaricus leucothites **(Vittad.) Wasser**	**Saprobe**	**Tanzania**	**Boa, 2004; Dejene *et al*., 2017a**
Leucoagaricus rhodocephalus **(Berk.) Pegler**	**Saprobe**	**Tanzania**	**Boa, 2004**
Leucoagaricus rubrotinctus **(Peck.) Singer**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Leucocoprinus birnbaumii **(Corda) Singer**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Leucocoprinus cepistipes **(Sowerby) Pats.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Inocybe **(Fr.)Fr.**	**Saprobe**	**Malawi**	**Boa, 2004**
Lycoperdon **sp Pers.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Lycoperdon perlatum **Pers.**	**Saprobe**	**Burundi**	**Boa, 2004**
Macrocybe Lobayensis **(R. Heim) Pegler & Lodge**	**Saprobe**	**Malawi**	**Boa, 2004**
Macrolepiota aberderense **Mbaluto**	**Saprobe**	**Kenya**	**Mbaluto, 2015**
Macrolepiota dolichaula **(Berk. & Br.) Pegler & Rayner**	**Saprobe**	**Malawi, Kenya, Tanzania, Uganda , Ethiopia**	**Pegler, 1977; Rammeloo and Wallyne, 1993; Harkonen *et al*. 2003; Boa, 2004; Njuguini *et al*. 2018; Nteziryayo *et al*. 2019; Ngom *et al*., 2022**
Macrolepiota mastoidea **(Fr.) Singer**	**Saprobe**	**Kenya**	**Pegler, 1977**
Macrolepiota procera **(Scop.) Singer**	**Saprobe**	**Kenya, Tanzania , Ethiopia , Malawi, Uganda**	**Pegler, 1977; Rammeloo and Wallyne, 1993; Boa, 2004; Tibuhwa *et al*., 2011; Tibuhwa, 2013; Hussein et al., 2015; Dejene *et al*., 2017b; Njuguini *et al*., 2018; Ngom *et al*., 2022**
Macrolepiota rhacodes **(Vittad.) Singer**	**Saprobe**	**Burundi**	**Boa, 2004**
Macrolepiota **Singer**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a; Njuguini *et al*., 2018**
Malombo	**Saprobe**	**Kenya**	**Wandati *et al*., 2013**
Marasmiellus inoderma **(Berk.) Singer**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Marasmius arborescens **(Henn.) Beeli**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**

Marasmius bekolacongoli **Beeli**	**Saprobe**	**Burundi, Rwanda**	**Degreef *et al*., 2016**
Marasmius oreades **(Bolton) Fr.**	**Saprobe**	**Burundi**	**Boa, 2004**
Micropsalliota brunneosperma **(Singer) Pegler**	**Saprobe**	**Malawi**	**Boa, 2004**
Morchella elata **Fr.**	**Saprobe**	**Burundi**	**Boa, 2004**
Morchella esculenta **Fr.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2016**
Mycoamaranthus congolensis **(Dissing & M. Lange) Castellano & Walleyn**	**Ectomycorrhizal**		**Degreef *et al*., 2016**
Pholiota nameko **(T.Ito) S. Ito & S. Imai**	**Saprobe**	**Ethiopia**	**Gizaw, 2017**
Obulando	**Saprobe**	**Kenya**	**Wandati *et al* ., 2013**
Obumpokompoko	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009.**
Obutoosa	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009**
Olando	**Saprobe**	**Kenya**	**Wandati *et al*., 2014**
Oudemansiella tanzanica **nom. prov. Magingo**	**Saprobe**	**Tanzania**	**Magingo *et al*., 2004**
Panus conchatus **(Bull.) Fr.**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2015**
Parmelia sulcata **Taylor**	**Saprobe**	**Burundi**	**Boa, 2004**
Paxillus brunneotomentosus **Heinem. & Rammeloo**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Perenniporia mundula **(Wakef) Ryvarden**	**Saprobe**	**Malawi**	**Boa, 2004**
Phlebopus colossus **(R.Heim) Singer**	**Saprobe**	**Burundi, Malawi**	**Boa, 2004; Degreef *et al*., 2016**
Pholiota **sp (Fr.) P Kumm.**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Plebopus sudanicus **(Har. & Pat.)**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Pleurocybella porrigens **(Pers.) Singer**	**Saprobe**	**Burundi**	**Boa, 2004**
Pleurotus (HK-37)	**Saprobe**	**Tanzania**	**Raymond *et al*., 2013**
Pleurotus **(Jack. Ex. (Fr.) P. Kumm.**	**Saprobe**	**Uganda, Kenya,**	**Nakalembe *et al*., 2009; Gateri *et al*., 2014**
Pleurotus aff. cystidiosus **O.K. Mill.**	**Saprobe**	**Burundi**	**Buyck and Nzigidahera, 1995**
Pleurotus citrinopileatus **Singer**	**Saprobe**	**Kenya**	**Musieba *et al*., 2011; Musieba *et al*., 2012; Okoth 2013; Nteziryayo *et al*., 2019**
Pleurotus contrarius **Sacc.**	**Saprobe**	**Tanzania**	**Pegler, 1977**
Pleurotus cystidiosus **O.K. Mill.**	**Saprobe**	**Burundi, Rwanda, Tanzania**	**Huseein *et al*., 2016; Degreef *et al*., 2016**
Pleurotus djamor **(Rumph. ex Fr.) Boedijn**	**Saprobe**	**Tanzania, Kenya, Uganda, Rwanda**	**Boa, 2004; Harkonen *et al*., 2003; Tibuhwa, 2013; Nakalembe *et al*., 2015; Degreef *et al*., 2016; Njuguini *et al*., 2018;**

Pleurotus eryngii **(D C.) Quel.**	**Saprobe**	**Tanzania**	**Tibuhwa, 2011and 2013**
Pleurotus flabellatus **Sacc.**	**Saprobe**	**Tanzania, Kenya , Rwanda**	**Pegler, 1977; Mshandete and Cuff, 2008; Degreef *et al*., 2016**
Pleurotus florida **(Mont.).0 (Singer**	**Saprobe**	**Kenya**	**Wandati *et al*., 2014**
Pleurotus lignatilis **(Pers. Ex Fr.) Kummer**	**Saprobe**	**Uganda**	**Pegler, 1977**
Pleurotus limpidus **(Fr.) Sacc.**	**Saprobe**	**Tanzania**	**Pegler, 1977**
Pleurotus luteoalbus **Beeli**	**Saprobe**	**Kenya**	**Pegler, 1977**
Pleurotus opuntiae **(Durieu & Lev.) Sacc.**	**Saprobe**	**Kenya**	**Pegler, 1977**
Pleurotus ostreatus **(Jacq. ex Fr.) Kumm.**	**Saprobe**	**Burundi, Ethiopia, Tanzania , Uganda**	**Pegler, 1977; Woldegiorgis, 2015; Ngom *et al*., 2022**
Pleurotus sajor- caju **(Fr.) Sing.**	**Saprobe**	**Tanzania**	**Harkonen *et al*., 2003; Mdachi *et al*. 2004; Tibuhwa, 2011; Tibuhwa, 2013**
Pleurotus sapidus **(Quel.)**	**Saprobe**	**Kenya**	**Musieba, 2013; Otieno *et al*., 2015**
Pleurotus tuber-regium **(Rump. Ex Fr.) Singer**	**Saprobe**	**Burundi, Malawi, Tanzania**	**Rammeloo and Wallyne 1993; Boa, 2004; Harkonen *et al*., 2003; Tibuhwa, 2011 and 2013; Degreef *et al*., 2016**
Pluteus umborosus **(Pers.) P. Kumm.**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2016**
Polyozellus multiplex **(Underw.) Murill**	**Saprobe**	**Burundi**	**Boa, 2004**
Polyporales **Gaum.**	**Saprobe**	**Tanzania**	**Hussein *et al*., 2016**
Polyporus **P.Micheli ex Adans**	**Saprobe**	**Uganda, Tanzania, Ethiopia,**	**Nakalembe *et al*., 2015; Harkonen *et al*., 2003; Tibuhwa 2013., Dejene *et al*. 2017b;**
Polyporus brasiliensis **Speg.**	**Saprobe**	**Malawi**	**Boa, 2004**
Polyporus cinnabarinus **(Jacq.) Fr.**	**Saprobe**	**Burundi**	**Nteziryayo *et al*., 2019**
Polyporus moluccensis **(Mont.) Ryvaden**	**Saprobe**	**Malawi, Tanzania**	**Boa 2004**
Polyporus tenuiculus **(P. Beauv.) Fr.**	**Saprobe**	**Kenya , Rwanda, Tanzania,Uganda,**	**Nakalembe *et al*., 2009; Tibuhwa, 2013; Hussein *et al*., 2016; Njuguini *et al*., 2018; Ngom *et al*., 2022**
Psathyrella atroumbonata **Pegler**	**Saprobe**	**Rwanda, Malawi,**	**Boa 2004; Rammeloo and Wallyne, 1993; Degreef *et al*., 2016**
Psathyrella candolleana **(Fr.) Maire**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**
Psathyrella tuberculata **(Path.) A.H. Sm.**	**Saprobe**	**Rwanda**	**Degreef *et al*., 2016**
Ptychoverpa bohemica **(Krombh) J. Schrot.**	**Saprobe**	**Burundi**	**Boa, 2004**
Pulveroboletus aberrans **(Heinemann &Goos.-Font)**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne,1993**
Pulveroboletus **Spec.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993**
Pycoporus sanguineus **(L.;Fr.)**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**

