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Ethnomycological Study of Wild Edible *Mushrooms* of Metu Town, Ilu Abba Bora Zone, Oromia Regional State

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Ethno mycological study of wild edible mushrooms of Met Town, Ilu Abba Bora Zone, Oromia regional state

BY

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A thesis presented to the school of graduate studies of the addis Ababa University in partial fulfillment of the requirement for the MSc in Biology (summer-In- service)

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Abstract

This ethnomycological study was conducted to assess interactions of Metu town inhabitants with the *wild edible mushrooms, particularly indigenous knowledge and perceptions, diversity of the edible mushrooms and difference among inhabitants in consumption of the WEMs. Cross-sectional study was conducted with the probability and non-probability methods for selection of respondents and also Sem-structured questionnaire with a closed and open-ended questions, deep interviews and observations participants were conducted for data collection methods. In addition, descriptive statistical analysis was conducted to compare indigenous knowledge and perception of inhabitants for WEMs among different categories of informants. All of the respondents revealed that they knew WEMs. Majority (91.4%) of them responded that they had experience to share benefit of the WEMs, but few (8.6%) of them were not beneficial. School, agricultural sector, health sector, NGO and religious office workers were main source of the information of the WEMs. Similarly, majority (91.4%) of them argued that mushrooms were utilized for a food and medicinal purpose, but few (4%),(3%) and (1.5%) of them revealed that they were also utilized for religious case, others and entertainment purposes in respectively. In addition, they uses for ceremonial, hallucinogenic properties and others functions. Among those about 42%, 26.8%, 21.2% and 9.6% of them were experienced to utilize mushrooms for their nutritional values in respectively due to its a good tastes, substitute a meat and fish, delicacy and good smell to get heat and energy, bodybuilding and increase their body resistance. Moreover, among 198 respondents, majority (88.9%) of them confirmed that they were not experienced to utilize mushrooms for medicinal purpose, but few (11.1%) of them revealed that they had experience in using mushrooms for their medicinal value particularly about 28%, 23%, 11.6%, 29% and 4%of them confirmed that they were utilized for the treatment of inflammation, homeostatic, analgesics, diuretic and tumors. in respectively and preferred to use it because of they easily found in environment, too cheap and better to cure than modern medicine. Similarly, majority (73%) of them confirmed that they were involved in collection of WEMs and they differentiate mushrooms based on its smells, colors and tastes during summer, spring and autumn period of seasons particularly from a termite mound area under big tree, on log or wood swampy trees, farmlands, cattle field area and dry lands. About 44.4%, 25.3%, 18.2%, 7.1% and 5.1% of them responded that they have been collected wild edible mushrooms by chance randomly, observing muddy of soil, sound birds, and deliberately. They were collected mainly by men, elders, children and women in respectively. However, they have been not practiced to preserve that might be happened due to lack of an experience share to preserving mushrooms among their parents in the area, lack of well-developed indigenous knowledge of the WEMs. Majority (81.8%) of respondents argued that mushrooms were not practiced to buy/sale in local market but only (18.2%) of them were argued it. In addition, about 78% of them argued to utilize mushrooms in fresh form, but 22% of them confirmed that they were utilized in dried form. Mushrooms include T. schimperi, T. letestui and T. rosbustus and T. microcarpus are the most expensive in area due to its medicinal values, meaty flavor, good smell and delicacy for food consumption and also they are frequently bought by urban inhabitants, rural social group, illiterates and also literates peoples in respectively. Most of time they are transporting by human carrying and domestic animals such as by donkey. About 50.3% of respondents confirmed that mushrooms coverage were decreased due to deforestation, habitat destruction, Overgrazing and populations pressure role. Majority (86.8%) of respondents argued that mushrooms were not possible to adopt/cultivate of WEMs and also about 44.2%, 29.9% of them confirmed that wild mushrooms development was discouraged by both rain and soil properties and heavy thunder rain. In general, anthropogenic activities, negative perception, increasing urbanization, agrochemical, exotic plants and deforestation are main factors cause for the disturbance of WEMs and also they poor conserved efforts of wild edible mushrooms. Therefore, both methods of conservation in-situ and ex-situ mushroom conservation strategy, disseminate information of WEMs to become behavioral change and transformation conception habit of inhabitants to edible mushrooms are the main recommended.*

Keywords: Ethnomycology, Indigenous knowledge, Wild edible mushrooms, respondents, conservation.

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List- of Acronyms

AMA- African Mycology Association

ASEMM- African Society for Edible and Medicinal Mushrooms

BRFSS- Benishangul-gumuz region Food Security Strategy

USD- United States Dollar

WEM- Wild Edible Mushrooms

NWFP - Non-Wood Forest Products

WEM- Wild Edible Mushrooms

CHAPTER ONE

1. Introduction

1.1. Back Ground of the Study

Mushrooms are part of fungi that free of chlorophyll, cannot process photosynthesis and belong to the Basidiomycota and Ascomycota divisions and also which freely grows in cool and moist places. There are about 140,000 important mushroom species have been reported, (Boa, 2004), and high diversity, but there are few reports in Africa. Ethnomycology is a multidisciplinary field of study involving many aspects of mycology (collecting, describing, and taxonomy), linguistics (vernacular names) and anthropology and sociology (investigations) (Lampman, 2004; Aryal and Budathoki, 2012). So, there is less consideration of communities of African (some developing countries) for the ethnomycological study. However, our understanding on African ethnomycology is still limited, unevenly distributed and information has become available the last few decade (Rammeloo and Walleyn, 1993).

The study of mycology is not getting attention as well as the plants and animals. However, they have been used mushrooms for varies functions. According to (Miriam et al., 2006), humans-mushroom interaction has dated back to many millennia; however, the written evidence of ethnomycological knowledge is a recent conception. Similarly, a number of ethnomycological works have been published from Asia, Africa, South America, North America and Canada. Most of the study was conducted in developed countries than the developing countries. However, according to many reports were revealed, there are high diversity of mushrooms in developing country.

Most of Ethnomycology studies represent diverse areas of mushroom knowledge that includes collection, income generation (Miriam et al., 2006), entheogenic (spirituality and mythological values) (Am et al., 2012), mycopharmaceuticals, nutriceuticals, folk mushroom taxonomy and the dynamics of inherited folk knowledge of mushrooms (Osarenkhoe et al., 2014). However, there are few African countries that have been really benefited from an extensive ethnomycological survey, the most important ones including; Bénin (De Kesel et al., 2008),

Burkina Faso (Guissou et al., 2008), Cameroun (Yongabi et al., 2004), Central African Republic and Nigeria (Oso, 1985), Togo, Gabon (Osarenkhoe et al., 2014).

Joint efforts are therefore necessary to capture the representative macro fungi species of Africa with a view to revising their global representation (Osarenkhoe et al., 2014) may be under the platform of either the African Mycology Association (AMA) or the African Society for Edible and Medicinal Mushrooms. Mushroom hunting refers to the habit of picking edible and medicinal mushrooms from the wild and surrounding woodlands (forests, plantations), farmlands and grasslands along with other non-wood forest products (NWFP) (Boa, 2004). Wild mushroom collection practice and the consequences of over-exploitation of mushrooms in forest ecosystems may affect species composition, richness and diversity (Garibay-orijel et al., 2012).

The rural people in most parts of developing countries still rely on wild edible mushrooms for their livelihood especially as a low-cost alternative to animal proteins and flavoring in diets, source of income and raw material in local traditional medicine practice (Osarenkhoe et al., 2014). The appearance of the majority of edible mushrooms, in the tropics, is restricted to the rainy season, a season which represents the low availability of food hence mushrooms were the most favorable option for overwintering the food shortage season (Boa, 2004).

Many ethnomycological studies showed that women and children are more involved in collecting wild edible mushrooms either for food preparation or sale at local markets, dye extraction for rural cosmetics or for religious rites (Miriam et al., 2006; Garibay-orijel et al., 2012; Treu and Adamson, 2006; Yongabi et al., 2004). It is, therefore, rational to assume that women have better knowledge than men in the identification of edible and poisonous mushrooms as well as, their characteristic and identification features, which are mostly macroscopic. In addition, women have a better knowledge on their spatial distribution in terms of habitat, phenology and associated substrate(s), processing (handling, drying and cooking) and appropriate local uses (Adhikari et al., 2006; Garibay-orijel et al., 2012).

On the contrary, a study by Akpaja et al., (2003) reported that aged (50 - 75 years old) men have relatively sufficient knowledge of indigenous wild edible and poisonous mushrooms. However, the influence of occupation type on the depth of indigenous knowledge of wild edible mushrooms remains unclear, observation at different parts of Africa affirmed high knowledge of

mushroom heritage in local men linked to forest-related occupations like game hunting, farming, palmwine tapping, foresters, firewood collector and herbalists. Different studies have shown that mushroom collectors derive local (indigenous) names of various edible mushrooms from their habitat, season/phenology, shape, color, myth and uses (Garibay-orijel et al., 2012; Lampman, 2004; Tibuhwa, 2012).

There are information of some mushrooms on the ethnomedicinal uses of some mushrooms such as Pleurotus tuberregium used for headache, stomach pain, fever, cold, constipation (John and Akpaja, 2005); Lentinus squarullosus for mumps, heart diseases (Osarenkhoe et al., 2014); Termitomyces microcarpus for gonorrhea; Calvatia cyathiformis for leucorrhea (Oyetayo, 2011); Ganoderma lucidum for treating arthritis, neoplasia; G. resinaceum used for hyperglycemia, liver diseases (hepatoprotector) (Treu and Adamson, 2006) have been reported.

These information's are mainly obtained from traditional herbalists in west and central Africa and many of these mushrooms are obtained only in the wild, which need urgent understanding, documenting and detail study of their medicinal properties. With regard to nutritional composition of mushrooms, in general contains protein (2–40%), fat (2–8%), carbohydrates (1–55%), fiber (3–32%) and ash (8–10%) (Firenzuoli et al., 2008). Growing interest has developed during the last decade in assessing the human-mushrooms interaction among different ethnic groups in Ethiopia. According to Dawit Abate (1998), indigenous communities in south and southwestern part of Ethiopia have a good habit of hunting and consumption of wild edible mushrooms from nearby forest during the wet season thus considered mycophilic, while the peoples in the north and northeastern parts are regarded as mycophobic. There have been only few specific ethnomycological studies in the country (Tuno, 2001). Tuno has described mushroom utilization by the Mejenger, an ethnic group who resides in the southwestern part Teferi Yenealem *et al.,* (2013) and Taddesse Yebo (2010). This field of study like other ethnobiology fields derived from insatiable and dynamic need of human to improve food and medicine base.

Wild edible mushrooms are part of a food material in the Metu area. However, mushrooms consumption habit was not equal distributed among the Metu inhabitants. There is high diversity of WEMs, but they were not well explored and documented in the area. However, there are indications of sharply decreasing of indigenous knowledge and positive attitude and significant

skills gap regarding to differentiating, adopting/cultivating and preserving between genders, age classes and educational background social classes. In addition to that, there are some indications that was showed not well transferred of WEMs information to new generations that might be happened due to poorly involvement of different institutions in disseminating and less significant attention among the WEMs.

The diversity of mushrooms is still sharply on decreasing that might be caused due to the factors include increase of urbanization, population pressure, lack of significant attention for the mushrooms consumption, lack of well documented mushrooms, poorly explored mushrooms, agrochemical input, change of the consumption habit, exotic plants and deforestation. However, there is high flow of Metu rural peoples towards a Metu town as result population's size is rapidly on increasing from time to time. This dynamic change was a cause for the increasing of the Unemployment of the youths which could be courage youths for adopting to drug abuses habit like chewing chat, smoking cigarette and also come up of the youths to street in the area. Similarly, there are some indications of shortage food material in the Metu town. In despite of that, there is high supplementation of food materials in the rural residence than the town area.

In addition, rural inhabitants have high knowledge and positive attitude and conserving indigenous knowledge of edible mushrooms than urban inhabitants in the area. Therefore, inhabitants will be solved their challenges of the indigenous knowledge of the edible mushrooms is only when ethnomycological study was got significant consideration among inhabitants.

Research Question

The study will design to answer the following questions:

What are factors that influence indigenous knowledge and attitudes of Metu inhabitants on the wild Edible mushrooms (WEMs)?

What the common genus of Wild Edible Mushrooms (WEMs) that found in Metu town?

What are the factors that influence for the development (WEMs)?

Which are the species of mushrooms that used as nutrition value in Metu town?

Objectives of the Study

The General Objectives of the study are:

To assess the perception and knowledge of Metu inhabitants on the (WEMs).

The specific objectives of this study are:

To collect and identify wild edible mushrooms in to the genus level in the Metu town area.

To identify and assess indigenous knowledge, diverse uses and attitude of the people towards WEMs in Metu town.

To state the factors that influence on the diversity, composition and richness of wild edible mushrooms in Metu town.

To recommend inhabitants to improve their consumption habit of WEMs in Metu town.

1.2 Statement of the problems

This ethnomycological study was assessed the perceptions and knowledge of Metu town inhabitants integration with the consumption habit of the wild edible mushrooms(WEMs). So that, according to this study documentation and exploration of wild edible mushrooms are an argent issues for the investigators to transfer for the up come generations. In addition to that, ethnomycological study of edible mushrooms regarding to the cultivating/adopting mushrooms, developing the collections of mushrooms habit in the area and disseminating the differentiation of the edible mushrooms are also very important for inhabitants. This investigation will be enable to transfer basic information of edible mushrooms and conserves an indigenous knowledge of mushrooms to transform inhabitants for their consumption habit.

CHAPTER TWO

2. REVIEW OF LITERATURE

2.1 Ethnomycological on the Wild edible Mushrooms

This review literature is concerning to ethnomycological study that deal the interaction of the human with the wild edible mushrooms. Man has been hunting for the wild mushrooms since antiquity (Cooke, 1977). Thousands of years ago, fructifications of higher fungi have been used as a source of food due to their chemical composition which is attractive from the nutrition. During the early days of civilization, mushrooms were consumed mainly for their palatability and unique flavors (Rai, 1994, 1997). Present use of mushrooms is totally different from traditional because, lot of research has been done on the chemical composition of mushrooms, which revealed that mushrooms can be used as a diet to combat diseases.

Carbohydrates are less than 60% and lipids are between 2 to 8%. Orgundana and Fagade (1981) indicated that an average mushroom is about 16.5% dry matter out of which 7.4% is crude fiber, 14.6% is crude protein and 4.48% is fat and oil and indicated that edible mushrooms were highly nutritional and compared favorably with meat, egg and milk food sources. Of several thousand mushroom species known worldwide, only around 2000 are considered edible, of which about 20 are cultivated commercially with only 4 to 5 under industrial production (Chang, 1990). There is also a significant difference in the nutrient contents of pileus verses stalks (Latifah et al., 1996; Zakia et al., 1993).

2.1.1 Carbohydrates

The carbohydrate content of mushrooms represents the bulk of fruiting bodies accounting for 50 to 65% on dry weight basis. Free sugars amounts to about 11%. Florezak et al. (2004) reported that *Coprinus atramentarius* (Bull.: Fr.) Fr. contain 24% of carbohydrate on dry weight basis. The mannitol, also called as mushroom sugar constitutes about 80% of the total free sugars, hence it is dominant (Tseng and Mau, 1999; Wannet et al., 2000) reported that a fresh mushroom contains 0.9% mannitol, 0.28% reducing sugar, 0.59% glycogen and 0.91% hemicellose. Carbohydrates of *Agaricus bisporus* were reported by Crisan and Sands (1978). Raffinose,

sucrose, glucose, fructose and xylose are dominant in it and Water soluble polysaccharides of mushrooms are antitumor (Yoshioka et. al., 1975). Wani et al. 2599.

2.1.2 Proteins

Protein is an important constituent of dry matter of mushrooms (Lasota, 1995; Zrodlowski, 1995; Chang and Buswell, 1996). Lintzel (1941) reported the digestibility of mushroom protein to be as high as 72 to 83%. Protein content of mushrooms depends on the composition of the substratum, size of pileus, harvest time and species of mushrooms (Bano and Rajarathnam, 1982). Protein content of the mushrooms has also been reported to vary from flush to flush (Crisan and Sands, 1978). Haddad and Hayes (1978) indicated that protein in *A. bisporus* mycelium ranged from 32 to 42% on the dry weight basis. Abou et al. (1987) found 46.5% protein on dry weight basis in *A. bisporus*. Samajipati (1978) found 30.16, 28.16, 34.7 and 29.16% protein in dried mycelium of *A. campestris, Agarics arvensis and Morchella esculenta* respectively. In terms of the amount of crude protein, mushrooms rank below animal meats but well above most other foods including milk (Chang, 1980). On a dry weight basis, mushrooms normally contain 19 to 35% proteins as compared to 7.3% in rice, 12.7% in wheat, 38.1% in soybean and 9.4% in corn (Crisan and Sands, 1978; Li and Chang, 1982; Bano and Rajarathnam, 1988).

Verma et al. (1987) reported that mushrooms are very useful for vegetarian because they contain some essential amino acids which are found in animal proteins. The digestibility of *Pleurotus* mushrooms proteins is as that of plants (90%) whereas that of meat is 99% (Bano and Rajarathnam, 1988). Rai and Saxena (1989a) observed decrease in the protein content of mushroom on storage. The protein conversion efficiency of edible mushrooms per unit of land and per unit time is far more superior compared to animal sources of protein (Bano and Rajarathnam, 1988).

2.1.3 Fats

In mushrooms, the fat content is very low as compared to carbohydrates and proteins. The fats present in mushroom fruiting bodies are dominated by unsaturated fatty acids. Singer (1961) determined the fat content of some mushrooms as 2.04% in *Suillus granulates*, 3.66% in *Suillus luteus* and 2.32% in *A. campestris.* Hugaes (1962) observed that mushrooms are rich in linolenic

acid which is an essential fatty acid. Total fat content in *A. bisporus* was reported to be 1.66 to 2.2/100 g on dry weight basis (Maggioni *et al.,* 1968).

Kanwar et al. (1990) has reported a fat content of 11.52% in the *Amanita ceasarea* fruiting bodies on dry weight basis. In 100 g fresh matter of *A. bisporus* (Lange) Sing and *Pleurotus ostreatus* (Jacq: Fr.) Kumm, the content of fatty compounds were found to be 0.3 and 0.4 g respectively, but on dry weight basis, it is 2 and 1.8 g respectively. Mushrooms are considered good source of fats and minerals (Jiskani, 2001). Yilmaz *et al., (*2006) and Pedneault et al. (2006) reported that fat fraction in mushrooms is mainly composed of unsaturated fatty acids.

2.1.4 Vitamins

Mushrooms are one of the best sources of vitamins especially Vitamin B (Buswell, 1996; Mattila *et al.,* 2000). Vitamin content of edible mushrooms has been reported by Esselen and Fellers (1946) and Litchfield (1964). Manning (1985) gave a comprehensive data of vitamin content of mushrooms and some vegetables. According to Mattila et al. (1994), wild mushrooms contain much higher amounts of vitamin D2 than dark cultivated *A. bisporus.* Mushrooms also contain vitamin C in small amounts (Sapers *et al.,* 1999; Mattila *et al.,* 2001) which are poor in vitamins A, D, and E (Anderson and Fellers, 1942).

2.1.5 Mineral constituents

The fruiting bodies of mushrooms are characterized by a high level of well assimilated mineral elements. Major mineral constituents in mushrooms are K, P, Na, Ca, Mg and elements like Cu, Zn, Fe, Mo, Cd form minor constituents (Bano and Rajarathanum, 1982; Bano *et al.,* 1981; Chang, 1982). K, P, Na and Mg constitute about 56 to 70% of the total ash content of the mushrooms (Li and Chang, 1982) while potassium alone forms 45% of the total ash. Abou-Heilah et al. (1987) found that content of potassium and sodium in *A. bisporous* was 300 and 28.2 ppm. respectively. *A. bisporus* ash analysis showed high amount of K, P, Cu and Fe (Anderson and Fellers, 1942).

Kaul (1978) reported that *M. esculenta* contains Ca (0.5776 mg), P (3.313 mg), Fe (1.213 mg) and K (3.831 mg). Varo *et al.* (1980) reported that *A. bisporus* contains Ca (0.04 g), Mg (0.16), P (0.75 g), Fe (7.8 g), Cu (9.4 mg), Mn (0.833 mg) and Zn (8.6 mg) per kilogram fresh weight.

Mushrooms have been found to accumulate heavy metals like cadmium, lead, arsenic, copper, nickel, silver, chromium and mercury (Svoboda, 2000; Svoboda *et al.*, 2001; Issilogglu et al., 2001; Malinowska, 2004). The mineral proportions vary according to the species, age and the diameter of the fruiting body. It also depends upon the type of the substratum (Demirbas, 2001). The mineral content of wild edible mushrooms has been found higher than cultivated ones (Aletor, 1995; Mattilla *et al.*, 2001; Rudawska and Leski, 2005).

2.2 Importance of Mushroom Collection and Uses

Wild mushrooms have been utilized as important sources of food and medicine by rural communities that mostly depend on forests for their livelihoods. Such ethnomycological usage has been also traditional among the forest dweller communities in Ethiopia. The term "Enguday" or "Yejib tila" is commonly used by people to call wild edible mushrooms in the country. The literal meaning of "Yejib tila" is "shadow of the hyena" ("yejib": hyena and tila: "shadow") and implies wild mushrooms appear where hyenas cast shadows: wild mushrooms growth is somewhat mysterious (Abate, 2014).

Although wild mushrooms have been used as food and traditional medicine sources (Asfaw and Tadesse, 2001; Semwal *et al.*, 2014), indigenous knowledge among different tribes has not been given significant attention. Additionally, the documented information on the collection, its use and list of valuable mushrooms, is limited. In this section, we summarize available ethnomycological notes to serve as a compressive reference and for further investigations.

2.2.1 Mushroom use as food

Available ethno-mycology was provided a good illustration of certain ethnic group's use of wild mushrooms as a food source. Tuno (2001) described the traditional use of wild mushrooms by the *Majangir* ethnic groups as a subsidiary food gathered from the natural forests in southern Ethiopia. Muleta *et al.* (2013) and Abate (2014) also documented the culture of hunting and traditional use of mushrooms by the *Kaffa* ethnic groups in the southwest part of the country. In both cases local wild mushrooms have a long history as part of their livelihood because of their nutritional value and good taste (Muleta *et al.*, 2013; Tuno, 2001).

Those mushrooms collected from the forest are eaten fresh and efforts to preserve are not a widespread practice in either of the two ethnic groups. Important ethnomycological resources also come from Muleta *et al.* (2013) who indicated the existence of mushroom hunting cultural practices in the Bonga area in the southern region. In his research, Muleta *et al.* (2013) mentioned wild edible mushrooms are important sources of food supplement for rural communities, and the rural people preferred mushrooms primarily because of their unique flavor and texture. Mushrooms are used to make soup, salad and other traditional meals. The rare practice of mushroom drying and preservation existed among the local communities in the Bonga area (Muleta *et al.*, 2013).

A noticeable interest on wild mushrooms was also reported at the Benihsnagul Gumz region, western Ethiopia (Alemu *et al.*, 2012). In this region, the main tribal groups *i.e. Gumz* and *Berta* are practicing mushroom collection for subsistence, and they appreciate mushrooms as valuable food sources. They also use mushrooms as seasonal coping food, during food shortage periods, mainly in the rainy season when grain scarcity occurs (Alemu, 2012).

Wild mushroom fruiting and collection are restricted to the rainy season, mainly from June to September in Ethiopia. For some species like *Lentinus* sp., collection occurs during the dry season (Tuno, 2001). The most commonly used species, shown in Table 1; include *Agarics arvensis, A. campestroides*, *Laetiporus sulphureus*, *Termitomyces microcarpus*, *T. clypeatus, Lentinus* sp., *Schizophyllum commune* and *Dictyophora indusiata* (Abate, 2014, 2008; Muleta *et al.*, 2013; Tuno, 2001). Among these species, *L. sulphureus* and *S. commune* are well exploited and documented for their ethnomycological use in Ethiopia (Tuno, 2001).

Habitat information for commonly used species was also noted **(Table 1):** they grow mainly in natural forests, grazing areas and termite mounds (Abate, 2014). However, taxonomic description and voucher collections of most of the species are lacking, indicating further work is needed in fungi taxonomy and classification. The information from the literature is very limited and does not reflect the wider cultural usage in the country. Thus, as there are numerous benefits that can be derived from traditional uses, further ethnomycological work is clearly needed to maximize the benefits from traditional knowledge and use of wild mushroom resources in Ethiopia.

2.2.2 Mushrooms as traditional medicine

Wild mushrooms are known to be rich sources of various bioactive substances (Lindequist *et al.*, 2005) and many of them have been reported to be used in folk medicine worldwide. Interestingly, traditional medicinal uses of mushrooms are reported by Abate (2014) from the *Kaffa* ethnic groups in southern Ethiopia. Among other species, *Laetiporus sulphureus* is reported to be commonly used for treating pain during childbirth, and its powder is usually preserved for long periods of time to use as drug during child delivery in Kaffa area (Abate, 2014).

The medicinal use of mushrooms, whose traditional knowledge for the practice is handed down generational lines via oral communications, has also been reported by Alemu (2012) from the Benihsnagul Gumz region, western Ethiopia. In all cases, most of the knowledge on medicinal uses was found to be confined to elderly people of the village or handled secretly by traditional healers of the locality. They both are key informants for the identification of medicinal species since they use different mushrooms for their traditional medicinal practices (Abate, 2008). Consequently it is difficult to get list of species that have been used traditionally for medicinal purpose from any ordinary person (Abate, 2014).

Although mushrooms are NTFPs, 394 information on their diversity is hardly ever documented and the country remains mycologically unexplored (Sitotaw *et al.*, 2015b). So far, limited number of species with saprobic or ectomycorrhizal habits have been reported from different regions. The most important published reports on list of mushrooms in Ethiopia comes from the work of Abate (2014), (2008); Alemu (2013) and Muleta *et al.* (2013) from natural forests in the highlands of the country. Some specific *Agarics* species were reported by Abate (1999) and Sitotaw *et al.* (2015a) from the Afro-montane forest regions in central Ethiopia. Moreover, Tuno (2001) also reported few edible mushrooms from the moist Afro-montane forest systems in the southwest part of the country.

Most recently, Sitotaw *et al.* (2015b) described seven edible *Termitomyces* species in the western lowland part, where the *Combretum* - *Terminalia* woodland vegetation's are dominant. A compilation of the wild edible or medicinal mushrooms and their associated habitats reported from

Ethiopia are presented **(Table 1).** Up-to-date fungal taxa names and authors' names were obtained from Mycobank database (http: //www. mycobank.org).

Some other researchers also have reported the potential availability of wild edible mushrooms in plantation forest systems from Ethiopia (Megersa *et al.*, 2017; Semwal *et al.*, 2014). They highlight the existence of valuable genera such as *Suillus, Lactarius, Lepista* and *Cantharellus*. In a similar way, a survey report of NTFPs from the *Combretum–Terminalia* woodland vegetations in Western Ethiopia reflected wider availability of edible mushrooms (Alemu *et al.*, 2012). However, this report lacks field observations that justify the claims, and the species mentioned here are not properly identified. Almost all the species lack scientific names, underlining the fact that the majority of wild mushrooms in Ethiopia remain unnamed or await scientific description. More recently, our research team reported a total of 26 wild edible mushrooms from natural and exotic forest plantations in southern Ethiopia (Dejene *et al.*, 2017, 2016). Most species are not known by the local communities, and their edibility was assessed from other countries experiences. Interestingly, we found some edible mycorrhizal mushroom in non-native tree plantation forests. A list of the species reported is presented **(Table 1).**

2.2.3 Mushrooms for market sale

Wild mushrooms are generally not among NTFPs for sale in Ethiopia. They are collected mostly for subsistence use (Yehuala, 2010). The major reason is that the season for wild mushroom growth is short and during this season everyone can collect from the wild for their own consumption. However, in some places wild edible mushrooms can provide additional income to households when sold in the markets. For example, in local markets of Bonga and Assosa, mushrooms are available occasionally in association with other vegetal products (Abate, 2014), which the local people sell to earn some income to supplement their household economy.

The common species found fresh in local markets includes *Agaricus* sp., *Laetiporus* sp., and *Termitomyces* sp. (Abate, 2014). However, their market value is very low as the buyers are restricted among the local tribes, and many people were found to be quite ignorant about their edibility (Abate, 2014). Moreover, awareness to use mushrooms as a potential source of income in most rural part of the country is very low and complete lists of species for the local markets is also lacking in all the literature. Traditional taboos such as considering collecting wild edible

mushrooms as a sign of poverty also hinders wider mushroom utilization in a major part of the country, indicating that increasing awareness through collaborative efforts are essential to assist the nationwide efforts to combat food insecurity and ensure nutritional diversity in Ethiopia. List of species used for sale in some localities is presented in **Table 1.**

2.2.4 Gender and mushrooms

In Ethiopia, women are usually involved in collection of mushrooms and they recognize more fungi species than men. Children are also involved in the collection of some specific taxa like *Termitomyces* sp. (Abate, 2014; Alemu, 2013). Women have also basic knowledge of mushrooms in terms of habitats, niche, and associated substrates. They have also expertise to distinguish between edible and poisonous species. This might be because they are more often involved in preparing and cooking mushrooms than men.

Although it differs from place to place, the most recognized ways used to classify mushrooms as edible and non-edible are the colors, shapes and the presence or absence of strong bad smell (Tuno, 2001). These all help for the successful collection of wild edible mushrooms in the locality. The traditional processing knowledge, including handling and cooking are also well known and handled by women (Abate, 2014; Muleta *et al.*, 2013).

2.3 Diversity of wild mushrooms

Functionally wild mushrooms are categorized as saprophytes, that obtain nutrients from dead organic materials; parasitic which depend on living plants and mycorrhizal, that form associations with host plants from which each partner gets benefits from each other (Ferris *et al*., 2000). Mushrooms also tend to be linked to the vegetation of an area. Hence, understanding the ecology of host or keystone species helps to find the possible associated taxa in any habitat (Härkönen *et al*., 2003).

In Ethiopia there are diverse habitats (Friis *et al*., 2010) characterized by a high richness of species, including the fungi (Sitotaw *et al*., 2015b). However, the published literature to which we had access lack to portrait the country's mycoflora profile but only focuses on a handful of species. The discussion analyses the following categories: (1) mushrooms in indigenous forests,

(2) mushrooms in grazing lands, (3) mushrooms in termite mounds and (4) mushrooms in exotic tree plantations, List taxa of wild mushrooms Ethiopia that was referred in **Table 1.**

2.3.1 Mushrooms in indigenous forests

Indigenous forests are a typical part of Ethiopian landscape (Friis *et al*., 2010), covering a range of environments. The occurrence of mushrooms in these forests is widespread during the rainy season (Abate, 2014). Some taxa like *Lentinus* spp. are also unique as they fruit during the dry season (Tuno, 2001). The most important scholar references on fungal diversity come from the comprehensive works of Hjortstam & Ryvarden (1996) who reported fifteen *Corticiaceae* species (List of species not given), of which *Mycoacia brunneofusca* and *Vuilleminia obducens* were new to science. Decock *et al*. (2005) also reported a total of four taxa from the highland forests region, and of which *Fomitiporia tenuis* and *F. aethiopica* were newly reported to the world. Some other taxa have also been reported by Tuno (2001), Abate (2008), Alemu (2013), Muleta *et al*. (2013), Abate (2014) and Sitotaw *et al*. (2015a) from indigenous forests in different parts of the country.

Most recently, Megersa *et al*. (2017) reported 49 fungal taxa from Degaga natural forest in three years of collections (Complete list of the taxa not given). Also, our research team collected 64 macrofungal species in a single rainy season, suggesting the presence of moderate diversity of fungi in the dry Afromontane forests in the Southern region (Pers.obs). Interestingly, some of the taxa like *Agarics* spp., *Agrocybe* spp., and *Calvatia* spp. in our collections could only be identified at the genus level, while some others couldn't be identified at all, indicating the likely presence of species new to science. Based on a survey report of NTFPs from the Benishnagul Gumz Region, Alemu *et al*. (2012) also reflected a wider diversity of macro fungal species in Western dryland forests. The species reported there were described using local names only and lack their precise Latin names.