Rubinoboletus balloui **(Peck) Heinem. & Rammeloo**	**Ectomycorrhizal**		**Degreef *et al*., 2016**
Rubinoboletus luteopurpureus **(Beeli) Hein. & Rammeloo**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa, 2004**
Russula **Pers.**	**Ectomycorrhizal**	**Ethiopia**	**Gateri *et al*., 2014; Dejene, *et al*.2017**
Russula afronigricans **Buyck**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004**
Russula alboflocossa **Buyck.**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et* al., 2003**
Russula atropurpurea **(Krombh.) Britelm.**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne 1993**
Russula congoana **Pat.**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2013; Degreef, *et al*., 2016**
Russula cyanoxantha **(Schaeff.) Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Russula delica **Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Russula hiemisilvae **Buyck**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Harkonen *et al*., 2003; Mdachi *et al*., 2003; Boa, 2004; Degreef, *et al*., 2016**
Russula liberiensis **Singer**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
Russula ochroleuca **(Pers.)Fr.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Russula phaeocephala **Buyck**	**Ectomycorrhizal**	**Burundi , Tanzania**	**Buyck and Nzigidahera 1995; Boa, 2004; Degreef *et al*., 2016**
Russula rosea **Pers.**	**Ectomycorrhizal**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Russula roseoviolacea **Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Russula schizoderma **Pat**	**Ectomycorrhizal**	**Malawi**	**Rammeloo and Wallyne, 1993; Boa 2004**
Russula sejuncta **Buyck**	**Ectomycorrhizal**	**Burundi**	**Degreef *et al*., 2016**
Russula sublaevis **(Buyck) Buyck**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
Russula tanzaniae **Buyck.**	**Ectomycorrhizal**	**Tanzania**	**Boa, 2004**
Russula xerampelina **(Schaeff.) Fr.**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Rusulla cellulata **Buyck**	**Ectomycorrhizal**	**Burundi, Tanzania**	**Buyck and Nzigidahera 1995, Harkonen *et al*., 2003, Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016**
Rusulla ciliata **Buyck**	**Ectomycorrhizal**	**Tanzania**	**Harkonen *et al*., 2003; Tibuhwa 2013**
Rusulla compressa **Buyck**	**Ectomycorrhizal**	**Tanzania, Kenya**	**Harkonen *et al*., 2003; Boa, 2004:; Tibuhwa, 2013; Wandati *et al*., 2013**
Schizophyllum commune **Fr.**	**Saprobe**	**Malawi, Kenya , Tanzania, Ethiopia, Burundi**	**Pegler, 1977; Rammeloo and Wallyne 1993; Harkonen *et al*., 2003; Boa, 2004; Degreef *et al*., 2016; Dejene *et al*., 2017a; Muchane *et al.,* 2021**
Sparassis crispa **(Wulfen)Fr.**	**Saprobe**	**Burundi**	**Boa, 2004**
Stereopsis hiscens **(Berk. & Rav.) D. A Reid**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Stropharia rugusoannulata **Farlow ex Murill**	**Saprobe**	**Kenya**	**Njuguini *et al*., 2018**

Suillus cavipes (Opat.) A.H.Sm. & Thiers	Ectomycorrhizal	Burundi	Boa, 2004
Suillus granulatus (L.) Roussel	Ectomycorrhizal	Tanzania , Kenya, Malawi	Rammeloo & Wallyne 1993, Harkonen *et al*., 2003; Boa 2004; Tibuhwa 2013, Degreef *et al*., 2016, Njuguini et al., 2018; Muchane *et al.,* 2021
Suillus luteus (L.) Roussel	Ectomycorrhizal	Burundi , Ethiopia , Tazania , Kenya , Malawi	Buyck and Nzigidahera, 1995; Mdachi *et al*., 2003; Boa, 2004; Degreef *et al*., 2016; Dejene *et al*., 2017a; Njuguini *et al*., 2018
Termitomyces (Beeli) R. Heim	Termitophilic	Burundi	Buyck and Nzigidahera, 1995; Harkonen *et al*., 2003; Nakalembe *et al*., 2009; Gateri *et al*., 2014; Wandati, 2014; Woldegiorgis *et al*., 2015
Termitomyces (Oruka-stipe)	Termitophilic	Kenya	Wandati *et al.,* 2014
Termitomyces aurantiacus (Heim)	Termitophilic	Uganda, Tanzania, Ethiopia, Kenya, Malawi	Rammeloo and Wallyne, 1993; Buyck, 1995; Harkonen *et al*., 2003; Boa, 2004; Nakalembe *et al*., 2009; Tibuhwa, 2012 ; Tibuhwa, 2013; Dejene *et al*. 2017; Woldegiorgis *et al*., 2015
Termitomyces clypeatus Heim	Termitophilic	Kenya, Uganda, Tanzania, Ethiopia, Malawi	Pegler, 1977; Rammeloo and Wallyne 1993; Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2011, Tibuhwa, 2012; Tibuhwa, 2013; Nakalembe and Kabasa, 2009; Ashagriel *et al*., 2014; Woldegiorgis *et al*., 2015; Dejene *et al*., 2017b; Ngom *et al*., 2022
Termitomyces eurhizus (Berk.) Heim	Termitophilic	Kenya, Ethiopia, Tanzania, Uganda, Malawi	Pegler, 1977; Harkonen *et al*., 2003; Boa, 2004; Nakalembe *et al*., 2009, Dejene *et al*., 2017b
Termitomyces globulus R. Heim & Gooss.- Font	Termitophilic	Kenya, Uganda	Pegler, 1977; Nakalembe *et al*., 2009
Termitomyces le-testui (Pat.) Heim	Termitophilic	Tanzania, Burundi, Ethiopia, Kenya, Uganda 2004	Pegler, 1977;Harkonen *et al*., 2003; Boa, 2004; Tibuhwa, 2012; Ashagriel *et al*., 2014; Woldegiorgis *et al*., 2015; Degreef *et al*., 2016; Dejene *et al*., 2017a
Termitomyces mammiformis R. Heim	Termitophilic	Burundi, Tanzania	Pegler, 1977, Tibuhwa, 2012; Tibuhwa, 2013, Degreef *et al*., 2016
Termitomyces microcarpus (Berk. & Broome) R. Heim	Termitophilic	Tanzania, Ethiopia, Uganda, Kenya, Burundi, Rwanda; Uganda	Pegler, 1977;Rammeloo and Wallyne 1993; Harkonen., *et al*., 2003; Boa 2004; Nakalembe and Kabasa 2009; Olila *et al*., 2007; Tibuhwa, 2012; Tibuhwa, 2013; Woldegiorgis *et al*., 2015; Degreef *et al*., 2016 ; Dejene *et al*., 2017a ; Muchane *et al*., 2021; Ngom *et al*., 2022
Termitomyces robustus (Beeli) R. Heim	Termitophilic	Burundi, Rwanda, Tanzania, Ethiopia, Uganda, Malawi	Pegler 1977; Rammeloo and Wallyne 1993; Boa, 2004; Tibuhwa, 2013; Degreef *et al*., 2016; Dejene *et al*., 2017a; Ngom *et al*., 2022
Termitomyces saggitiformis (Kalchbr. & Cooke) D. A Reid	Termitophilic	Tanzania	Tibuhwa, 2012; Tibuhwa, 2013
Termitomyces singidensis Saarim & Hark.	Termitophilic	Tanzania	Harkonen *et al*., 2003; Boa, 2004;Tibuhwa, 2013
Termitomyces sp (Joga utuwe)	Termitophilic	Kenya	Wandati *et al*., 2013
Termitomyces sp (Mariondonik)	Termitophilic	Kenya	Wandati *et al*., 2013
Termitomyces striatus (Beeli) R. Heim	Termitophilic	Malawi, Burundi, Tanzania, Kenya, Uganda	Pegler, 1977; Rammeloo and Wallyne, 1993; Buyck and Nzigidahera, 1995 ; Boa, 2004; Tibuhwa 2013;Degreef *et al*., 2016
Termitomyces titanicus Pegler & Piearce	Termitophilic	Burundi, Malawi	Boa, 2004; Tibuhwa, 2012; Degreef *et al*., 2016
Termitomyces tylerianus Otieno	Termitophilic	Uganda, Tanzania, Kenya	Pegler, 1977; Rammello and Wallyne, 1993; Harkonen *et al.,* 2003; Nakalembe *et al*., 2009 ; Tibuhwa, 2013; Degreef *et al*., 2016
Termitomyces umkowaani (Cooke & Massee) D.A Reid	Termitophilic	Tanzania	Tibuhwa, 2011; 2012 & 2013; Muchane *et al*., 2021