All of the taxa reported in indigenous forests were saprophytic **(Table 1).** Unfortunately, most valuable ectomycorrhizal (ECM) species common in African forests like *Lactarius* spp. and *Amanita* spp. were not reported in any of the references assessed. This was not surprising as most of the tropical woody tree species are unable to form associations with ECM fungi (Brundrett,

2009), particularly those indigenous tree species of Ethiopia, List taxa of wild mushrooms Ethiopia that was referred in **Table 1.**

2.3.2 Mushrooms in grazing areas

Upland grazing areas are found on the highland plateaus about 2000-3000 m above sea level. The farming systems in these areas are characterized by livestock rearing in addition to crop production. Abate (1999), Alemu (2013), Abate (2014) and Sitotaw *et al*. (2015a) cited some taxa in these areas. The saprophytic species belong to the genus *Agaricus* spp. was the dominant so far reported in the upland grazing areas. Despite valuable, the diversity of fungal species in Ethiopian grazing lands might be a lot richer than what has been so far reported; something that further complementary studies could confirm. List taxa of wild mushrooms Ethiopia that was referred in **Table 1.**

2.3.3 Mushrooms associated with termites

The symbiotic association of *Termitomyces* fungal species with termites is a remarkable example of the coexistence of fungi with insects (Frøslev et al., 2003; Yamada et al., 2005; Damian, 2012). List taxa of wild mushrooms Ethiopia that was referred in **Table 1** stated with their habitat and referred sources.

Table 1. Summary of wild mushrooms reported so far from Ethiopia and with reference to their associated habitats.

List of taxa	Habitat	Sources
Agarics arvensis Schaeff.	NF, GA	Abate (2014), Alemu (2013)
Agarics campestris L.	NF, GA	Abate (1999), Abate (2008), Alemu (2013), Sitotaw *et al*. (2015a)
Agarics xanthodermulus Callac & Guinb.	GA	Sitotaw *et al*. (2015a)
Agarics xanthodermus Genev.	GA	Sitotaw *et al*. (2015a)
Amanita spp. Pers.	No avail	Megersa *et al*. (2017)
Armillaria spp. (Fr.) Staude	NF	Abate (2008), Abate (2014)
Auricularia spp. Bull. exJuss.	NF	Abate (2008), Abate (2014)
Bjerkandera adusta (Willd.) P. Karst.	No avail	Megersa *et al*. (2017)
Catathelasma ventricosum (Peck) Singer	No avail	Megersa *et al*. (2017)
Chlorophyllum molybdites (G. Mey.) Massee	NF, PT	Abate (2008), Abate (2014), Megersa *et al*. (2017)
Climacodon septentrionalis (Fr.) P. Karst.	No avail	Megersa *et al*. (2017)
Clitocybe nuda (Bull.) H.E. Bigelow & A.H. Sm.	NF	Alemu (2013)
Coprinus spp. Pers.	NF	Abate (2014)
Corticiaceae spp. Herter	NF	Hjortstam & Ryvarden (1996)
Craterellus spp. Pers.	No avail	Megersa *et al*. (2017)
Dictyophora indusiata (Vent.) Desv.	NF	Tuno (2001)
Diplomitoporus rimosus (Murrill) Gilb. & Ryvarden	NF	Hjortstam & Ryvarden (1996)
Fomitiporia aethiopica Decock, Bitew & G. Castillo	NF	Decock *et al*.(2005)
Fomitiporia pseudopunctata (A. David, Dequatre & Fiasson) Fiasson	NF	Decock *et al*.(2005)
Fomitiporia robusta (P. Karst.) Fiasson & Niemelä	NF	Decock *et al*.(2005)
Fomitiporia tenuis Decock, Bitew & Castillo	NF	Decock *et al*.(2005)
Ganoderma applanatum (Pers.) Pat.	No avail	Megersa *et al*. (2017)
Geastrum triplex Jungh.	No avail	Megersa *et al*. (2017)
Gymnopilus spp. P.Karst.	NF	Abate (2008)
Gymnopus eucalyptorum (Pers.) Roussel	No avail	Megersa *et al*. (2017)
Gyromitra spp. Fr.	NF	Alemu (2013)
Hypholoma spp. (Fr.) P.Kumm.	NF	Abate (2008)
Laetiporus sulphureus (Bull.) Murrill	NF	Abate (2008), Muleta *et al*. (2013), Abate (2014)
Lentinellus cochleatus (Pers.) P. Karst.	No avail	Megersa *et al*. (2017)
Lentinus spp. Fr.	NF	Tuno (2001), Abate (2008)
Lenzites betulina (L.) Fr.	No avail	Megersa *et al*. (2017)

Lepista spp. (Fr.) W.G. Sm.	No avail	Megersa *et al*. (2017)
Macrolepiota procera (Scop.) Singer	No avail	Megersa *et al*. (2017)
Macrolepiota spp. Singer	NF, GA	Abate (2008), Abate (2014)
Morchella esculenta (L.) Pers.	No avail	Megersa *et al*. (2017)
Mycoacia brunneofusca Hjortstam & Ryvarden	NF	Hjortstam & Ryvarden (1996)
Omphalotus olearius (DC.) Singer	NF	Abate (2008)
Onnia tomentosa (Fries) P. Karsten	No avail	Megersa *et al*. (2017)
Phallales spp. E. Fisch	NF	Tuno (2001)
Phellinus populicola Niemelä	No avail	Megersa *et al*. (2017)
Pholiota adipose (Fr.) P. Kumm.	No avail	Megersa *et al*. (2017)
Pholiota spp. (Fr.) P. Kumm.	NF	Abate (2014)
Physisporinus rivulosus (Berk. & M.A. Curtis) Ryvarden	NF	Hjortstam & Ryvarden (1996)
Polyporus cinnabarinus (Jacq.) Fr.	No avail	Megersa et al. (2017)
Polyporus spp. P. Micheli ex Adans.	NF	Alemu (2013)
Polyporus squamosus (Huds.) Fr.	No avail	Megersa et al. (2017)
Pycnoporus spp. P. Karst.	NF	Alemu (2013)
Ramaria stricta (Pers.) Quél.	No avail	Megersa et al. (2017)
Russula spp. Pers.	No avail	Megersa et al. (2017)
Schizophyllum commune Fr.	NF	Tuno (2001), Abate (2008), Alemu (2013)
Stereum rugosum Pers.	No avail	Megersa et al. (2017)
Suillus luteus (L.) Roussel	PT	Abate (2008)
Termitomyces aurantiacus (R. Heim) R. Heim	TM	Sitotaw et al. (2015b)
Termitomyces clypeatus R. Heim	TM	Muleta et al. (2013), Sitotaw et al. (2015b)
Termitomyces eurrhizus (Berk.) R. Heim	No avail	Megersa et al. (2017)
Termitomyces eurrhizus (Berk.) R. Heim	TM	Sitotaw et al. (2015b)
Termitomyces letestui (Pat.) R. Heim	TM	Sitotaw et al. (2015b)
Termitomyces microcarpus (Berk. & Broome) R. Heim	TM	Muleta et al. (2013), Abate (2014), Sitotaw et al. (2015b)
Termitomyces robustus (Beeli) R. Heim	TM	Sitotaw et al. (2015b)
Termitomyces schimperi (Pat.) R. Heim	TM	Sitotaw et al. (2015b)
Thelephora terrestris Ehrh.	No avail	Megersa et al. (2017)
Trametes gibbosa (Pers.) Fr.	No avail	Megersa et al. (2017)
Trametes versicolor (L.) Lloyd	NF, PT	Alemu (2013), Megersa et al. (2017)
Trichaptum biforme (Fr.) Ryvarden	No avail	Megersa et al. (2017)
Vascellum spp. F. Marda	GA	Abate (2008)
Vuilleminia obducens Hjortstam & Ryvarden	NF	Hjortstam &Ryvarden (1996)

GA: grazing area, NF: natural forest, TM: termite mounds and PT: plantation forest, No avail: habitat not available in the document. Fungal taxa names and authors' names were obtained from Mycobank database (http://www. mycobank.org).

The fungus produces small nodules, which are consumed by termites along with the degraded substrate piles, named combs. During rainy periods, the mycelium that grows degrading the termite combs produces mushrooms, which penetrate the termite nests and soil to reach the surface and thus spread their spores (Frøslev et al., 2003). In Ethiopia, according to (Muleta *et al.,* 2013; Abate, 2014; Sitotaw *et al.,* 2015b; Megersa et al., 2017) were repotred **(Table 2),** most of the Termitomyces fungal species are reported from the lowland areas of the country, where termite mounds are more abundant.

2.3.4 Mushroom cultivation Mushroom

Cultivation can contribute towards the goal of habitat conservation and food security. Around the world about 60 mushroom species have been cultivated commercially (Chang & Miles, 2004). The most common ones include Agaricus bisporus, Lentinula edodes, Pleurotus ostreatus, Flammulina velutipes, Volvariella volvacea, Grifola frondosa, and Pholiota nameko (Gizaw, 2010). In Ethiopia, the practice of mushroom cultivation is a recent activity, mostly restricted to urban areas (Yehuala, 2008; Abate, 2014). Agricultural and agro-industrial wastes have been used at a small scale to produce four most commonly cultivated mushrooms: A. bisporus, L. edodes, P. ostreatus (Yehuala, 2008; Gebrelibanos et al., 2016) and P. florida (Gebrelibanos et al., 2016).

The levels of essential and non-essential metals in cultivated mushrooms such as P. ostreatus and P. florida were also studied in Haramaya, Oromia Region (Gebrelibanos et al., 2016). However, lack of awareness and cultivation skills still leave plenty of room for improvement and growth regarding mushroom cultivation (Yehuala, 2008; Muleta *et al.,* 2013). Owing to their flavor and nutritional value, the consumption of cultivated mushrooms is now constantly increasing, particularly in the main cities. On the other hand, conservative eating habits are also hindering the transfer of cultivation technology at a local level, particularly in areas where mushroom consumption is not a common practice.

2.5 Status of the Wild edible Mushrooms

2.5.1. Mushrooms in Global

Wild edible mushrooms (WEMs) have been a collected and utilized by people in different part of the world for thousands of years. The archaeological record reveals edible species associated with people living 13, 000 years ago in Chile, (Rojas and Mansur, 1995) but it is in China where the consumption of WEF was first reliably noted, several years before the birth of Christ, (Aaronson, 2000). Edible fungi were a collected from forests in ancient Greek and Roman times and highly valued, though more by high-ranking people than by peasants, (Buller, 1914). Many countries in Europe and Asia have for the centuries valued various species of WEF, not only for food but also for their healing properties. Currently, China is the leading producer and exporter of cultivated mushrooms, (Boa, 2004).

Mushrooms have wide ranges of health benefits; their medicinal values include enhancing immunity, reducing cholesterol accumulation in blood, wound-healing and tumor-retarding effects, (Garibay-orijel and Cifuentes, 2006; Gregori and Pohleven, 2007; Oyetayo, 2011). Recently their value has been a promoted to tremendous level with medicinal mushroom trials conducted for HIV/AIDS patients, which have been making encouraging results, (Zhang *et al.*, 2014). Wild useful fungi, therefore, contribute towards diet, health, income and ecological role as a tool in the management of healthy ecosystems. Mushrooms are now getting significant attention all over the world due to their nutritional value such as high proteins, vitamins and fibre content apart from having certain medicinal properties. According to (Boa, 2004) was analyzed in **table 2** some of mushrooms tradition listed that included 210 countries.

Table 2 Mushroom tradition in 210 countries according to FAO-defined regions

Region	Countries	Strong mushroom tradition	Weak mushroom tradition	No, information
Africa	55	10 (18%)	28 (51%)	17 (31%)
Asia	51	15 (30%)	18 (35%)	18 (35%)
Europe	37	14 (62%)	9 (29%)	3 (9%)
America	47	7(15%)	11 (23%)	29 (62%)
Oceania	20	1 (5%)	3 (15%)	16 (79%)
TOTAL	210	47	69	83

Note: Tradition refers to cultural use and collecting to sell (Boa, 2004)

Mushrooms have wide ranges of health benefits; their medicinal values include enhancing immunity, reducing cholesterol accumulation in blood, wound-healing and tumor-retarding effects, (Garibay-orijel and Cifuentes, 2006; Gregori and Pohleven, 2007; Oyetayo, 2011). Recently their value has been a promoted to tremendous level with medicinal mushroom trials conducted for HIV/AIDS patients, which have been making encouraging results, (Zhang *et al.,* 2014).

2.5.2 Mushrooms in African

Most of the information on the biology and ecology of macrofungi is a based on studies carried out in developed countries (Zhao *et al.,* 2011). There is still no correct estimate of the diversity value of macrofungi represented in Africa. However, it has been an estimated that the continent constitutes at least 25% of the total mushroom biodiversity worldwide but contributes barely 0.4% of total mushroom sales and new mushroom products to the global market, (Miriam *et al.,* 2006).

The first account of the order Agaricales using modern taxonomic criteria, rather than an enumeration of species in Africa were published by Pegler, (1977) followed by Morris, (1987) and Westhuizen and Eicker, (1996). Wild edible mushrooms are well a known in most indigenous African recipes, (Tibuhwa, 2012a). During the rainy seasons, it is customary to find rural people across many African countries (including Benin Republic, Cameroon, Equatorial Guinea, Ethiopia, Ghana, Kenya, Malawi, Nigeria, Togo, Uganda and Zimbabwe) going out to search mushrooms on decaying wood and in the nearby forest, (Yongabi *et al*., 2004).

2.5.3 Mushroom in Ethiopian

Study on macrofungal biology and ecology is a very recent research area in Ethiopia and not well established. The mycobiota of different ecosystems and regions of Ethiopia have not been well explored and documented. There has been very few literature regarding macrofungal research in the country these include Ryvarden and Johansen, (1980) and Pegler (1977) has described the bracket and agaric fungi of East Africa including few parts of South and Eastern Ethiopia. Dawit Abate, (1999) has reported the presence of *Agaricus campestris* in some highland areas of the country.

The fatty acid profile, (Woldegiorgis *et al*., 2015a) antioxidant property (Woldegiorgis, *et al*., 2014) of some wild and cultivated edible mushrooms and medicinal property of *Laetiporus sulphureus,* (Woldegiorgis *et al*., 2015b) collected from Ethiopia have been an evaluated. This study include cultivated *Pleurotus ostreatus, Lentinula edodes, Agaricus bisporus,* and eight wild species of *A. campestris, Laetiporus sulphureus, Termitomyces clypeatus, T. microcarpus, T. aurantiacus* and *T. letestui*.

Ethnomycological studies among some ethnic groups in southwestern part have been a reported, (Teferi Yenealem *et al*., 2013; Tuno, 2001) that *Termitomyces* sp. and *Schizophyllum commune* were commonly collected and consumed by the local people. Another ethnomycological study in southwestern was condacted by Taddesse Yebo, (2010) that has shown the three ethnic groups in Kaffa zone, known as the Kaffecho, Chara and Nao from the three selected woredas Gimbo, Decha and Bonga areas often collect and consume WEMs for food and medicine.

2.6 Morphology based identification of WEMs

2.6.1 Taxonomic Description of Termitomyces

Morphological characters have been a used for the last 300 years to identify, classify, and infer phylogenies of fungi, (Seifert *et al.,* 2007). Most of the time, morphology based identification of a species in kingdom fungi is not easy. This can be an attributed to the lack of distinctive morphological characters and predominance of microscopic species in the Kingdom, (Schoch *et al.,* 2012). There are many genus of the wild edible mushrooms in ethiopia. However, there are two main edible mushrooms that have high diversity and avaliable in commonly in Ethiopia. These are Termitomphilous and Agaricus. Detail morphological description and illustration of each species provided below. These are:

Termitomyces aurantiacus

Pileus 6–10 cm in diam., conical–applanate, with a small and pointed perforatorium; surface bright reddish/orange to brown and darker at the centre, glabrous. Margin radially striate and splitting, slightly viscid when moist. Lamellae free, 3–6 mm wide, white and crowded, with few lamellulae. Context white, thick and firm. Basidiospores deposit pinkish cream. Taste mild. Odor mushroomy.

According to Heim (1985), *T. aurantiacus* can easily be distinguished from other species of the genus by its cylindrical pseudorrhiza and bright reddish to orange pileus and its firm texture (Pegler and Vanhaecke 1994) which is in line with our observation. However, in this study small squamules cited by He, (1985) on the surface of the stipe was not observed. This may be due to the nature of the ephemeral remains of partial veil that cannot be observed in mature specimen of *T. aurantiacus*. It is a well- known edible species among peoples in the community. (R. Heim) R. Heim in Termites et Champignons (Paris):56 (1977). **(Figure 1 (A1- 4)).**

Termitomyces clypeatus

Pileus 4–6 cm in diam., conical turns applanate when mature with strongly spiniform to acutely pointed umbo and with unevenly lobed margin; first brownish fading to ash-brown, lighter towards the margin, smooth, silky and viscid when wet, otherwise dry; context of pileus white, thin. Lamellae free, crowded, white to pinkish, pleasant, Odour mild and weak.