Termitomycetes eurhizus **(Berk) Heim**	**Termitophilic**	**Tanzania**	**Tibuhwa, 2012**
Termitomycetes le-testui **(Pat.) R. Heim**	**Termitophilic**	**Ethiopia, Tanzania**	**Boa, 2004; Tibuhwa, 2013; Kabede, 2017**
Termitomycetes rabuori **Otieno**	**Termitophilic**	**Kenya**	**Pegler, 1977**
Termitomycetes schimperi **(Pat.) R. Heim**	**Termitophilic**	**Burundi, Rwanda, Tanzania, Ethiopia, Malawi**	**Rammeloo and Wallyne, 1993; Pegler, 1977; Boa, 2004; Kabede, 2017; Dejene *et al*., 2017a; Degreef *et al*., 2016**
Trametes polyzona **Pers.**	**Saprobe**	**Burundi**	**Nteziryayo *et al*., 2019**
Trametes suaveolens **(L.) Fries**	**Saprobe**	**Burundi**	**Boa, 2004**
Tremella fuciformis **Berk.**	**Saprobe**	**Tanzania, Uganda**	**Tibuhwa, 2013; Ngom *et al*., 2022**
Tricholoma caligatum **(Viv.) Ricken**	**Saprobe**	**Burundi**	**Boa, 2004**
Tricholoma lobayense **Heim**	**Saprobe**	**Malawi**	**Rammeloo and Wallyne, 1993**
Tricholoma magnivelare **(Peck) Redhead**	**Ectomycorrhizal**	**Burundi**	**Boa, 2004**
Tricholoma spectabilis **Peerally & Sutra**	**Saprobe**	**Burundi**	**Buyck *et al*., 1995**
Trogia infundibuliformis **Trogia; Fr.**	**Saprobe**	**Malawi**	**Boa, 2004**
Tubosaeta brunneosetosa **(Sing.) E. Horak**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne, 1993**
Tylopilus niger **(Heinem. & Gooss.-Font.) Wolfe**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Vascellum **F. Smarda**	**Saprobe**	**Ethiopia**	**Dejene *et al*., 2017a**
Vasellum pratense **(Pers.) Kreisel**	**Saprobe**	**Malawi**	**Boa, 2004; Rammeloo and Wallyne 1993**
Volvariella bobycina **(Scheaeff.) Singer**	**Saprobe**	**Malawi, Tanzania**	**Boa, 2004; Pegler, 1977; Rammeloo and Wallyne, 1993**
Volvariella speciosa **(Fr.: Fr.) Sing.**	**Saprobe**	**Uganda**	**Nakalembe *et al*., 2009**
Volvariella volvaceae **(Bull.;Fr.)Sing.**	**Saprobe**	**Tanzania, Malawi, Kenya, Uganda**	**Pegler,1977, Rammeloo and Wallyne, 1993, Mshandete and Cuff, 2008, Harkonen *et al*., 2003, Boa, 2004, Tibuhwa *et al*., 2011, Tibuhwa, 2013**
Xerocomus pallidosporus **Heinem.**	**Saprobe**	**Malawi**	**Boa, 2004**
Xerocomus soyeri **Heinem.**	**Saprobe**	**Malawi**	**Boa, 2004, Rammeloo and Wallyne, 1993**
Xerocomus subspinulosus **Heinem.**	**Saprobe**	**Burundi**	**Buyck *et al*., 1995, Degreef *et al*., 2016**
Xerula radicata **(Relhan: Fr.) Dorfelt**	**Saprobe**	**Malawi**	**Boa, 2004**

Distribution of the wild edible Mushrooms in different Phyla and families

In the division *Ascomycota*, the macrofungi species belonged to the class *Lecanormycetes* represented by 1 species *Parmelia sulcatan*Taylor from the *Parmeliaceae* family and class *Pezizomycetes* represented by 3 species (*Morchella elata* Fr. , *Morchella esculenta* Fr. and *Ptychoverpa bohemica* (Krombh) J. Schrot.) from

Morchellaceae family. In the division *Basidiomycota*, the macrofungi species belonged to the class *Agaricomycetes* represented by species from *Agaricales* (47%), Russulales (16%), Polyporales (10%), *Cantharellales* (10%) and *Boletales* (8%). Species from other orders (*Auriculariales*, *Dacrymycetales*, *Hymenochaetales*, Incertae sedis, *Stereopsidales*, *Thelephorales*, and *Tremellales*) had less than 2% presentation.

Overall, the *Russulaceae* family had the highest number of species (51 species), followed by *Agaricaceae* (41 species), *Cantharellaceae* (30 species), *Lyophyllaceae* (26 species), *Polyporaceae* (21 species), *Amanitaceae* (20 species), *Pleurotaceae* (20 species), *Boletaceae* (18 species) and *Tricholomataceae* (11 species). The other families had less than 10 species (Figure 1). One species from order *Polyporales* was only identified up to order level while 9 species were described by their local names.