It is one of the smallest species in the genus. It partially resembles *T. tylerianus* in fruit body dimensions, but it differs in exhibiting a spiniform to acute umbo with a silky and greyish brown pileal surface and stipe with long black pseudorrhiza (Pegler, 1977). It is edible and used as medicine among the local people to treat problems related to gastric and constipation in adults and to treat underweight children. The health benefit of this species also indicated on reports from West Africa and Asia (Anderson *et al.,* 2013; Adhikari *et al.,* 2005; Boa, 2004; Okhuoya and Akpaja, 2005). **(Figure 1 (B1-4)).**

Termitomyces eurrhizus

Pileus 5–22 cm in diam., conico-campanulate to nearly plane with a broadly ambonate perforatorium; surface greyish brown over the perforatorium becoming usually lighter near the margin. Margin slightly incurved, splitting at maturity. Lamellae sub-free to adnexed, whitish cream to light pink, moderately crowded with few lamellulae. It is the long, thick pseudorrhiza, which is black below the ground level. The structure of this species has been dealt with considerable detail by Petch (1913) who accepted two distinct forms; with persistent annulus and with out annulus commenting that the two forms were identical in size, shape, structure of pileus and gills, size and colour of spores. No persistent annulus was clearly observed in all of our *T.*

eurrhizus collections in this study. However, it is quite clear that the two forms simply represent the same species.

As described in Pegler, (1977) and Wei *et al.,* (2004) the presence or absence of a ring is a more or less an accidental phenomenon brought about by a difference in the point of dehiscence of the universal veil. *T.eurrhizus* is a common species at grassland, edges of forests and cultivated fields in the study area. It is esteemed as delicacy by the indigenous people but not common at the local market. R. Heim[as 'eurhizus'], Arch. Mus. Hist. Nat. Paris, ser. 6 18: 140 (1942). **(Figure 1 (C1-4)).**

D. Termitomyces letestui

Pileus 12–20 cm in diam., convex, with mammillate perforatorium, surface cream to light brown becoming dark brown or rust brown towards the center, with squamulose at the disk. Margin incurved, splitting radially at maturity, R. Heim, Arch. Mus. Hist. Nat. Paris, ser. 6 18: 109 (1942) in the figure 1 as the **D1-4.**

It is recognized mainly by its large and fleshy pileus with a characteristic mammillate perforatorium (Heim 1945; Pegler 1977) and by the sheathing annulus. Termitomyces letestui is wide spread throughout Menge district and represent one of the largest species. It is one of the first mushrooms to appear at the beginning of the rainy season (mid of June). It is edible and highly prized due to its good test which is true in elsewere in Africa and Asia (Tibuhwa, 2012a; Tang, et al., 2006; Rammeloo and Walleyn, 1993). **(Figure 1 (D1-4)).**

E. Termitomyces microcarpus

Pileus 1.5–2.5 (3) cm in diam., convex then expands to broad convex and almost applanate, often umbonate, upper surface whitish to cream, darkening at the center, dry. Margin incurved or straight. Lamellae free, thin, white, 1-2 mm wide, moderately crowded with lamellae. Context white, thin. Annulus absent. Basidiospores deposit cream. Taste mild. Odor mild, sometimes odourless, (Berk. & Broome) R. Heim, Arch. Mus. Hist. Nat. Paris, ser. 6 18: 128 (1942) in the figure 1 as the E1-4. Distinctive characteristics of this Termitomyces species is its small size, occurrence in dense troops and the absence of pseudorrhiza, however, its association with termite, the presence of pinkish spore and other micromorphological characters that it shares

with other species in the genus lead mycologists to put it under this genus (Heim,1952, 1977; Pegler, 1977). **(Figure 1 (E1-4)).**

In contrast to previous researches (Pegler, 1977; Pegler and Vanhaecke 1994), T. microcarpus from Menge has cream color spore deposit instead of the pink spore deposit. It is common and abundant around the farming field and semi-opening bamboo forest in Menge District from the end of June to August. It is edible and well148 liked for its test and flavor and medicinal benefit, however, due to its small size people do not prefer it since it takes much time to collect even for one meal.

F. Termitomyces robustus

Pileus 7-11 cm diameter, at first conical then expanding to convex, pointed to perforatorium, surface grey. Annulus absent in mature specimens. Basidiospores deposit pinkish-cream. Termitomyces robustus is readily recognized by its large, tough basidiomata with brown cap surface conical umbo and a swollen stipe and blackish psudorrhiza (Pegler and Vanhaecke 1994); Tibuhwa et al., 2010; De Kesel, 2011; Tibuhwa, 2012b).

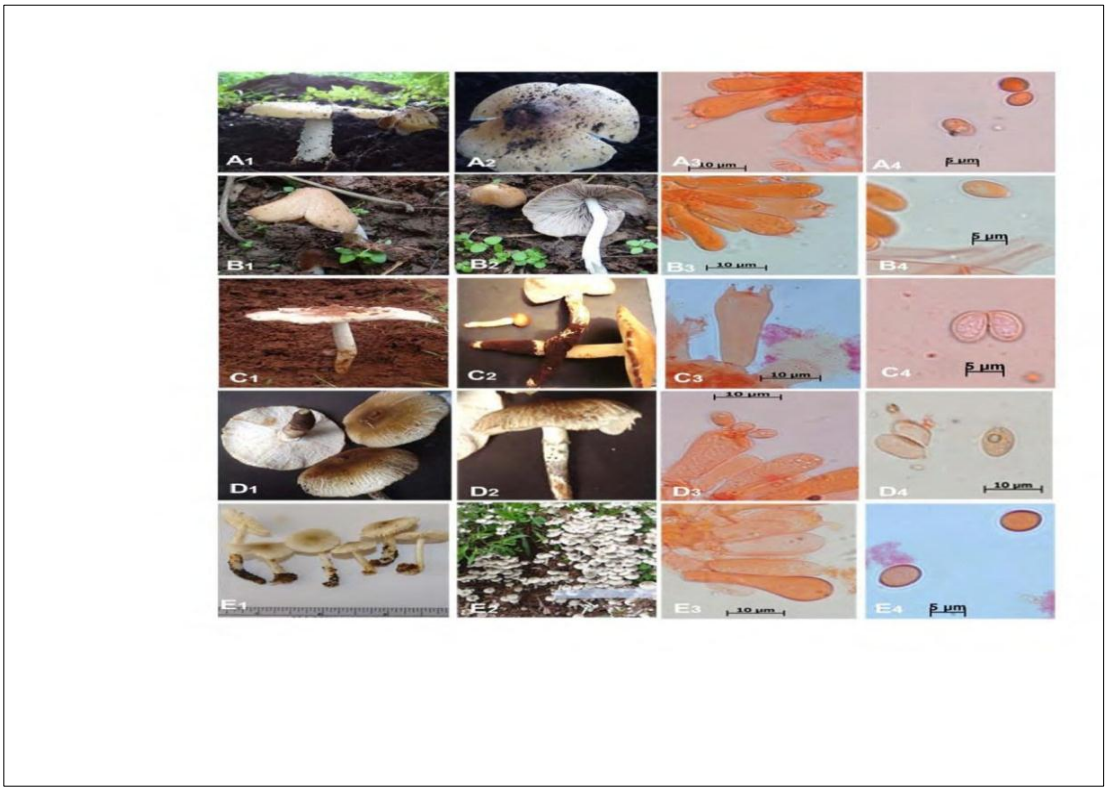
The fruiting body appear after good rains from mid-July until the end of September. Taste and Odor mild, (Beeli) R. Heim, Termitomyces schimperi Pileus 18-40 cm in diam., convex to flat, lacking umbo, covered with thick large persistent scales concentric and forming plate-like covering at disc, surface white but stained light brown to reddish-brown by the soil of the mound. Margin entire, splitting radially, with persistent, long and membranous partial veil. Lamellae free to adnexed, up to 10 mm wide, whitish to cream, moderately crowded. **(Figure 1 (F1-4)).**

G. Termitomyces schimperi

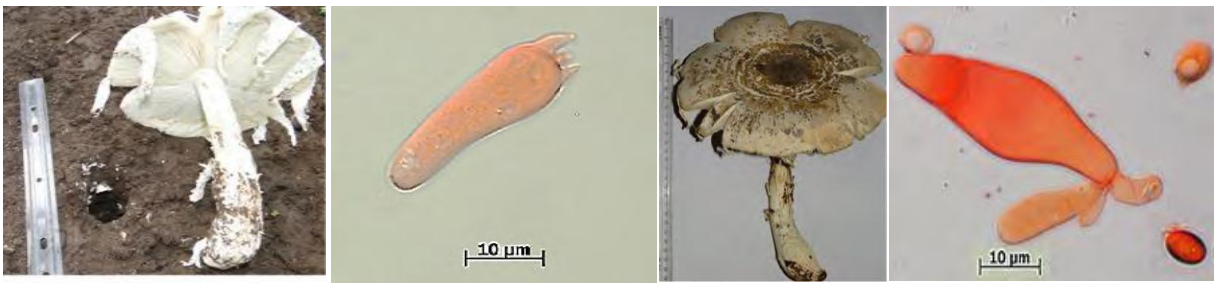
Pileus 18-40 cm in diam., convex to flat, lacking umbo, covered with thick large persistent scales concentric and forming plate-like covering at disc, surface white but stained light brown to reddish-brown by the soil of the mound. Margin entire, splitting radially, with persistent, long and membranous partial veil. Lamellae free to adnexed, up to 10 mm wide, whitish to cream, moderately crowded. Stipe 30–40 × 3–4 cm, cylindric, swollen towards the base then tapering to

a long pseudorrhiza. Context thick, white. Annulus absent. Basidiospores deposit cream to pinkish. Taste mild. Odor pleasant.

Termitomyces schimperi is well known for its large robust fruiting body, usually the cap may reach about 40 cm. in diam (Pegler, 1977; Pegler and Piearce, 1980; Singer, 1986). It is easily recognized by its rough scaly cap and stem, the brown scales of the cup usually in the form of radiating concentric rings unlike many other *Termitomyces* species it lacks umbo. Usually found on top of termite hills and appear after heavy rains from July to mid September which is the main rainy season in the study area. It is well known for its large robust fruiting body; usually the cap may reach about 40 cm. in diam (Pegler, 1977; Pegler and Piearce, 1980; Singer, 1986). Pat.) R. Heim, Arch. Mus. Hist. Nat. Paris, ser. 6 18: 114 (1942).



F1-F4*: T. robustus*



G1-G4: *T. Schimper.*

Figure 1. species of Termitomyces

2.6.2 Taxonomic desriptions Agaricus

The phylogenetic analyses place all the *Agaricus* collections into a monophyletic genus *Agaricus* and distributed in different clade. Most of the major clades were comparable and generally appearing in the same order and well supported with the high ML/MP value and Bayesian Inference (PP). All most all the temperate species were distributed into the major eight previously accepted taxonomic sections of subgenus *Agaricus;* Bivelares, Chitonioides, Xanthodermatei, Sanguinolenti, Agaricus, Spissicaules, Arvenses and Minores, Rediet Sitota (2017).

Among these, three of them (Bivelares, Chitonioides and Arvenses) are entirely temperate. In addition to the major sections of subgenus *Agaricus*, the phylogenetic analysis in this study confirmed that there are four additional clades that contain only tropical species (African and Asian), Rediet Sitota (2017). Six of the Ethiopian *Agaricus* sequences were placed into these four clades with support value greater than 80% and have a lower support value as compared to the rest. *Some* Taxon list and their respective support value are provided in (Table 1). Xanthodermatei are monophyletic. In the three trees obtained during the analysis, section

Xanthodermatei appeared polyphyly/paraphyletic. It includes three major sub clades which are sister to each other and designated in Rediet Sitota (2017) (Table 1).

Figure 2. Agaricus species (H1)

According to different literatures, agarics species are found on grazing land particularly a land of the where the decayed wood of trees. Interestingly, some of the taxa like Agarics spp., Agrocybe spp., and Calvatia spp. in our collections could only be identified at the genus level, while some others couldn't be identified at all, indicating the likely presence of species new to science. Based on a survey report of NTFPs from the Benishnagul Gumz Region, Alemu *et al.* (2012). The occurrence of mushrooms in these forests is widespread during the rainy season, (Abate, 2014).

2.6.3 Description of the Laetiporus sulphureus

The following Figure 3 of the *laetiporus sulphureus* mushroom is one of the important mushrooms.

Figure 3. Laetiporus sulphureus (I1)

This *Laetiporus sulphureus* grow on the wood of trees and had yellowish color. *Laetiporus sulphureus* is relatively it is hard than the termitomyces species. The fatty acid profile, *(Woldegiorgis et al., 2015a)* antioxidant property (Woldegiorgis, et al., 2014) of some wild and cultivated edible mushrooms and medicinal property of Laetiporus sulphureus, (Woldegiorgis *et al.,* 2015b) collected from Ethiopia have been an evaluated.

2.7 Factors that Influencing Macro-Fungial Diversity

2.7.1 Vegetation

Since plants constitute the habitat and energy source for most macro fungi, vegetation type influences the composition and the quantity of species. Plant associations or vegetation zones are valuable standards to use when dividing a land for sampling. Some earlier studies found that the distribution of macro fungal species (especially ectomycorrhizal fungi) to be correlated with forest type (deciduous trees or conifers), since every fungus shows a certain degree of host or substratum specificity (Anderson *et al.,* 2013). However, in other studies it was believed that precipitation to be better than vegetation type as a predictor of species richness of macro fungi (O'Dell *et al.,* 1999).

2.7.2 Succession

There are several viewpoints to consider succession of macro fungi. The first involves changes in community structure frequently are associated with changes in the quality of the substratum. Certain species only grow well on leaf litter that previously has been decomposed by other fungi (Hedger, 1985). Similarly, trunks of fallen trees host a group of fungi that fruit at the beginning of log decomposition and others that fruit only later (Heilmann-Clausen 2001). The second perspective of succession happens during changes in the vegetation that has a direct influence on fungi with the establishment of an association with new host and changes in the amount and quality of accessible organic matter (Hedger, 1985).

2.7.3 Geography

The diversity of habitats rather than geography was believed to have the strongest impact on fungal species richness, however, currently it has been reported that the effects of elevation on

temperature and precipitation influence fruiting within a geographic region (Mueller *et al.,* 2007; Lee and Lee, 2004). Consequently, certain species may fruit at different seasons of the year across wide geographic distances or along strong lavational gradients (Ohenoja, 1993). Some ectomycorrhizal fungi (e.g., Cortinariaceae) were thought to be most diverse at middle and high latitudes, whereas Agaricales in general (especially saprobic Tricholomataceae) were considered most diverse at low latitudes (Sapphire *et al.,* 2002). The aspect of the site may also have an impact on the fungi appearing, as south-facing slopes will generally get more sunlight than north-facing slopes, so a south-facing slope can expect higher soil temperatures and lower moisture contents of the soil (Ohenoja 1993). Lee and Lee, (2004) found that fungal diversity increased in their plots which faced north, due to higher relative moisture levels in the soil.

2.7.4 Seasonality and Year-to-Year Variation

Yearly difference in the presence of sporocarps along with diverse seasonal peaks of abundance for distinct species can occur several times (Hanlon *et al.,* 2012). Lodge (1996) also reported that several species in the Entolomataceae fruited every second or third year in a wet subtropical forest in Puerto Rico, whereas a limited number of other species were found only once during 13-years of survey.

Erratic weather conditions can cause unusual patterns of fruiting, however; in regions with dry summers, for instance, fruiting of species rarely follows a summer shower (Hanlon *et al.,* 2012). Although, the fruiting of macro fungi is most often limited by an absence of precipitation, excess moisture can hinder fruiting in most species (Ohenoja, 1993). Typical data for measuring species richness in a location may involve intense collecting over a period of several days/years when sporocarp production is high (Lodge, 1996).

2.8 Physicochemical properties of soil and mushrooms

It is an established fact that the bulk density of soil affects porosity and that porosity proportionally affects the water holding capacity, pH, electrical conductivity and organic matter of casing soil. A significant correlation between the number of sporophores that were produced and the free pore space in the casing mixture was documented earlier (Flegg, 1953). Similarly, space in casing facilitates better air exchange has a relation to moisture and also affects microbial

buildup particularly that of pseudomonads (Nair & Hayes, 1974; Raincy *et al*, 1986; Stainer et al, 1986 and Kurtzman, 1995).

It was suggested that casing material must have a high water holding capacity (Flegg, 1953b). In the present investigation the casing material FYM alone and in combination had a better WHC, which resulted in good crop yield. The acidity and alkalinity of the casing also affect the production. In this study pH ranged from 6.8-7.16. A pH range between 7-8 has also been reported by several workers (Howker, 1966; Atkins, 1972; Edwards, 1978). It is clear that a slight alkaline pH of FYM had a positive impact in enhancing the yield of mushrooms in both Crops. Decrease in number of pinheads is almost proportional to increase in conductivity (Shandilya & Hayes, 1987). These findings are in agreement with the findings of various workers (Bels-Koning, 1950; Tschierpe & Sinden, 1972; Nair & Hayes, 1981 and Rainey et al, 1986) who have reported the importance of air pores in the casing layer. They have also suggested that the number of mushrooms is larger with higher pore spaces and that this has a positive effect in both, the yield and mean mushroom weight.

The nutritional requirement of *A. bisporus* has been studied and reviewed (Stoller, 1941; Treschow, 1944; Sarazin, 1955; Bohus, 1959) but for the requirement of micro-elements for *A. bisporus,* not sufficient information is available on the presence of macro- and micro-nutrients in casing and their effects on the mushroom yield. In a study, Watson (1973) found that a large proportion of nitrogen in liquid culture could be taken up by mycelium as long as phosphorus was not limiting but where the phosphorus level was low; an increase in nitrogen did not lead to an increase in growth of N2 uptake. He suggested that the optimum requirement for phosphorus is 10~3 Mol.

A level below this reduces mycelia growth while higher levels were inhibitory under certain conditions (Treschow, 1944). This may explain why the higher phosphorus content in FYM and spent compost might be the limiting factor for a higher yield. In addition to iron other micronutrients such as zinc, copper and manganese also play a significant role in destroying the quinone that is a metabolite of *A. bisporus* which is released by its mycelium and inhibits its fructification (Stoller, 1979). The presence of iron, copper, manganese and zinc in FYM alone and in the combination with spent compost may be one of the reasons for a better crop with them (Garchaetal. 1987a).

2.9 Agrochemical Input

Pesticides are necessary evils to kill unwanted life (i.e pest and disease causing organisms) in the agro-ecosystem. These are indispensible tool for protecting the crops and increasing food production. Soil applications of fungicides have been frequently used to control soil borne fungal diseases, particularly those causing damping-off. Domsch (1964) has reviewed the extensive literature concerned with soil fungicides and their effect on the soil micro-flora. Much of the literature covers two aspects of soil fungicide effects, either the effect in controlling certain diseases caused by a fungus, or the effect on the total soil mycoflora. Direct evidence is lacking on the effects of soil fungicides on the activity of natural ecological groups of fungi. The effect of pesticides on soil organisms and soil biological functioning has been reviewed by different workers. This included separate consideration of the effects of pesticides on soil organisms (microbial populations, microbial biomass, mycorrhizal fungi, root pathogens and soil fauna) and soil biological functions (i.e soil enzymes, nitrogen transformations (N fixation, N mineralization, denitrification) and organic matter decomposition).

Generally speaking pesticides have variable effects on soil biology, with the majority of observations in the "no effect" category and with herbicides generally having less impact than insecticides, nematicides and fungicides. However, all of the selected pesticides (herbicides included) were found to have a negative effect on some component of the soil biology. These effects are generally transient, with the affected soil organism groups or biological function recovering to pre-treatment levels usually is a matter of days or weeks. A large number of pesticides are used in agriculture. They fall in the soil and affects soil micro- organisms. Soil micro- organisms play an important role in element cycles, biological processes and soil fertility.

The direct effect of pesticides on soil microorganisms appears as a change on their numbers and species diversity. There are many publications about the effect of pesticides on the soil microorganisms. When assessing effects of pesticides on soil microorganisms, fungicides were found to have the maximum inhibiting effect (Kruglov, 1991). Abdel Mallek *et al.*, (1992, 1997) found that Benlate and Captan inhibited the growth and spore formation of Alternaria alternaria, Cochliobolus sativus, Fusarium moniliforme, Fusarium oxysporum and Drechslera halode. Ryan (1999) reported that the conventional practice of fertilizer and pesticide application may affect

some groups of organisms in the soil, but the overall effect on the soil community would be small.

Dey *et al.,* (2010), observed the effect of some pesticides on the growth and multiplication of soil fungi and soil micro-fauna and found that pesticides effect the flora and fauna both qualitatively and quantitatively and studied the effect of some insecticide/ weedicide (viz Endosulfan, Paraquat, Fipronil, 2, 4- D and Imidacloprid) on the soil microbial population of tea agro-system and found that the population of bacteria, fungi and actinomycetes declined following the pesticide treatment but gradually recovered with time, which shows that the microbial population can recover with time from the deleterious effect of pesticide applied to soil. In the present work some observations were made on the effect of some fungicide on the population and diversity of fungal flora in the tea agro ecosystem soil.

2.10 Threats of wild edible mushrooms that to associated knowledge and conservation plan

Fungi are certainly poorly understood and appreciated compared to plants and animals, moreover, currently they are highly threatened by habitat loss, pollution, over-exploitation and climate change. From the total estimated species of fungi, only 8–10% have been discovered and described (Blackwell, 2011). The International Union for the Conservation of Nature (IUCN) assesses threats to biodiversity by analyse the status of individual species and provides a report of Red Lists in order to catalyse action for biodiversity conservation, however, these lists have a bias towards well-known groups of species (Moore, 2001). The global red lists comprise almost 77,000 species, of which 26,000 are vertebrates. In contrast, as of July 2016, IUCN has evaluated the conservation status of 34 fungus species. The list includes only nine from Ascomycota and 25 Basidiomycota (IUCN, 2016). This actually indicates that fungi are the most under-researched and under-funded group of organisms indicating a critical and immediate action to collect more information on their conservation status. However, in recent decades, enormous advances in the knowledge of taxonomy, distribution, ecology, and conservation status of macrofungi in developed countries enable this biodiversity to be appreciated, considered and incorporated into conservation actions at both the national and global level (Moore, 2001).

The main causes are inappropriate forest and farmland management and air pollution; however, fungal Red-list analysis rarely seems to be considered in national programmes (Blackwell, 2011). Currently, concerns for the diversity and conservation of macrofungi such as identification and designation of protected areas, inclusion in monitoring programmes, and production of management guidelines are starting to be considered in a few developing countries (Crabtree *et al*., 2010; Sysouphanthong *et al.,* 2013).

The plant conservation strategy, endorsed by the Convention on Biological Diversity (CBD), is an obvious sister strategy because of the close interrelationship between fungal and plant diversity. The modified objectives are: 1) understanding and documenting fungal biodiversity; 2) conserving fungal biodiversity; 3) using fungal diversity sustainable; 4) promoting education and awareness about fungal diversity; 5) building capacity for fungal conservation (Garibay-orijel *et al*., 2012). Local knowledge has also been found useful for ecosystem restoration and often has ingredients of adaptive management (Garibay-orijel *et al.,* 2012). Local knowledge helps in scenario analysis, data collection, management planning, designing of the adaptive strategies and institutional support to put policies into practice (Anderson *et al.,* 2013). Local knowledge systems are disappearing at a rate that may not allow us even to know what value, such systems had. Thus application of scientific research and local knowledge contributes both to the equity, opportunity, security and empowerment of local communities, as well as to the sustainability of the natural resources (Lampman, 2004) and this issue could possibly be accomplished with the use of ethnoeconomics or ethnoecological studies.

2.11 An indigenous Knowledge

Herbal medicine is a good example of indigenous knowledge (IK) which has affected the lives of people around the globe. The literature on indigenous knowledge does not provide a single definition of the concept. This is in part due to the differences in background and perspectives of the authors, ranging from social anthropology to agricultural engineering. Nevertheless, the various definitions also have some common traits. These are captured in the writings of two of the leading authorities on IK, PICTA in Tunis on October 21-23, 1998.

Indigenous technologies, practices, and knowledge systems have been studied extensively by sector specialists and even more so by social anthropologists. However, most studies are

descriptive; they concentrate primarily on the social or ethnological aspects of knowledge rather than on the technical ones. The following highlights the special features of indigenous knowledge, which distinguishes it broadly from other knowledge. According to the literature4, IK is: 1. local, in that it is rooted in a particular community and situated within broader cultural traditions; it is a set of experiences generated by people living in those communities. Separating the technical from the non-technical, the rational from the non-rational could be problematic. Therefore, when transferred to other places, there is a potential risk of dislocating IK. 2. tacit knowledge and, therefore, not easily codifiable. 3. transmitted orally, or through imitation and demonstration. Codifying it may lead to the loss of some of its properties. 4. experiential rather than theoretical knowledge. Experience and trial and error, tested in the rigorous laboratory of survival of local communities constantly reinforce IK. 5. learned through repetition, which is a defining characteristic of tradition even when new knowledge is added. Repetition aids in the retention and reinforcement of IK. 6. constantly changing, being produced as well as reproduced, discovered as well as lost; though it is often perceived by external observers as being somewhat static PICTA in Tunis on October 21-23, 1998.

2.11.1 The important for both the local communities and the global community

The development partners need to recognize the role of IK, understand its workings in the context of the local communities, and integrate systematically the most effective and promising of such practices into the development programs they support. As mentioned above, the impact and sustainability of international practices could be enhanced if they are adapted to the local conditions and the indigenous practices. Yet, IK is still an underutilized resource in the development process. Special efforts are, therefore, needed to understand, document and disseminate IK for preservation, transfer or adoption and adaptation elsewhere.

By helping to share IK within and across communities the development community can learn a lot about the local conditions that affect those communities. IK should complement, rather than compete with global knowledge systems in the implementation of projects. By investigating first what local communities know and have in terms of indigenous practice, development partners could better help improve upon those practices by bringing to the dialogue international practices from development experiences in other parts of the world. Moreover, this process can contribute

to better cross-cultural understanding and to the promotion of culture in development. But, above all, investing in the exchange of indigenous knowledge and its integration into the development process can help to reduce poverty.

2.11.2 Exchange of Indigenous Knowledge

Although IK is readily shared among members of a community (in so far as these IK practices are a part of the daily life of the community), it is generally shared to a lesser degree across communities. Moreover, as IK is predominantly tacit or embedded in practices and experiences, it is most commonly exchanged through personal communication and demonstration: from master to apprentice, from parents to children, from neighbor to neighbor, from priest to parish. Recording tacit knowledge, and transferring and disseminating it is, therefore, a challenge. Exchange within a community where providers and recipients speak the same language and share its underlying cultural concepts is much more easily accomplished than transferring tacit knowledge across cultures. To facilitate the understanding of the exchange process, it is useful to break down the process into its various elements.

Exchange of indigenous knowledge is a process, comprising essentially six steps: The process typically begins with recognition and identification of knowledge as expressed in a technology or a problem solving strategy. However, identification of IK can at times prove difficult. For example, some IK may be embedded in a mix of technologies or in cultural values, rendering them unrecognizable at first glance to the external observer. Others may have become part of everyday life of a community to an extent that makes it difficult to isolate such practices even by individuals or communities applying them. In such cases, technical and social analyses of certain practices may be needed to identify IK.

The next typical step is to validate IK in terms of its significance and relevance (to solving one or several specific problems), reliability (not being an incidental occurrence), functionality (how well does it work), effectiveness and transferability. The users themselves should preferably conduct or be involved in the validation at the original site of application of IK. Transfer of IK from one community to another may in some cases prove difficult. This is because most IK is stored in tacit form, which in certain circumstances may make it transferable only through direct practice and apprenticeship. Proof of an efficient process at the point of origin does not

necessarily ascertain its efficacy under seemingly similar conditions in other locations. Lessons from earlier transfers of modern as well as appropriate technologies indicate that the cultural, political, and economic environment and the level of technical competence of recipients are critical for sustainable adoption and adaptation of foreign technologies. Consequently, it is important to carry out pilots to test the new technology with the recipient. Nevertheless, in some cases it should be possible to undertake a general assessment of transferability, subject to confirmation with follow up pilots.

Storage in retrievable repositories is the next typical step in the process. This involves categorization, indexing, relating it to other information, making it accessible and conserving, preserving and maintaining it for later retrieval. Meta-information needs to be produced to make retrieval more user-friendly. This could include electronically stored and indexed abstracts, directories of experts or applications. Storage should not, however, be restricted to only text documents. It should also include other retrievable types of repositories of information such as tapes, films, databases and IK practitioners.

The transfer of IK goes beyond conveying it to the potential recipients. An important element of the transfer is to test the knowledge in the new environment. Economic and technical feasibility, social and environmental impact and other criteria as deemed necessary by the recipients need to be examined by the IIRR in 1996. Once the transfers and adaptation process has been carried out successfully through a pilot, the dissemination of IK to a wider community adds the developmental dimension to the exchange of knowledge and could bring about a wider and deeper impact of the knowledge transfer. Depending on content and context, dissemination activities could include public awareness campaigns, public broadcasting, advertisements, seminars, workshops, distribution of information material, publications and the incorporation of IK in extension programs or curricula. Dissemination activities could be either targeted to specific groups or address the general public. Governments could encourage the process by creating a favorable political, economic and legal framework PICTA in Tunis on October 21-23, 1998. Exchange of IK is the ideal outcome of a successful transfer. This is essentially a learning process whereby the community where an IK practice originates, the agent that transmits the practice, and the community that adopts and adapts the practice all learn during the process. The following is an example of a successful exchange of IK.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Description of the Study Area

Metu town is one of an Illu Abba Bora zone district in Oromia regional state that located in the southwest part of Ethiopia. It is the capital town of Ilu Aba Bora Zone, which is located 600 km far away from Addis Ababa.

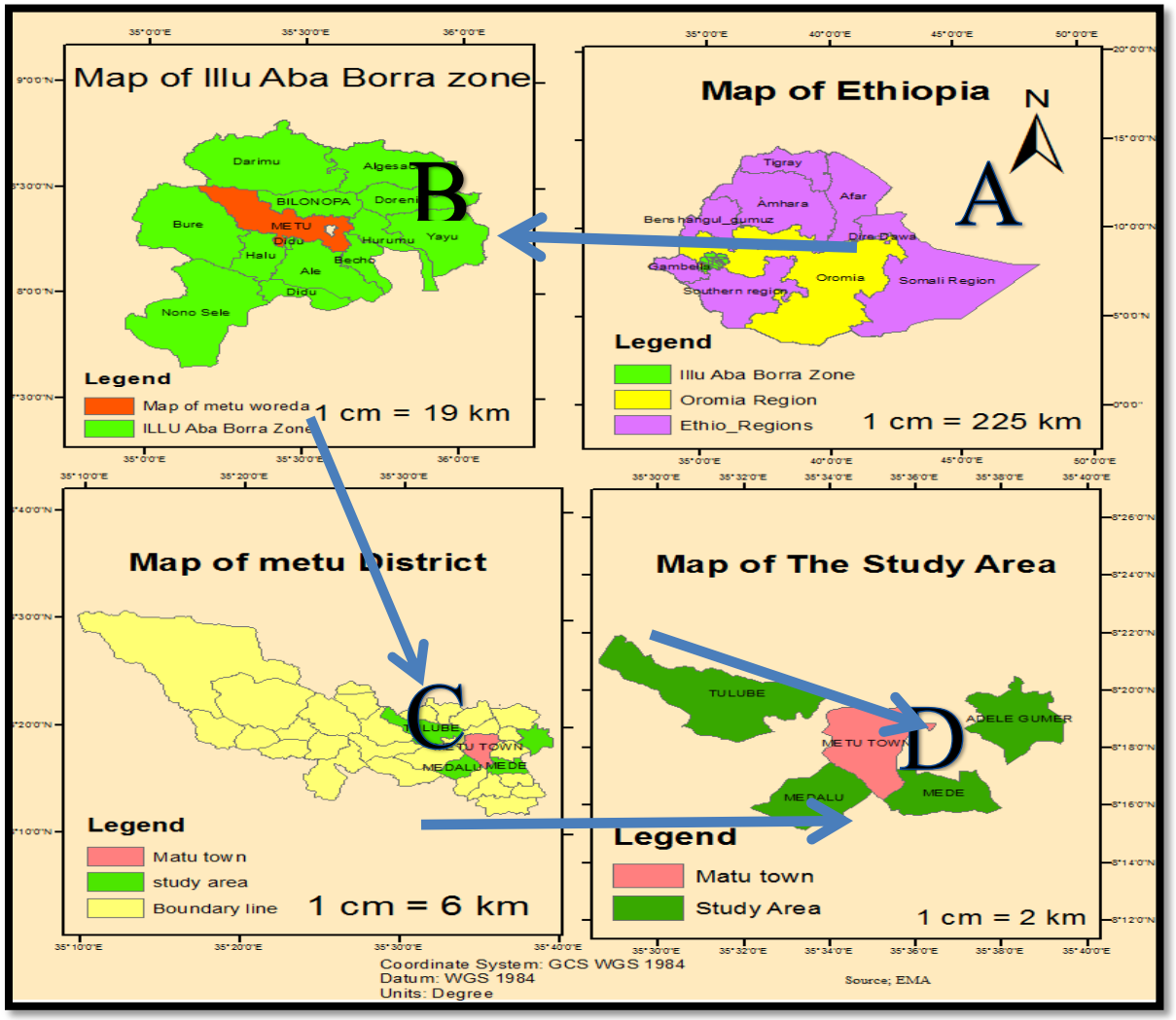


Figure 4. Map of the study area

Metu town is a site of this ethynomycological study. Metu town has four kebeles that surrounded by the green area of the different kebeles of Metu district. Therefore, this study was conducted to assess indigenous knowledge and attitude of Metu inhabitants in the Metu town.