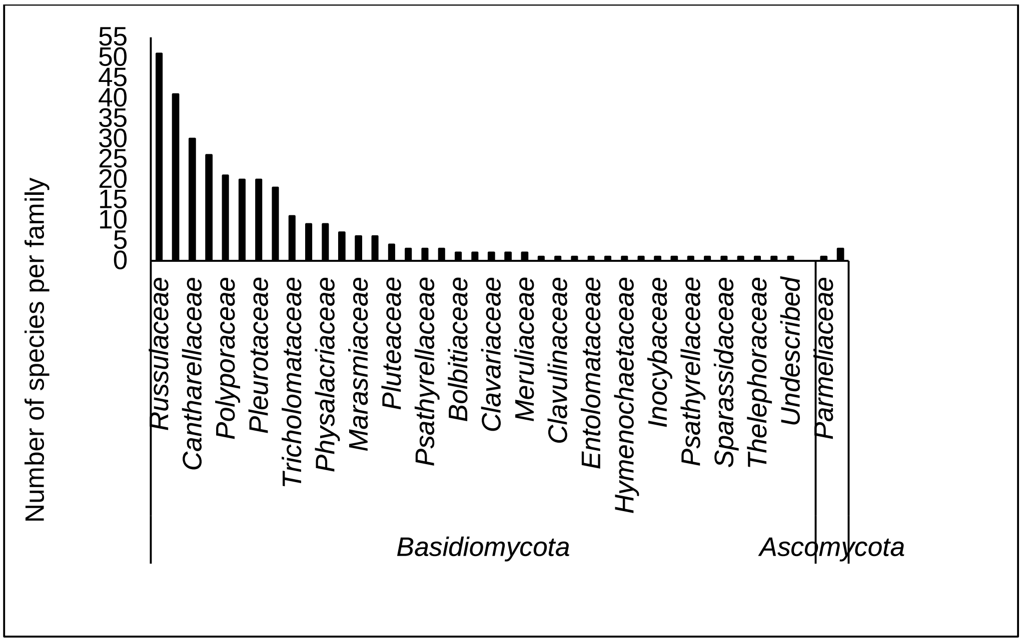

Figure 1: Distribution of WEMS into phyla and families

Distribution of Wild Edible Mushrooms in East African Countries

The WEMs occurred in all 8 East African countries namely Burundi, Kenya, Ethiopia, Somalia, Rwanda, Tanzania, Uganda and Malawi. Tanzania (143 species), Malawi (90 species) and Burundi (89) had the highest number while Somalia had the least with only 2 species (*Agaricus campestris* (L. ex Fr.), *Agaricus amboensis* (Fayod) Sacc.) from *Agaricaceae* family (Figure 2). The number of WEM species in other countries declined in order, Kenya (53 species), Ethiopia (46 species) Rwanda (28) and Uganda (28 species). WEMs communities in Tanzania, Malawi, and Burundi were dominated by ectomycorrhiza species while in other countries, the highest proportion of WEMs communities comprised saprophytic macrofungi species (Table 2).

Table 2: Wild edible / medicinal mushrooms species in East African countries

	Countries								
Families	Kenya	Uganda	Tanzania	Burundi	Rwanda	Malawi	Ethiopia	Somalia	Total
Agaricaceae	11	5	13	3	3	12	16	2	65
Amanitaceae	1	–	4	8		13	–	–	26
Auriculariaceae	4		4	1	2	2	1	–	14
Bolbitaceae	–	–	–	–	–	1	–	–	1
Boletaceae	–	–	5	4	1	7		–	17
Boletinellaceae	–	–		1		2		–	3
Bondarzewiaceae	–	–	1	–	–	–	–	–	1

Cantharellaceae	–	–	21	15		6	1	–	43
Clavuriaceae	–	–	–	–	–	1	–	–	1
Clavulinaceae	–	–	1	–	–	–	–	–	1
Dacrymycetaceae	–	–	–	–	1	–	–	–	1
Entolomataceae	–	–	1	–	–	–	–	–	1
Fomitopsidaceae	–	–	1	1	–	–	1	–	3
Ganodermataceae	1	–	1	–	–	–	1	–	3
Gyroporaceae	–	–	–	–	–	1	–	–	1
Hygrophoropsidiaceae	–	–	–	–	–	–	1	–	1
Hymenochaetaceae	–	–	1	–	–	–	–	–	1
Inocybaceae	–	–	–	–	–	1	–	–	1
Lyophyllaceae	12	10	15	9	3	7	10	–	66
Marasmiaceae	–	–	–	3	3	–		–	6
Meruliaceae	–	–	–	–	–	1		–	1
Morchellaceae	–	–	–	2	–	–	1	–	3
Parmeliaceae	–	–	–	1	–	–	–	–	1
Paxillaceae	–	–	–	1	–	–	–	–	1
Physalacriaceae	1	1	3	–	6	2	1	–	14
Pleurotaceae	9	3	10	4	3	1	1	–	31
Pluteaceae	1	2	2	–	–	2		–	7
Polyporaceae	2	3	8	3	1	7	3	–	27
Psathyrellaceae	–	–	–	–	1	2	3	–	6
Repetobasidiaceae	–	–	–	1	1	–	–	–	2
Russullaceae	1		32	19	–	12	1	–	65
Schizophyllaceae	1	–	1	1	–	1	1	–	5
Sparassidaceae	–	–	–	1	–	–	–	–	1
Stereopsidaceae	–	–	–	–	–	–	1	–	1
Strophariaceae	1	–	1	2	1		2	–	7
Suillaceae	2	–	2	2	–	2	1	–	9
Therephoraceae	–	–	–	1	–	–	–	–	1
Tremellaceae	–	–	1	–	–	–	–	–	1
Tricholomataceae	–	–	–	5	2	6		–	13
unidentified	4	4	–	–	–	–	–	–	9
Total	51	28	128	88	28	89	46	2	

Groups of Wild mushrooms in East Africa and substrate utilization

(a) Saprophytic WEMs

In East Africa, saprophytic WEMs diversity comprised 147 species (46% of total) within the division *Basidiomycota* (51 genera within 26 families) and *Ascomycota* (3 genera within 2 families) (Fig. 2). WEMs in *Ascomycota* belonged to the *Parmeliaceae* family (*Parmelia sulcate* Taylor) and *Morchellaceae* family (*Morchella elata* Fr., *Morchella esculenta* Fr. *Basidiomycota* division, *Agaricaceae* family (40 species) had the highest number of species, followed by *Polyporaceae* (21 species), *Pleurotaceae* (20 species), *Physalacriaceae* (9 species), *Tricholomataceae* (7 species), *Auriculariaceae* (7 species), *Marasmiaceae* (6 species), *Strophariaceae* (6 species) and *Psathyrellaceae* (4 species) families. The other families had less than 4 species (Fig. 2).

(b) Ectomycorrhizal WEMs

In Eastern Africa, ectomycorrhizal WEMs comprised 131 species (41% of the total) within the division *Basidiomycota* (23 genera within 12 families) (Fig. 4). *Russulaceae* family (51 species) had the highest number of species, followed by *Cantharellaceae* (30 species), *Amanitaceae* (19 species), *Boletaceae* (18 species) and *Suillaceae* (3 species). The other families had less than 2 species (Fig. 4). The highest documented ectomycorrhizal species belongs to the genus *Cantharellus* and *Russula* sp (26 species), followed by *Amanita* (20 species) and *Lactarius* (16 species) respectively (Table 1, Fig. 2).