Metu town extends from 80 15'30''-8020'30'' N latitudes and 41032'00''-41037'00''E longitude, Source: RUPI (March 2010). The elevation of Metu town ranges from 1535 - 1790 meters above sea level. According to the records of meteorological information a temperature, annual rainfall and elevation, this found in a Woyna-Dega (semi-humid) climatic zone. The warm season lasts for 2.8 months, from February 15 to May 9, with an average daily high temperature above 81°F. The hottest day of the year is April 6, with an average high of 84°F and low of 58°F. The cool season lasts for 2.4 months, from June 25 to September 6, with an average daily high temperature below 74°F (Metu district agricultural office, 2010).

The coldest day of the year is December 26, with an average low of 49°F and high of 81°F. A wet day is one with at least 0.04 inches of liquid or liquid-equivalent precipitation. The chance of wet days in Metu varies very significantly throughout the year. The chance of a wet day peaks at 89% on August 2. The smallest chance of a wet day is 7% on December 30 (Metu district agricultural office, 2010).

Among wet days, we distinguish between those that experience rain alone, snow alone, or a mixture of the two. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 89% on August 2. The rainless period of the year lasts for 1.2 months, from December 23 to January 30, (Metu district agricultural office 2010). The topography within 2 miles of Metu contains significant variations in elevation, with a maximum elevation change of 807 feet and an average elevation above sea level of 5,511 feet. Within 10 miles contains significant variations in elevation (2,677 feet). Within 50 miles contains large variations in elevation (7,592 feet).

3.2 Design of the Study

A cross sectional was conducted for this ethynomycological study which with both probability and non-probability for the selection of the respondents' and also with the quantitative and

qualitative methods for the data collection. The descriptive analysis and data interpretation methods were conducted for the data analysis.

3.3 The populations of the study

According to the 2007 National census report, Metu town has 28,782 of the population size of whom 14,400 were men and 14,382 were women. However, according to population size was assessed the current population size of Metu town, it is estimated to be 57,109 that more the than double of the 2007 of National census report which is unbelievable report. All the Metu town inhabitants were included which contain four kebeles (01-04) in this ethynomycological study as populations of the study. The status of population's size of Metu town is sharply increasing from year to years. This dynamics change of population might cause due to migration of rural peoples towards urban for different reasons.

3.4 Sampling Technique

Both random sampling and purposive methods were a conducted to select representative of inhabitants as the respondents of ethnomycological study. Random sampling is the methods of selection from the given populations. Therefore, general respondents of the study were selected from the populations of Metu town by considering of the calculation formula of the Daniel (1995). However, key respondents were a selected by a purposive sampling method by the help of the four kebele of administrations.

3.5 Determination of Sample Size

Sample size of this study was composed two groups of respondents. These are general and key respondents. General respondents were calculated from the population size (28,782) of Metu town that a data was taken from the census of Ethiopia in 2007. Sample size was a calculated by using Daniel (1995) that considering the following calculation formula.

$$n = \frac{NZ^2 PQ}{D^2 (N-1) + 2PQ}$$

Where, n= number of the sample size
N= total population (age ≥11)
P= prevalence of the problem
Z= confidence interval
D= Margin of the error
P=15%=0.15
Z= 95% from table of degree of freedom, value of 95% is 1.96 From the formula p+ Q=1
Q=1-p
= 1-0.15 = 0.85

$$n = \frac{(28{,}782)\ (1.92)2\ (0.15)\ (0.85)}{(0.05)2\ (28{,}782-1) + 2(0.15)\ (0.85)}$$

$$n = \frac{13528}{72.2075}$$

n =187

Therefore, **187** of respondents were selected randomly and also whereas **11** of the respondents were selected purposively from the population of Metu town. Total, 198 of the respondents were selected for this study and then 187 of the respondents were simple divided for the four kebeles (**n/4**). Finally, from 198/4 was produced (47, 47, 47 and 46) and simple voted for the 01-04 kebeles.

3.6 Data collection instruments

The Ethnomycological survey was carried out different field trips to be made between April 2019 and May 2019. Ethnomycological data collection methods was made with the both qualitative with structured interview using open ended questions, focused group discussions, participant observation and quantitative research techniques with using structured questionnaires to quantify pre-or post-categorized answers to questions in very close interaction with respondents. In addition to that, unstructured questionnaire was prepared for the key respondents. The collected data were emphasized to assess an interaction of Metu inhabitants with the wild edible mushrooms that including: local name, practice for food, habitats, seasonality period of species, form of mushrooms used fresh or dried, methods of preparation for food, preservation storage, taboos and beliefs related to collection recorded, current status of mushrooms, related folks, opportunity and challenges that related with the consumption habit of the Metu town inhabitants for the wild edible mushrooms were conducted in this ethnomycological study.

In addition, respondents on the source of knowledge, method of indigenous knowledge transfer and attitudes of the current status/abundance of mushrooms, factors affecting the abundance and awareness on commercial cultivation of mushrooms were collected. Eleven key respondents (6 male and 5 female) were participated in a preference ranking exercise in the manner recommend to identify the most preferred species for food.

A market survey of wild edible mushrooms was made in each major market place and the availability, price, who often involve in purchasing and vending mushrooms was documented to identify the extent of use and income generating potential. The existing threats to wild edible mushrooms and traditional conservation practices was gathered during the interviews. Voucher specimens and colored photos were used during interviews and discussions with key respondents and local field assistants.

3.6.1 Administration of Questionnaires

The data collection was carried out using structured questionnaires which would be filled by data collectors. The questionnaire was prepared by English and translated to Afan Oromo, the local language, and re-translated back to English to make the reliability of the instrument. Before undertaking the data collection the instrument was pre-tested by taking 5% eligible for the feasibility of the questionnaires, but pre-tested data was not included in the main data.

The supervisors were selected by considering knowledge of educations background. Both interviewers and supervisors were providing short train for two days and demonstrated and practiced the data collection technique. Guideline were prepared that could guide for the data collectors and this material were provided with brief explanation during the training sessions. At the end of each day the supervisor were checked the completeness of the questionnaires.

3.7 Data collection process

The four data collectors were selected from unemployed competent youths. Each of data collectors were divided for four kebeles and they took detail training on the concept of questionnaires and the basic ethical principles and then they were distributed questionnaire for the respondents.

Similarly, we were conducted assessment of the field observation for collection of the common mushrooms from the green area including Soor, Medalu, Bishary and Madee green area. Some mushrooms were collected from their habitats to identify mushrooms that commonly eaten in the area. In addition to that, photo, video of interview and video of the preparation of the meal from mushrooms were recorded.

3.8 Collection of the Wild Edible Mushrooms

Mushrooms which important and conspicuous part of most terrestrial ecosystems were collected from the fields. Although the collection techniques employed for collecting mushrooms are not this much complex, they differ considerably from those used to collect plants. Pressing mushrooms will destroy their value as scientific specimens and often render a taxonomic determination impossible. In the following paragraphs, a summary of techniques for gathering, documenting and preserving mushroom specimens is given. Although these may seem at times photo of the camera of the species of the edible mushrooms were provided for useful specimens for later study.

3.8.1 Methods of the ethnomycological data collections

Adequate notes are essential to make complete and valuable specimens. I recorded note of the mushrooms with its habitat and substrate during collection of the mushrooms. The habitat description should include the kind of trees growing in the area, because many fleshy fungi were associate with particular types of tree roots, or they may be substrate dependent. When collecting a specimen from soil, be sure to dig down deep enough to remove the whole specimen. Otherwise, remove part of the substrate with the specimen still attached. Try to collect young as well as mature individuals; several stages of development may be necessary for identification purposes.

Once it was collected, the mushroom must be handled carefully. Specimens should be wrapped in aluminum foil or waxed paper for protection and moisture retention. A sheet of foil or paper is torn so that a collection can be rolled up inside with the ends twisted closed. The wrapped mushroom can then be placed in a sturdy basket, box, or bag, and carried to the laboratory or base camp.

3.8.2 Macroscopic Examination

I collected some of the most commonly important macroscopic wild edible mushrooms (WEMs) from the Mettu area the around forests where they are natural found areas towards center of the study for examine about wild edible mushrooms (WEMs) in detail. Benefits include showing the specimens in their natural habitat in natural daylight. In addition, a "natural" scene can be arranged artificially from native plant materials on return to the laboratory or base camp. Another alternative is to arrange a flat or upright, neutral background against which the specimens were photographed. Whichever alternative is employed, the photographer should ensure that all possible salient features of the mushrooms were observed.

3.8.3 Documentation of the ethnomycological study

The collected photo of some of the most commonly known and used wild edible mushrooms (WEMs) were labeled and listed the species diversity of wild edible mushrooms (WEMs) in this written report document. Describing the fresh characteristics of macrofungi is of paramount importance to preparing a valuable specimen because many important and diagnostic features will disappear when the specimens are dry. Most importantly, color, shape, and size will change after drying, and the odor and/or taste if present will no longer be evident. So, I was notes on the fresh appearance should include any descriptive information that will not be evident after drying.

The quality of light for color interpretation is important. Natural daylight is best, but lacking that, there are lamps which feature full spectrum bulbs, LED's or tubes that approximate daylight. Standard fluorescent tubes are notorious for lacking red wave lengths of light. Agaric (or bolete) sporocarps (basidiomata) can be divided into 3 parts: the pileus or cap, including the interior flesh, the hymenophore (lamellae or tubes/pores), and the stipe (including the interior flesh).

3.9 Data Analysis

Data was organized for descriptive statistical analysis. These are demography characters and information of the indigenous knowledge and attitudes towards wild edible mushrooms. In order to assess the variation of indigenous knowledge and attitudes towards wild edible mushrooms

utilization and practice among the men and women, young to middle aged and elderly, literate and illiterate SPSS software version 24 was applied.

Descriptive statistics was also applied to identify the number and percentage of species, genera and families of mushrooms used in the community, preferred habitat for their growth, when and how to collect wild mushroom, indigenous knowledge transfer and conservation practice. Values or scores given by key informants on use-preference of wild edible mushroom were added and ranked to get the output of preference ranking following Martin (1995).

3.10 Data Dissemination

The findings of this study should be disseminated to Metu agricultural Bureau and to different organizations that could be a contribute in the improvement of the status of knowledge and attitudes for the nutritional values of the mushrooms among Metu town inhabitants. The findings were also a presented for Addis Ababa University College of natural science institute of Biotechnology and also for various seminars and workshops.

3.11 Ethical Considerations

In this ethnomycological study, ethical principle was careful considered to respect the inhabitants to get significant information concerning to the indigenous knowledge of wild edible mushrooms. Metu town an inhabitants were asked by recommendation letter of the research for their willingness to respond me. Therefore, respondents were encouraged confidentiality and don`t ordered to told me without their permission.

CHAPTER FOUR

4. Result and Discussion of the Study

4.1 Socio-demographic characteristics

Socio-economic characteristic of the Metu town inhabitants were mainly depended on the agricultural, commercial and governmental product activities, but majority of them have been highly linked with the rural product of activities.

Table 3 Socio-Demographic Characteristics

Table 3 Demographic characters respondents

Variable	Alternative	Respondents F	%
Sex	Male	106	53
	Female	92	47
	Total	198	100
Age	17-Nov	9	4.5
	18-24	40	20.2
	25- 34	64	32.3
	35-45	54	27.3
	46-50	23	11.6
	>51	8	4
	Total	198	100
Ethnic group	Oromo	167	84.8
	Amhara	13	6.6
	Tigre	7	3.5
	Others	5	2.5
	Total	198	100
Educational back ground	Illiterate	44	22.2
	1-4	23	11.6
	5-10/12	82	41.4
	Cert/Diploma	22	11.1
	University	27	13.6
	Total	198	100
Type of occupation	Farmers	66	33.3
	Merchants	32	16.2
	Unemployed	38	19.2
	Employed	62	31.3

The Metu town socio-demographic character was illustrated in the following table 3 that consisted of a variable include sex, age, ethnic, and education background and occupation status.

According to a table 3 showed, the study covered 198 respondents of Metu town and about 106(53%) of them were a males and (47%) of them were females. About (32.3%) of respondent involved in the study was between the ages 25-34 years old, (27.3%) of them was between the ages 35-45 years old, (20.2%) of them was between the ages 18-24 years old, similarly, about 9(4.5%) and 8(4%) of them was between the ages 11-17 and the rest were more than 51 years old. From those respondents about (87.8%) of them was literate group, but (22.2%) of them was illiterate group of inhabitants. Similarly, from the participants of respondents majority (84.8%) of inhabitant was oromo ethnic group. From those respondents, about (33.3%) of them that involved in the study was a farmers, (31.3%) of them were government workers, (19.25) and (16.2%) of them were a merchant and day-to-day workers the inhabitants in the study area in respectively.

4.2 An indigenous Knowledge and Awareness of Inhabitants on WEMs

Mushrooms are part of wild edible materials that commonly utilized for different values for the long years, but it's not used in the moment as well as the last of 10 and 20 years in the area and in Ethiopia. From those respondents, all of them confirmed that they had knowledge of wild edible mushrooms and also good experience of interaction with mushrooms for their a food consumption and they had been utilized for the treatment of some types of diseases in the study area.

Among those respondents majority (91.4%) of them responded that they were involved to benefit from the value of mushrooms, but few (8.6%) of them responded that they are not involved. So, mushrooms had been utilized mainly for the food and medicinal purposes in the study area. According to Firenzuoli (2007) report, there is a large body of report that reveals various uses of mushrooms (functional food, and as natural therapy in the form of a medicinal extract mostly for prevention and treatment of cancer as well as other diseases) in countries like China and Japan.

According to this study, there are some indications for the presence of diverse indigenous knowledge and positive attitude for the uses of WEMs among inhabitants. Even, it is on

increasing from time to time due to lack of well documented, explored and poorly transfer IK for the new generation in the study area.

The fact that elders of Metu inhabitants had great contribution in initiating them for mushroom consumption and they had well awareness about the nutritional and/or medicinal values of mushroom than the others social classes. Studies also revealed that the United Nations Food and Agriculture Organization (FAO) strongly advices the consumption of mushroom due to their high nutritional and medicinal values (Marshal and Nair, 2009). Therefore, indigenous knowledge and positive attitude of edible mushrooms transfer in oral change to in written document among the inhabitants should get significant consideration in the Metu area and in the Ethiopia.

4.3 An informational source for Edibility of the wild edible Mushrooms

According to **figure 5** illustrated that regarding to how inhabitants had information of wild mushrooms for a food consumption and others purposes, majority (72.2%) of them confirmed that they were learned from schools and few (18.2%), (4%), (3%) and (2.5%) of them confirmed that they were learned from agricultural experts, health workers, NGOs and religious in respectively in their Metu area. So, schools have been played great role in disseminating of the IK of the mushrooms than the others organization and there are little efforts by schools, agricultural experts and health workers to create awareness among consumers about importance of mushroom consumption.

Similarly, according to report of (Teferi et.al 2013) that conducted in other part of Ethiopia was revealed, those who had information about mushroom usage for consumption was from school (70.59%) followed by friends (12.42%) and agricultural centers (7.19%), in respectively. Therefore, all organizations and civil societies should involve in the transforming indigenous knowledge of inhabitants regarding to the consumption habit inhabitants in their area. Unless and otherwise, Indigenous knowledge and positive attitude of the mushrooms are under threaten condition for the sustainable use in the Metu Area.