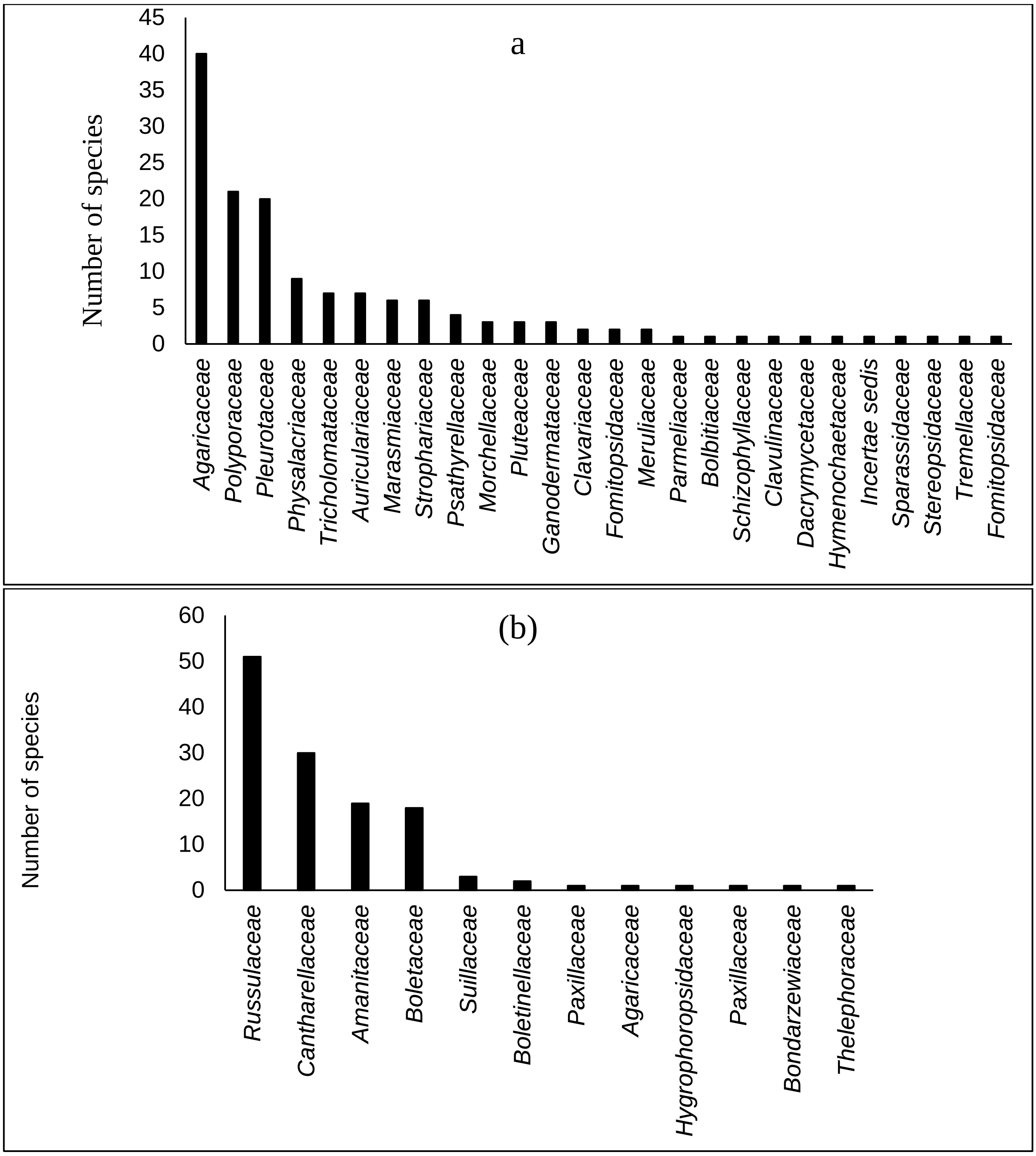

Figure 2: Number of Saprobe(a) and Ectomycorrhizal (b) wild edible mushroom species per family in Eastern Africa

(c) Termitophillic WEMs mushrooms

In East Africa, termitophillic species documented are 25 species (7.8% of the total). The species were reported in all the countries of East Africa with the exception of Somalia (Table 1).

Domestication Status of WEMs in East Africa

Domestication of wild edible mushrooms is gaining popularity in the East African region. Domestication is the process of bringing WEMs into cultivations. There are about 2000 WEMs in the world, but only around 30 species are in cultivation. In East Africa 14 saprophytic species (Amylosporus IJ-2014, *Coprinus cinereus* (Schaeff.) Gray, *Lentinus sajor caju* (Fr.; Fr.), *Lentinus squarrosus* Mont., *Hypholoma fasciculare* (Huds: Fr.) P.Kumm., *Nameko pholiota* (T.Ito) S. Ito & S. Imai, *Oudemansiella tanzanica* Magingo, *Pleurotus citrinopileatus* Singer, *Pleurotus flabellatus* Sacc., *Polyporales* sp Gaum., *Polyporus cinnabarinus*, Trametes polyzona Pers., Volvariella volvacea (Bull.;Fr.)Sing.) have been tissue cultured, and tested for spawn production and mushroom production under different growth conditions (Table 3). However, the cultivation of WEMs in this region is still in its early stages with only 24 species under experimental trials (Table 3).

The species *Auricularia polytrica* (Mont.) Sacc., *Laetioporus* sp Murr., *Polyporus tenuiculus* (P. Beauv.) Fr., *Pleurotus cystidiosus* O.K. Mill. and *Termitomyces* sp (Beeli) R. Heim. are still at spawn and tissue culture stages (Table 3). Auricularia auricula (Bull.: Fr.) did not fruit despite successful growth in spawn run and pinning stages (Table 3).

Process of cultivating wild edible mushrooms in East Africa

(a) Tissue culture and mycelia colonization rates of WEMs

The pure mycelial culture was established from fourteen mushroom species (Table 3). The main culture media used were Potato Dextrose Agar (PDA) and Malt Extract Agar (Malt) (Table 3). However, to culture *Pluteus umbrosus* (Pers.) P. Kumm., *Hypholoma fasciculare* (Huds: Fr.) P. Kumm., *Trametes polyzona* Pers., *Pleurotus citrinopileatus* Singer and *Lentinus squarrosus* Mont. AVOINE media was used (Table 3). SDYA media was also used for obtaining *Pholiota Nameko* mycelial culture (Table 3). The species were incubated upside down at 25-30 oC depending on the species' temperature requirements for 4 up to 48 days (Table 3). Pure cultures were subcultured for one to three months and cultures were stored at 4 °C to – 30 °C and some in liquid nitrogen at 196 °C..

Table 3: Domestication status of edible and medicinal Mushrooms in Eastern Africa

Species	**Tissue culture**			**Spawn production**		**Mushroom cultivation**					**References**
	Media	**Incubation**	**Sub strat e**	**Incubation**	**Incubation**	**Subst rate**	**Spawn**	**Pinning**	**Fruiting**	**Yield**	
				Temperature							
		Period			**period**		**run**				
		--days-		**°C**	**---days---**		**---------------days------------**			**-g/kg-**	
Coprinus cinereus	PDA	4	a	–	10	g	7 (12)	9 (15)	11 (17)	238	Mshandete and Cuff, 2008; Raymond *et al.*, 2013
Volvariella volvacea	PDA	5	a	–	12	g	9	11	13	114	Mshandete and Cuff, 2008
Pleurotus flabellatus	PDA	6	a	–	13	g	12	14	17	371	Mshandete and Cuff, 2008
Oudemansiella tanzanica	MALT	7	b	–	21	i, h, g	18 (19)	20 (21)	19 (22)	–	Magingo *et al* , 2004
Auricularia auricula	MALT	5 (7)	a, b	–	12	j, h, l, j	8 (14)	13 (23)	20 (35)	96-(266)	Onyango *et al* 2011
Pleurotus citrinopileatus	PDA, AVOINE	7 (10)	a, c	25	–	h, i, k, m, n, o, p, q, v, x	8 (21)	13 (28)	-	28.3 (397.7)	Nteziryayo et al., 2019
Pleurotus sp.2 (HK-37)	MALT	5 (7)	–	28	–	g	12 (14)	18 (43)	20 (46)	119.2	Raymond *et al* 2013)

Pleurotus cystidiosus	PDA	27	a	–	–	–	–	–	–	–	Juma *et* al., 2015
Pleurotus djamor	PDA	–	–	–	–	–	–	–	–	123 (238)	Nakalembe *et al*., 2015
Polyporales sp.	PDA	48	a	25	–	t	67		105	23.29	Juma *et al*., 2015
Polyporus tenuiculus	PDA	20	a	–	–	–	–	–	–	–	Juma *et al*., 2015
Laetioporus sp. IJ-2014	PDA	24	a	–	–	–	–	–	–	–	Juma *et al*., 2015
Lentinus squarrosus	AVOINE	–	a	25	–	u	25(27)	–	–	212.6	Nteziryayo *et al*., 2019
Amylospora sp. IJ-2014	PDA	23	a	25	–	t	31	–	43	15.5	Juma *et al*., 2015
Auricularia polytrica	PDA	27	a	–	–	–	–	–	–	–	Juma *et al*., 2015
Nameko pholiota	PDA, MALT & SDYA	18(28)	a,b,c ,d,e, f	–	–	–	60	–	–	55 (797)	Gizaw, 2015
Termitomyces microcarpus	PDA	10	b	–	3 (31)	i, u	–	–	–	–	Olila *et al*., 2007
Lentinus saju caju	PDA & MALT	4	a	25	10	n, v	24 (28)	49 (52)	1 (2)	52	Hussein *et al*., 2015
Panus conchatus	PDA & MALT	4	a	–	17	n, v	–	–	–	–	Hussein *et al*., 2016
Pluteus umbrosus	AVOINE	7	a	25	17	n, v	–	–	–	–	Hussein *et al*., 2016
Hypholoma fasciculare	AVOINE	–	a	25	–	u	24(26)	–	–	153.5	Nteziryayo *et al*., 2020
Trametes polyzona	AVOINE	–	a	25	–	u	28(30)	–	–	208.7	Nteziryayo *et al*., 2020
**Pleurotus ostreatus*	MEA	–	a	–	14	v, j, w, x, y	15(20)	20(29)	22(31)	803 (2170)	Tekeste *et al*., 2020
**Agaricus subrefescens*	–	–	f2	–	–	z	14(21)	7(29)	22(31)	684 (1428)	Thongklang *et al*., 2014

Key: Spawn substrate included (a) Sorghum grains, (b) Millet grains and (c) Wheat grains (d) Barley grain (e) rice (f) shredded maize (f2) Rye grain. Cultivation substrate included (g) Sisal waste (h) Rice straw, (i) Saw dust, (j) Sugarcane bagasse (k) Wheat straw, (l) Grass straw, (m) Maize cobs, (n) Banana leaves, (o) Ground nut, (p) Soya bean, (q) Coffee husk, (r) Coconut waste (s) Bean straw (t) Dried sugarcane tops (u) Cotton waste (v) Barley straw (w), Sasame stalks (x), Teff straw (y) Commercial compost. The values in parenthesis are maximum number of days taken or yield produced. The words in asterisks are for species commonly cultivated in the world.

(a) Spawn preparation

Spawn preparation started by obtaining good quality grains. Sorghum was the most used grain in spawn production in the EA region (Table 4). The grains were first soaked in water overnight followed by boiling for 10-20 min. Excess water was drained and 1-2% calcium carbonate (agricultural lime) was added and mixed thoroughly with the grains (Table 4). The grains were allowed to drain off excess water through a sieve or by spreading on a clean plastic sheet to air dry. Once drained, the grains were filled into 330-750 ml bottles up to ¾ of the jar, which are closed with lids and autoclaved for I hour at 121oC to kill the contaminants (Table 4). The bottles were allowed to cool and then inoculated aseptically with 2 pieces of 1cm culture of mushroom mycelia. The inoculated bottles were fitted with lids which were then shaken thoroughly by hand to spread the mycelia. The bottles were incubated at 25-28oC with caps loosely fitted in a well ventilated incubator for10 days- 21 days depending on the species (Table 3).

(a) Substrate preparation requirements and growth conditions for wild edible mushrooms

Different types of agricultural and industrial waste have proved potential in the cultivation of fourteen species of domesticated mushrooms in the EA region (Table 4). This is evident by the ability of the species to colonize the substrates and form fruitbodies. The preparation of substrates in this study employed two methods of substrate preparation which were compost and non-compost methods. The compost preparation method was used to cultivate *Coprinus cinereus* (Schaeff.), *Pleurotus flabellatus* (Sacc.) and *Volvariella volvaceae* (Bull.;Fr.) Sing. on sisal waste and manure. The outdoor compositing outdoor method took 21 days. For the non-composited substrates, the materials are first soaked in water in the ratio of 1:2 (substrate: water) overnight for 4 days (Table 4). Prepared substrates were subjected to sterilization and pasteurization at 100-121oC for 1-6 hours and pasteurization at 70oC for two hours. The sterilized bags are allowed to cool to prevent the mycelium from heat destruction. Thereafter, 1-6% (three-six teaspoonfuls) of spawn were inoculated into each bag of the substrate (Table 4). The bags were transferred to the incubation room with temperatures between 23-30°C and humidity ranging between 69-81%. The mycelial colonization progress was monitored daily until the bags were fully colonized (Table 4). Contaminated bags were removed once spotted and taken outside the incubation room for disposal. Once fully colonized the bags were transferred to the fruiting room with lower temperatures 18-30^{o}C and humidity 50-95% (Table 4).

Table 4: Mycelial run requirements for Wild Edible Mushrooms in East Africa (EA)

Species	**Culture**	**Media treatment**		**Incubation**		**Culture preservation**	**References**
	Source	**Reagent**	**Antibiotic**	**Temperature (^{0}C)**	**Days**		
Oudemansiella tanzanica	Tissue	-	-	25	7	-	Magingo *et al*., 2004
Pleurotus HK-37	Pure culture	Distilled water, 70% Ethanol	-	-	8	-	Raymond *et al*., 2013
Coprinus cinereus	Tissue	3% hydrogen peroxide, 70% ethanol	250mg/l ampicillin	28	4	Malt at 4 °C	Mshadete and Cuff, 2008
Pleurotus flabellatus	Tissue	-	250mg/l ampicillin	28	6	Malt at 4 °C	Mshadete and Cuff, 2008
Volvariella volvaceae	Tissue	-	250mg/l ampicillin	28	5	Malt at 30 °C	Mshadete and Cuff, 2008
Lentinus saju caju	Tissue	Distilled water, 70% ethanol, MEA	-	28	4	MEA at 4 °C & liquid nitrogen	Hussein *et al*., 2016
Lentinus squarrosus	Tissue	Distilled water, 70% Ethanol	1 capsule chloramphenical	25		-	Nteziryayo *et al*., 2019
Amylospora sp IJ -2014	Tissue	PDA		25	-	-	Juma *et al* ., 2015
Nameko pholiota	Pure culture	-	0.025g chloramphenicol/250	25	30	-	Gizaw, 2015
Hypholoma fasciculare	Tissue	Distilled water, 70% ethanol	-	25		AVOINE at 4 °C (monthly subculturing)	Nteziryayo *et al*., 2019
Trametes polyzona	Tissue	Distilled water, 70% ethanol	-	25		-	Nteziryayo *et al*., 2019
Pleurotus citrinopileatus	Tissue	Distilled water, & 70% ethanol	-	25		-	Musieba *et al*., 2012; Musieba *et al*., 2013, Nteziryayo *et al* ,2019
Auricularia auricula	-	-	-	-	-	-	Onyango *et al*., 2011

From the study, 47 edible species were analyzed for nutritional and medicinal benefits. Among the most commonly utilized species are the *Termitomycetes*, *Pleurotus* and *Ganoderma* species. Species belonging to *Termitomycetes* were the most (21%) analyzed in this study followed by *Pleurotus* species (12%) (Table 5)