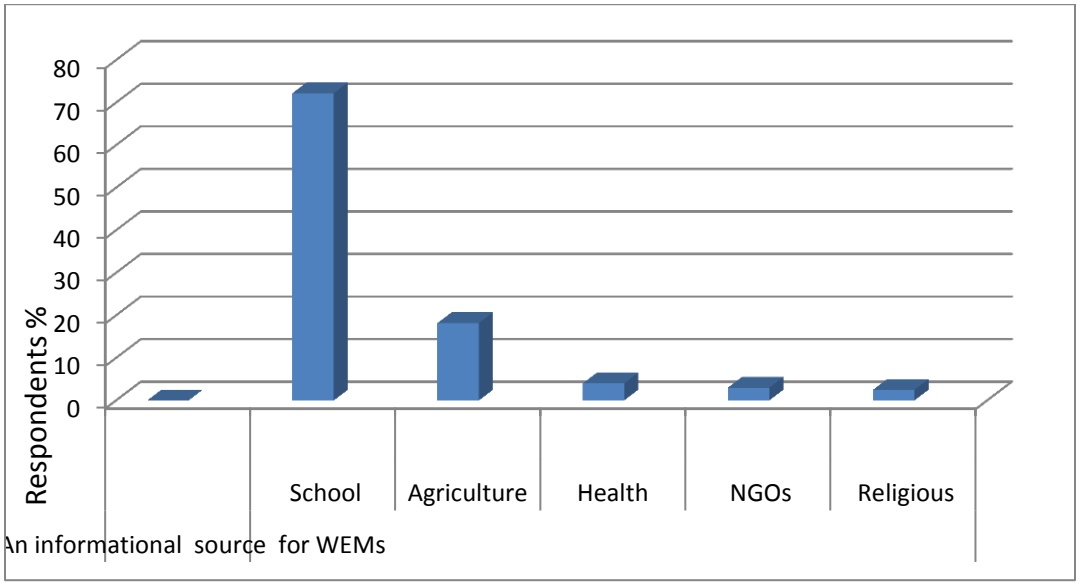


Figure 5. An informational source for WEMs consumption

4.4 The importance of the mushrooms consumption

According to Figure 6 showed that regarding to importance of mushrooms collection among inhabitants, majority (91.4%) of them revealed that mushrooms were utilized for a food consumption and medicinal purpose but few (4%), (1.5%) and (3%) of them revealed that mushrooms were utilized for the religious case, entertainment and others purposes (recreation, soil fertility) in respectively in their area. Based on the key respondents revealed that they have been also utilized mushrooms mainly for the food consumption and medicinal value. In other hand, there are inhabitants who never utilized mushrooms in their life in the study area due to different factors.

Similarly, according to report of (Teferi et.al April 2013) revealed that a some number of respondents (38.41%) mentioned that there is no obstacle that discourages to consume mushroom. However, others (37.19%) mentioned culture as a discouraging factor for mushroom (figure 6).

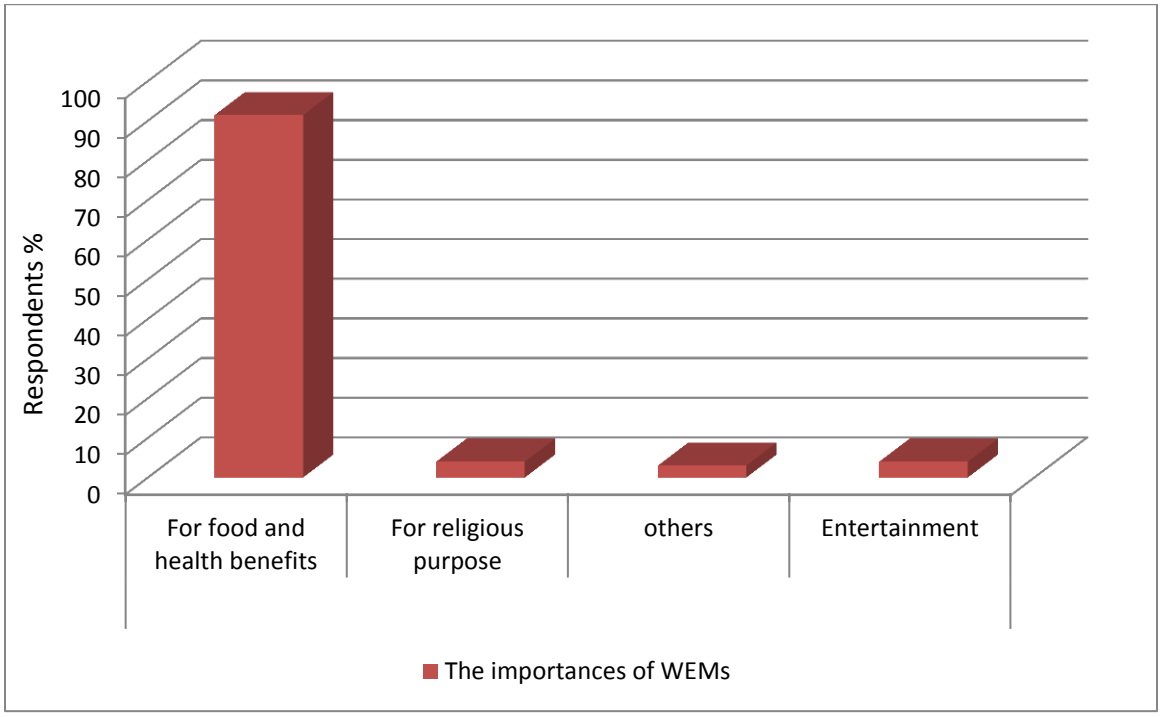


Figure 6. Importance of mushrooms

From those inhabitants majority (76%) of them revealed that they had experience to utilize edible mushrooms for nutritional values, but few (34%) of them were not. There are many items of edible mushrooms, but both genus of Termitomyces and Agaricus mushrooms were the most frequently utilized for food consumption in the area, because they are dominantly found in the area, larger in size, delicacy and flavor test and etc.

According to figure 7 illustrated that regarding to the reasons of mushrooms consumed in the area, (42%) was consumed for its good taste (favor), (26.8%), (21.2%) and 19(9.6%) were for its substitute a meat and fish, delicacy (very soft) nature and good smell in respectively. Similarly, according to (Ayodele et al., 2011) report that mushrooms were eaten the extensive use of species from this family might relate to their appealing taste (as a substitute for meat) and provide better income.

Therefore, mushrooms are consumed due to their good taste, substitute to meat, delicacy and good smell rather than for their chemical composition in the area. In contrast, according to (Rai, 1994, 1997) thousands of years ago, fructifications of higher fungi have been used as a source of food due to their chemical composition which is attractive from the nutrition point of view.

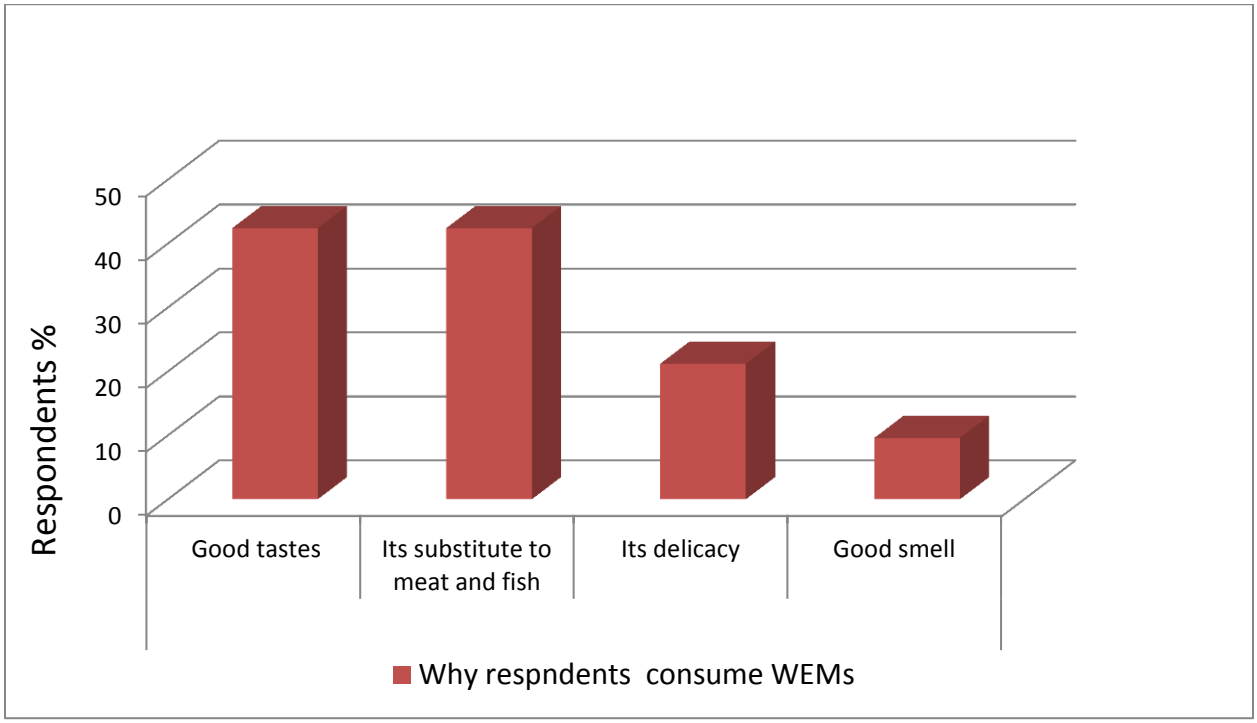


Figure 7. why inhabitants consume WEMs

Similarly, from total of 198 respondents, about (39.9%) of them responded that they consume mushrooms due to get heat and energy nutritional value. Even, they said "human fi jabina namaaf kenna." in Afan Oromo. Literary meaning: it can give an energy and strength for humans, (34.3%) was revealed to get body building value and also (20.9%) was eat for body resistances value (figure 8).

Similarly, according to Suman and Sharma (2007) have reported, 1000 times higher production of mushroom protein and good amino acid content per unit area. Furthermore, contribution of mushrooms to make valuable addition to the often unbalanced diets of people in developing countries (Marshal and Nair, 2009) as well as their potential as substitutes to muscle protein and digestibility (89%) have already been documented.

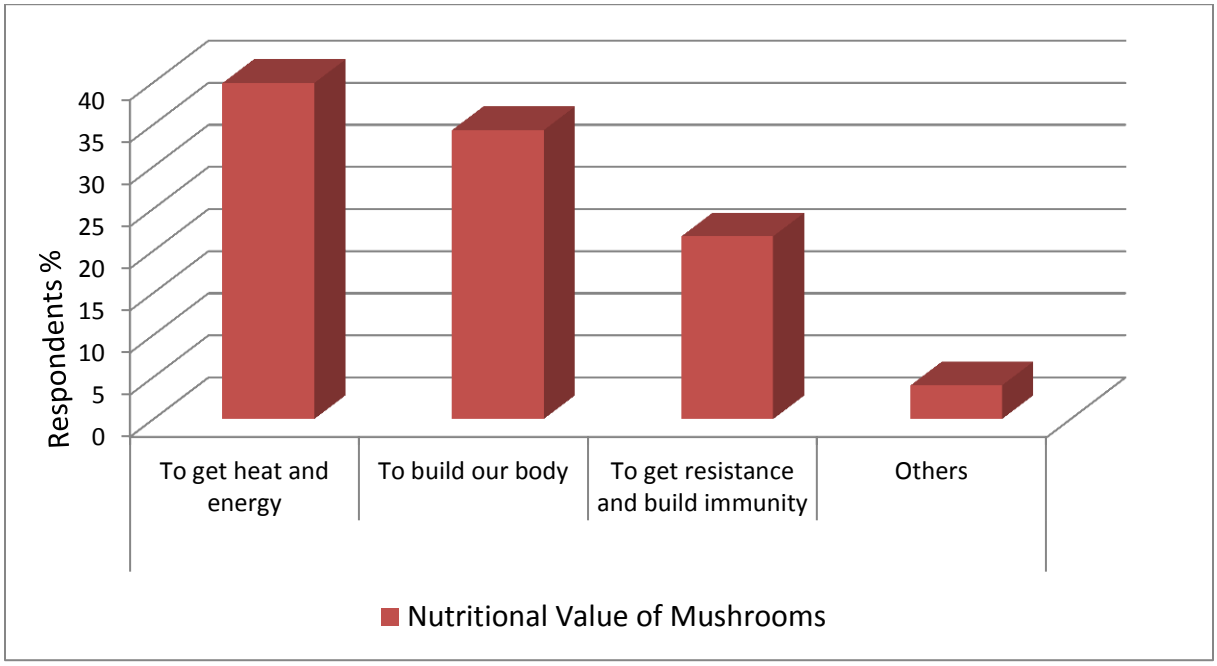


Figure 8. Nutritional value of mushrooms

From those respondents, majority (88.9%) of them confirmed that they were not experienced to utilize wild mushrooms for medicinal purpose, but few (11.1%) of them revealed as they have been experienced to use mushrooms for the medicinal value. In other hand, often while usage of mushrooms for food consumption, considered as used for the medicinal value in the same time. Genus of Termitomyces, agaricus and Laetiporus sulphureus of mushrooms have been commonly utilizing mushrooms for treatment of some type diseases (Table 4).

From those respondents, 29%, 28%, 23%, and 11.6% of respondents responded that mushrooms were utilized for the treatment of diuretic, inflammation, homeostatic and analgesics disease in respectively and the rest for the tumors (figure 9). According to (Daba *et al.*, 2008) report, mushrooms have high fiber content, proteins, microelements and lower caloric content are found almost ideal for a nutrition program aimed to the prevention of hypercholesterolemia and cardiovascular diseases.

Based to the responses of key respondents revealed that amongst mushrooms like *T. microcarpus, T. clypeatus and Laetiporus sulphureus* etc were served for a medicinal value particularly T. microcarpus was used for treatment of constipation, tumor and gastric problems, *T. clypeatus* was used for underweight of the peoples, L. sulphureus was used for the treatment

of wound treatment of the common cold and pneumonia types of disease "qoricha qufaasisa" (a drug that used for the treatment of the lung infection). However, often mushrooms utilization for medicinal value was considered to uses for the general than for specific types diseases (multi treatment of disease).

Similarly, according to report of (Abate, 2014), Laetiporus sulphureus was commonly used for a treating pain during childbirth, and its powder usually preserved for long periods to use as drug during child delivery in Kaffa area. In addition, according to Zyang 2014 value promoted to tremendous level with medicine level conducted for the HIV/AIDS patients.

Therefore, ethnomycological study was one of the alternative technological study that has high promise to solve many global health issues regarding in investigation of the new medicine and encourage traditional medicine use to minimize some risk disease through provide the new that will be replace resisted drugs and for non-cured type of diseases.