Table 5: Nutritional status of wild edible mushrooms of East Africa

Species	Proximate Analysis	Mineral Content	Vitamins	Amino Acids	Anti-oxidants	Reference
Afrocantharellus splendens	-	-	-		+	Tibuhwa *et al*., 2014
Agaricus bisporus	+	+	+	+	+	Wandati *et al*., 2013
Agaricus campestris	-	+	-	-	+	Woldegiorgis *et al*., 2015
Agaricus sp	-	-	-	+	-	Mdachi *et al*., 2004
Amanita zambiana	+	+	-	-	+	Wandati *et al*., 2013
Auricularia judae	-	-	-		+	Hussein *et al*., 2015
Boletus clavipes	-	-	-	+	-	Mdachi *et al*., 2004
Boletus pruinatus	-	-	-	+	-	Mdachi *et al*., 2004
Cantharellus Rufopunctatus	-	-	-		+	Tibuhwa et al., 2014
Cantharellus	-	-	-	+	-	Mdachi *et al*., 2004
Ganoderma lucidum	-	-	-	+	-	Mdachi *et al*., 2004
Inonotus sp	-	-	-	+	-	Mdachi *et al*., 2004
Joga kadzonzo	+	+	-	-	+	Wandati, 2014
Joga muhama	+	+	-	-	+	Wandati, 2014
Lactarius sp	-	-	-	+	-	Mdachi *et al*., 2004
Lentinus edodes	-	+	-		+	Woldegiorgis *et al*., 2015
Lentinus sajor caju 1	-	-	-		+	Hussein *et al*., 2015
Lentinus sajor caju 2	-	-	-	-	+	Hussein *et al*., 2015
Lentinus squarrosulus	-	-	-	-	+	Hussein *et al*., 2015
Lentinus sulpureus	-	+	-	-	+	Woldegiorgis *et al*., 2015
Macrolepiota procera	-	-	-	-	+	Hussein *et al*., 2015
Malombo	+	+	-	-	+	Wandati *et al*., 2013
Auricularia sp	+	+	-	-	+	Wandati *et al*., 2013
Obulando	+	+	-	-	+	Wandati *et al*., 2013
Oando	+	+	+	+	+	Wandati *et al*., 2013
Panus cochatus	-	-	-	-	+	Hussein *et al*., 2015
Pleurotus caju	-	-	-	+	-	Woldegiorgis *et al*., 2015
Pleurotus florida	-	+	+	+	+	Wandati *et al*., 2013

Pleurotus ostreatus	-	-	-		+	Woldegiorgis *et al*., 2015
Pleurous tenuiculus	-	-	-		+	Hussein *et al*., 2015
Polyporus tenuiculus	+	+	+	+	-	Nakalembe, 2013;Nakalembe *et al*., 2015
Russula hiemisilvae	-	-	-	+	-	Woldegiorgis, *et al*., 2015
Rusulla compressa	+	+			+	Wandati, 2014
Suillus sp	-	-	-	+	-	Woldegiorgis *et al*., 2015
Termitomyces (oruka-stipe)	+	+	+	+	+	Wandati *et al*., 2013
Termitomyces aurantiacus	-	+	-	-	+	Woldegiorgis *et al*., 2015
Termitomyces clypeatus	-	+	-	-	+	Woldegiorgis *et al*., 2015
Termitomyces eurhizus	+	-	-	+	-	Nakalembe *et al*., 2013
Termitomyces globulus	+	-	-	+	-	Nakalembe *et al*., 2013
Termitomyces letestui	-	+	-	-	+	Woldegiorgis *et al*., 2015
Termitomyces microcarpus	-	+	+	-	+	Woldegiorgis *et al*., 2015; Nakalembe *et al*., 2015
Termitomyces tyleranus	-	+	+	-	-	Nakalembe *et al*., 2015
Termitomyces sp	-	+	-	-	-	Woldegiorgis *et al*., 2015
Termitomyces sp	+	+	+	+	+	Wandati *et al*., 2013
Termitomyces sp *(joga utuwe)*	+	+	-	-	+	Wandati *et al*., 2013
Termitomyces sp *(mariondonik)*	+	+	-	-	+	Wandati *et al*., 2013
Volvariella speciosa	-	+	+	-	-	Nakalembe *et al*., 2015

Key: analyzed (+), Not analyzed (-)

Discussions

The numbers of WEMs observed in this review corresponds to the number of identified and described wild edible mushroom species (300 species) reported in sub-Saharan Africa (Soro et al., 2019). This is a high number considering we have about 2000-2166 edible mushroom species which have been reported from all over the world (Rai et al., 2005; Nakalembe et al., 2015; Li et al., 2021). From the results, EA is endowed with a wide range of WEMs whose benefits can be applied to support mushroom industry as well as tree restoration programs, especially with tree species growing in association with ectomycorrhizal fungi.

There are over six thousand (6000) ECM fungi species mainly in division *Basidiomycota* and into lesser extent in division *Ascomycota* (Smith and Read, 2008). ECM fungi are characterized by presence of a fungal mantle that envelops host roots and a hartig net that surrounds root epidermal. In addition, the ECM fungi form soil-borne mycelia network important in uptake and translocation of nutrients and water to host tree species as well as movement of nutrients between individual tree hosts (Simard and Durall, 2004). These ECM fungi develop a dense mycelia network of about 200 m in a gram of dry soil. This mycelia network in soil is very important in the formation of soil aggregates, which in return facilitate carbon sequestrations in soil (Walland, 2006). ECM macrofungi are also the most expensive macrofungi, with a total market of billions of US dollars. The highly traded ECM species include *Tuber melanosporum*, *Tuber magnatum* (white truffle), *Tricholoma matsutake*, *Boletus edulis*, *Cantharellus* cibarius and *Amanita caesarea*. The majority of these species were from Miombo woodland and associated with Brachystegia, Julbernardia, Isoberlinia and Uapaca tree species known to symbiotically associate with ectomycorrhizal mushrooms species (Degreef et al., 2020). Miombo woodland makes up approximately 10% of the ecosystem in Kenya, Tanzania, Uganda and Burundi extending to DRC Congo, Malawi, Zimbabwe, Angola, Zambia and Mozambique explaining the high number of ectomycorrhiza mushroom species found in Tanzania, Burundi and Malawi (Degreef et al., 2020). The Ectomycorrhiza mushrooms form part of the most appreciated wild edible mushrooms (Kamalebo and De Kesel, 2020). All chanterelles are edible most and appreciated owing to large quantities harvested during the rainy seasons and the long shelf life. Apart from local consumption, the sale of the produce takes place in the markets and along the roads in many African countries (Degreef et al., 2016). Besides, *Amanita* comprises highly toxic species such as *Amanita phalloides* and *Amanita muscaria*, it's a genus with valuable members such as *Amanita losii* which has been proposed as the most productive (Degreef et al., 2020). The high number of *Russula* species could be attributed to its associations with different tree hosts. Other ectomycorrhiza species were documented in exotic plantation forests such as *Pinus*, *Cypress* and *Eucalyptus*. A few are from *Acacia* species plantations.

Ectomycorrhiza mushrooms are valuable WEMs widely collected for food and are also an important income source, generating US 70 per month for families during the rainy season (Degreef et al., 2020). Despite the key role of Miombo mushrooms in communities, the species are threatened by the practice of felling host trees that form symbiotic relationships with mushrooms to create farmlands and fuel sources (Degreef et al., 2020). As well, ectomycorrhizal mushrooms cannot be cultivated, due to their symbiotic nature with specific tree species. Thus, sustainable harvesting remains the most appropriate strategy for the conservation of beneficial mushrooms and their habitat. The other alternative is to cultivate ectomycorrhizal seedlings which have been inoculated with specific fungus for continued mushroom supply when conditions are conducive for fructification. It is important to note that native fungi fail to form symbiotic relationships with exotic tree species and therefore the right fungus should be identified for appropriate indigenous tree species (Ducousso et al., 2012). Therefore, sustainable land management practices and cheap fuel alternatives have been proposed to secure and sustain ectomycorrhiza mushrooms (Degreef, et al., 2020).

Termitomyces is a paleotropical genus of agarics growing in association with termites and their nests. The species belong to *Lyophyllaceae* (division *Basidiomycota*) with 30-40 species estimated globally (Kirk et al., 2008). Although species in this genus are saprobic, decomposing plant-derived material (e.g., wood, dry grass, and leaf litter) organic matter, the species are completely dependent on termites to survive. They are the most preferred species that form a favorite delicacy for most African and Asian communities. Their good flavor, taste and texture make them acceptable among these communities (Sathiya et al., 2020). Out of 27 that have been documented in Africa and Southeast Asia, 23 species are edible and 3 species are medicinal. *Termitomyces* mushrooms live in a mutualistic obligate relationship with termites, also found in Miombo woodland, although widely distributed in montane areas (Harkonen et al., 2003). Unlike many saprophytic mushrooms, termitomycetes species are difficult to cultivate artificially due to the complexity of the symbiotic relationship that exists between the termites and the mushroom forming fungi (Hsieh and Ju, 2018). However, attempts to culture mycelia on artificial media have been fruitful. In order to maintain sustainable utilization of *termitomycetes* in their natural habitats, efforts are needed to limit the destruction of ecosystems that are known to harbor the species in East Africa. Even as communities harvest the species for home consumption, surplus can be sold to buy other types of foods and for improved livelihoods. Communities that shy off from consuming wild mushrooms should also be educated on which species are edible and sustainable methods of harvesting.

Cultivation of WEMs in this region is however still in its early stages with only 24 species under experimental trials. This is in comparison with 100 under artificial cultivation and 60 % of the species at commercial level in China (Willis, 2018). Of this, about 20 species are currently being cultivated at an industrial level (Gizaw, 2015). The advantage of cultivating mushrooms is the diversification of livelihoods and strengthening the resilience of farmers, the crop has a short cycle that takes only 2 months. Mushrooms are grown at a very low cost since cultivation is mostly done indoors with low requirements for water compared to other crops (FAO, 2017). Cultivation of wild edible mushrooms is also an environmentally friendly technological process of recycling organic waste (Girmay et al., 2016; Hussein et al., 2016). Since small-scale cultivation of over 20 species is undertaken across China, the model used can be used for technology transfer to researchers and farmers in East African countries and Africa at large. The demand for mushrooms is also growing in East Africa (Kenya, Tanzania, Burundi, DR Congo, Uganda) though partly met despite importation and wild gathering efforts (Degreef et al., 2016).

Domestication of WEMs in the region is an enormous opportunity to expand the mushroom industry since most WEMs have regional adaptability, grow rapidly at higher temperatures (>25°C) and their growth conditions can easily be replicated using locally available agricultural and industrial waste (Table 3). Types of agricultural and industrial wastes include wheat straw, rice straw, beans and barley, leaves of various trees, maize stalks, millets, cotton husks and banana leaves (Table 3) (Magingo et al., 2004)

The attempt to domesticate species would also offer year round valuable protein sources and broadening of income avenues for families in East Africa. However, none of these species have been commercially introduced into cultivation and the availability of their mother cultures (germplasm) for research and propagation purpose is uncertain. Despite the limited effort to successfully cultivate these species in East Africa, the attempts made elsewhere have been successful (Thawthong, et al., 2014; Rizal et al., 2015; Bandara et al., 2020). Thus, further studies are required in the region to determine optimal conditions (temperature, humidity, pH, aeration, suitable substrates) for each species in order to successfully grow them invitro.

The process of domesticating WEMs begins with the identification and selection of edible mushroom species whose cultivation potential is known. The cultivability of a species is established by determining if species in the same genus are cultivatable. The edibility of wild mushrooms is best obtained through local knowledge from herbalists, local collectors, and local communities. The knowledge can also be combined with scientific information (Thawthong et al., 2014). The choice of the best substrate for any mushroom species is also a very important step in the successful cultivation of mushrooms. Thus, the process is followed by selection of suitable artificial media and agricultural or industrial substrates. The process of cultivating mushrooms addresses the problem of agricultural and industrial waste by converting it into rich protein food sources (Mshandete and Cuff, 2008, Raymond, et al., 2013, Degreef, et al., 2020). Culturing the species on artificial culture helps to obtain pure mycelia of a specific strain to be cultivated (Mshandete and Cuff, 2008). The step is followed by choice of spawn with high quality viability which is the ability of the mycelia to produce fruiting bodies under different treatments of substrates, suitable conditions such as pH, temperatures and humidity (Thawthong, et al., 2014). Two methods are used in substrate preparation which mainly varies with species requirements. The two main methods are composting and non-composting. During the compost preparation, the substrate is made into piles that are turned after every three days from the 5th day of substrate preparation to the 21st day. According to Mshandete and Cuff (2008), the compositing method during substrate preparation manipulates the natural succession of microorganisms which involves preparing compost using agricultural or industrial wastes, organic and inorganic manures, and calcium sulfate (gypsum). The non-composting method involves soaking the substrate overnight to soften it. The aim of soaking is to moisten the substrate which is followed by draining off excess water by spreading it on a surface that allows excess water to drain off (Nteziryayo et al., 2019). To ensure that the right moisture is retained, a palm squeeze test is done to ensure that water does not drip between the fingers (Hussein et al., 2016). Pasteurization of the substrate is meant to kill the microorganisms that would compete with mushroom mycelium and hinder production. In some instances, supplements are added to the substrates as a nitrogen source such as chicken manure, cow dung, or rice bran at a rate of 1 to 30% depending on the type of supplement used. The aim is to increase mushroom yield and overall production (Mshadete, 2013).

Among the species analyzed for nutritional composition, *Ganoderma lucidum* is known for immunity enhancement, especially among HIV & AIDS patients, *Volvariella volvaceae* for lowering high blood pressure, and *Schizophyllume commune* for fighting cancer (Chandrawanshi et al., 2017). Attempts to domesticate the species in EA have only been made for *Volvariella volvaceae* which was successful. Medicinal mushrooms owe their potential to the secondary metabolites they produce which enhance their immunomodulation, antibacterial, antifungal, antioxidant, antidiabetic, anticancer, antiallergic, anticholesterolemic, cardiovascular protector, antiparasitic, antiviral, hepatoprotective and detoxification effects (Valverde et al., 2015).

Species belonging to *Termitomycetes* were the most (21%) analyzed in this study followed by Pleurotus species (12%) (Table 5). This is probably because Termitomycetes mushrooms are the most consumed edible mushrooms due to their good taste and flavor and ease of availability during the rainy seasons. Pleurotus mushrooms grow easily on dead logs immediately after an adequate rainy season and its also the 2nd most cultivated species in the world making it a species of interest to researchers. The composition of edible mushrooms meaty taste and immunity enhancement properties make them acceptable as nutritional sources worldwide (Teklit, 2015). Also, the protein content in wild edible mushrooms is almost equal to that of milk (Lister, 2015) which makes them a good alternative to expensive and unavailable meat, especially among rural poor populations (Musieba et al, 2012) Additionally, wild mushrooms comprise carbohydrates, vitamins, minerals, antioxidants, phytochemicals and fiber essential for human health (Lister, 2015, Juma et al., 2016, Bandara et al., 2017). The valuable vitamins which are also lacking in most food sources such as Vit D, E, B1, ,B2 and B12 form part of the nutritional composition of most mushrooms (Valverde et al., 2015). Vitamin D in mushrooms is the only non-animal source and thus an important diet, especially, for vegetarians. As a result, mushrooms are gaining popularity recently promising to be potential functional food and medicines that would prevent and treat diseases such as diabetes, cancer and malnutrition (Zhang et al., 2012). It's worth noting that some of the medicinal mushrooms documented in East Africa are cultivatable such as Ganoderma lucidum, a means through which communities can exploit to generate income.

Conclusion

There is a high diversity of cultivatable wild edible saprophytic mushrooms in Eastern

- Africa with the potential to expand the mushroom industry.
- The yield of wild edible mushrooms is almost comparable to that of exotic species though domestication of the species is still in infancy stages.
- The East Africa region is endowed with many agricultural and industrial wastes suitable for the cultivation of most saprophytic mushrooms in the region.
- Efforts made to analyze Wild edible mushrooms in the region are an indication of the growing interest to explore natural resources for improved health and nutrition.
- Availability of the WEMs mother cultures (germ-plasm) for research and propagation is uncertain.

Recommendation

- Further research is needed for more detailed information on diversity, domestication, nutrient content analysis of cultivatable wild mushrooms and their suitable growth requirements for the best yields.
- More research is required to determine nutritional and phytochemical composition of over 80% wild edible/ medicinal mushrooms in East Africa region.
- Regional gene bank is needed for storage and conservation of wild mushrooms germplasm.

Author Contributions

All authors have equal contribution.

Conflict of Interest

The authors declare no conflict of interest.

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