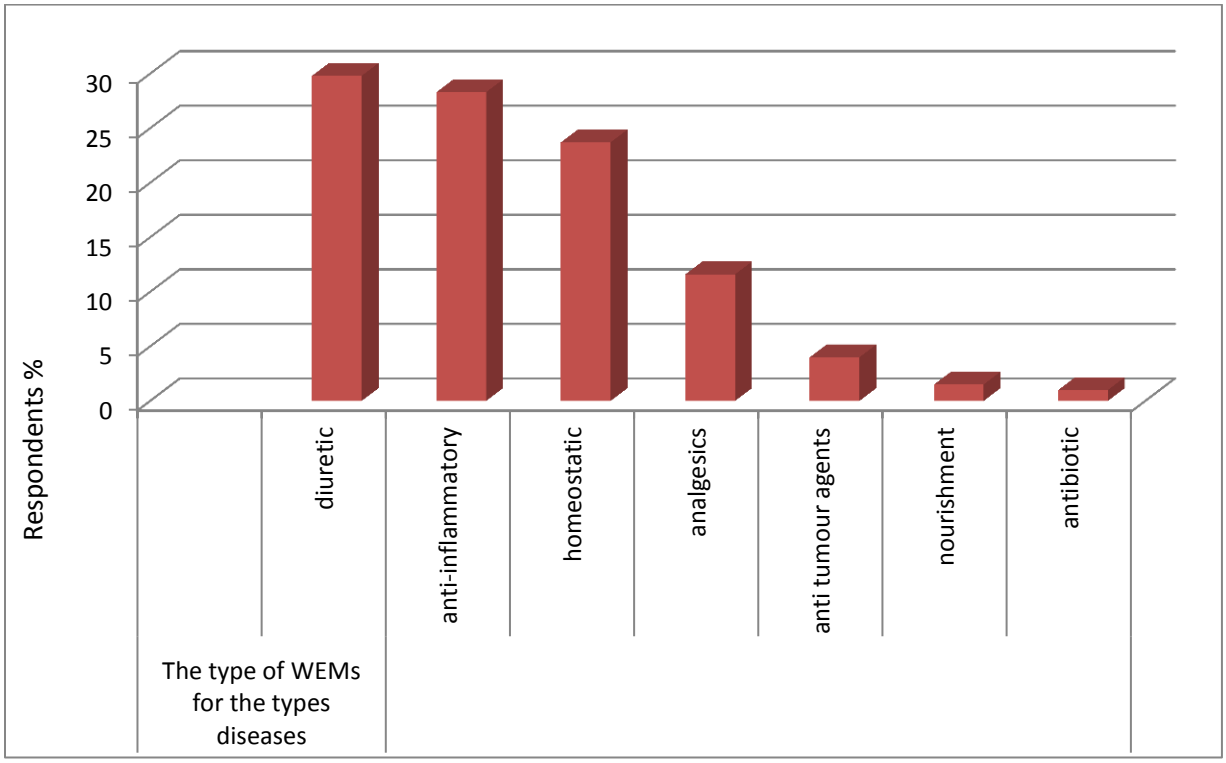


Figure 9. The type of WEM for what type of diseases

From 198 respondents, about 43%, 40%, 11% and 6% of them confirmed that they were preferred mushrooms for their traditional medicinal uses because they easily found in an

environment, too cheap, better to cure than modern medicine and others in respectively (Figure 10). similarly according to key respondents revealed that mushrooms were preferred to utilize for the medicinal value due to its easily found in an environment, too cheap, better to cure than modern medicine, lack of money to buy modern medicine and they belief to usage of mushrooms was more effective than the modern medicine. In addition, experience of using wild edible mushroom in the area for a long time by the local people may also help to easily adopt the cultivation activity if supported by concerned body in the future (Teferi *et.al.*, 2013).

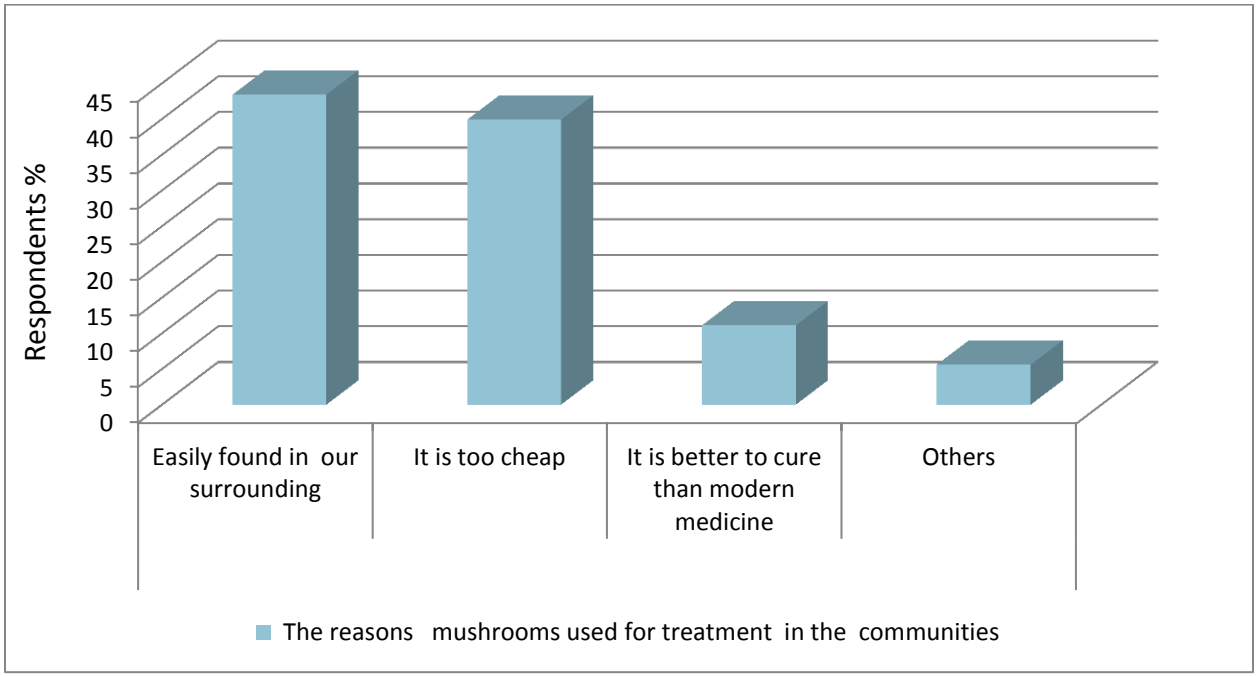


Figure 10 the reasons of mushrooms used for treatment in the community

Based on data of Figure 11 showed regarding to traditional belief of tribe/community Metu town inhabitants for appearance/presence of the mushrooms in their area, some (41.4%) of respondents argued that mushrooms were used for a ceremonial purpose and few (32.3%), (19.7%) and (6.6%) of them confirmed that they were used for a religious purpose, hallucinogenic properties and others purpose of traditional belief in respectively. In addition, the sites where mushrooms emerges often consider as the place of the blessed and fertile soil for produce high yield crops in the Metu area.

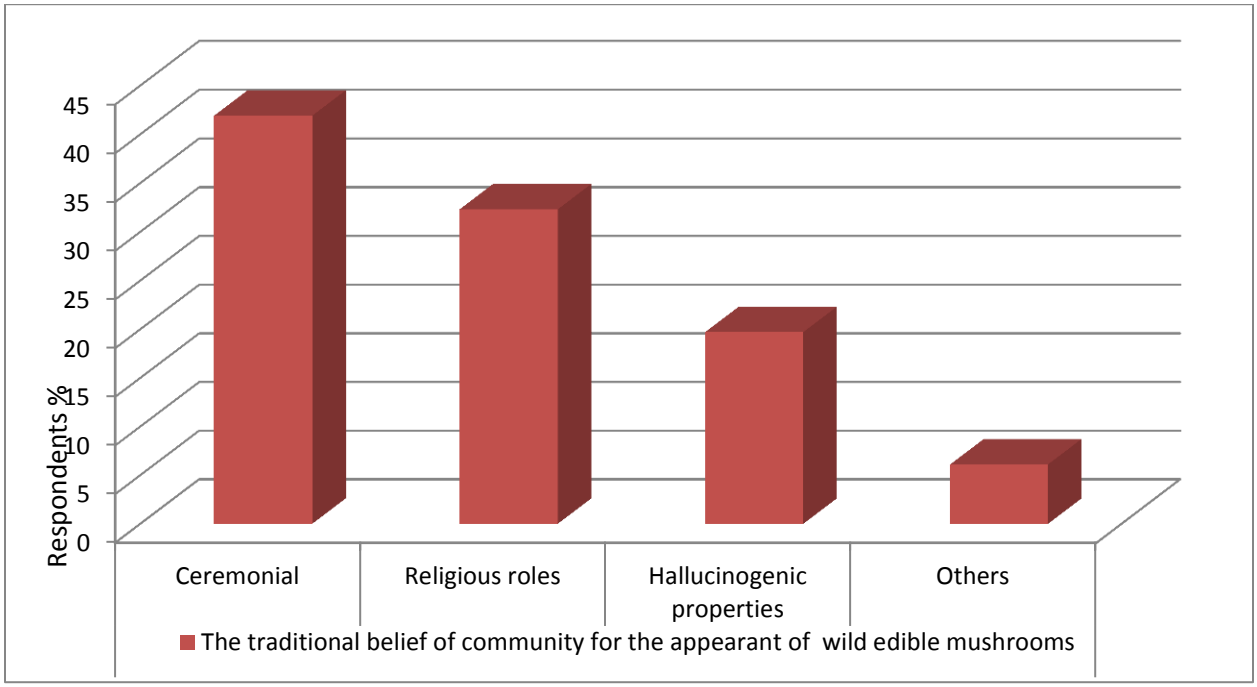


Figure 11. the traditional belief of community for the WEMs

4.5 Collections of Wild Edible Mushrooms

Among those respondents, majority 73% of them confirmed that they were involved/experienced in collecting of the wild edible mushrooms, but few 27% of them were not involved in their area. Similarly, some 50.4% of them confirmed that mushrooms were differentiated because of its smells, 43.2% based on its colors and few 7% based its taste. similar in addition to data that collected from the general respondents, key respondents revealed that folk name and habitats and physical (shape) of mushrooms are commonly used for the identification mushrooms.

In addition, they were revealed regarding to which social classes that frequently involved in mushrooms collections, men, elders and children social classes that frequently in respectively but women had a basic knowledge in terms of mushrooms habitats, niches and associated substrates than men and also others social classes. This variations of skills among social groups might be happened due to women exposed for process of mushrooms preparation for the consumption and also relatively they perform in responsible way for their family care than the others social classes. However, women were poorly involved in the mushrooms collection in the

study area than the others because cultural back ground that relatively women's were not exposed field work as well as the others.

Similarly, according to (Adhikari *et al.,* 2006; Garibay-orijel *et al.,* 2012), rational to assume that women have better knowledge than men in the identification of edible and poisonous mushrooms as well as, their characteristic and identification features, which are mostly macroscopic.

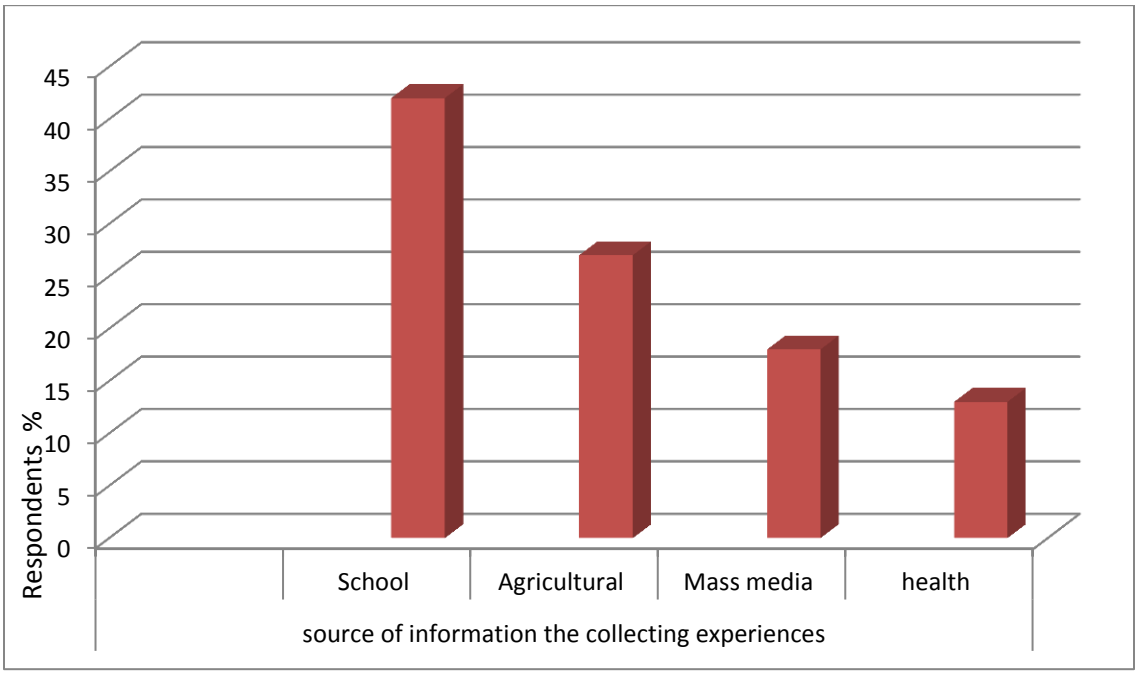


Figure 12. the source of knowledge for the experience of the WEMs collection

Among those respondents revealed that regarding to experience share for the mushrooms collection in the study area, about some (42%) of them responded that it was shared from the schools and few 27%, 18% and 13% of respondents revealed that they learned from agricultural sector, mass media and health sector. In other hand, according to key respondents confirmed that mushrooms are not well collecting as well as the last two decay of year in Metu area (12). Similarly, according to report of (Agrahar-Murugkar and Subbulakshmi, 2005) the tradition of collecting and consuming of WEMs among rural populations in countries such as India is on the decline because of growing urbanization and the associated changes in food habits.

In general, ability/skill of the distinguish of wild edible mushrooms from the non-edible mushrooms is the most challenge activity in the Metu area. So, sustainable uses indigenous

knowledge of the mushrooms among inhabitants is one activity that required significant attention in the ethnomycological study. Therefore, establishment of the center of training for the ethnomycological study and ethnobotany at Metu area is the most recommended suggestion to transform the collection habit of inhabitants for the consumption and others purpose in this study. All organizations are not equal responsible in disseminating IK and positive attitude regarding to their importance due to lack of well significant attention for the mushrooms collection among inhabitants.

According to figure 13 revealed that regarding to collection periods of the wild edible mushrooms take place in the Metu town, majority (81.8%) of them revealed that WEMs were collected during summer season, but few (9.6%) and (8.6%) of respondents confirmed that mushrooms were collected mainly in the spring and during autumn period of seasons in respectively. However, there are few the wild edible mushrooms which can grow in dry seasons, but majority of them are not utilize for the food consumption in the area.

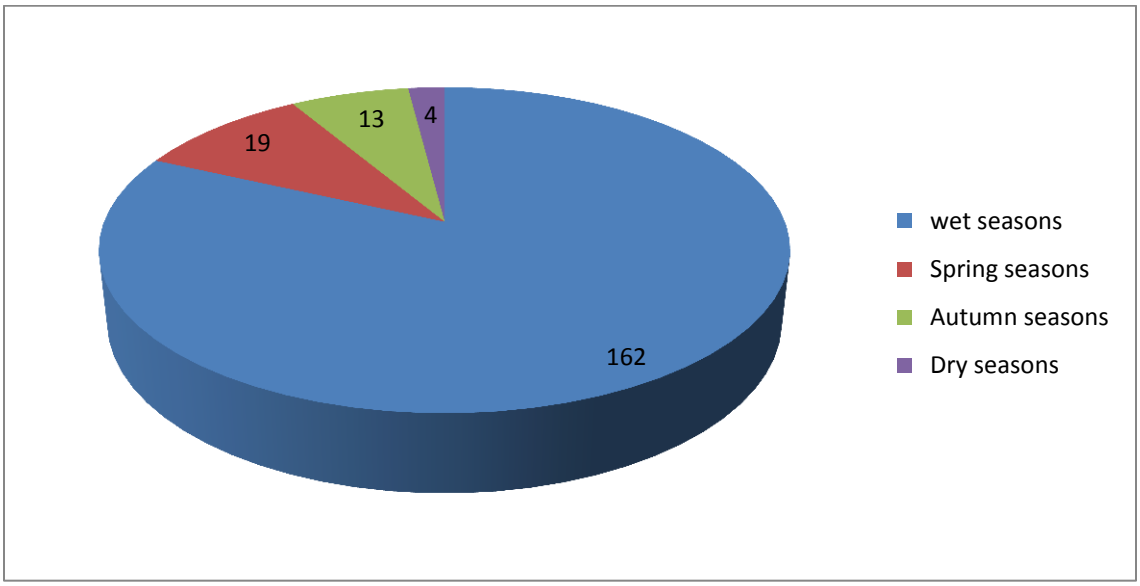


Figure 13. Abundance period of WEMs

Similarly, according to (Sitota *et.al.*, 2007) report in Menge District, almost all the respondents know that the mushroom growth season is strictly associated with the rainy season. Both general and key informants agree that mushrooms fruit from May to September, with July and August being the months with highest abundance for most species, however, according to key

informants, the season is slightly variable every year due to the erratic rains in the region. “mushrooms of the dry season”, in which Laetiporus sulphureus, Auricularia sp and Ganoderma sp.

4.6 The specific locations for the collections of the WEMs

According to figure 14 revealed, 40.4% of respondents confirmed that mushrooms were collected from a termite mound area especially under big tree, 36.9% from on log or wood swampy trees, 16.7% from the farmlands, 3.5% from the cattle field and 1.5% of respondents argued that they were collected from dry lands.

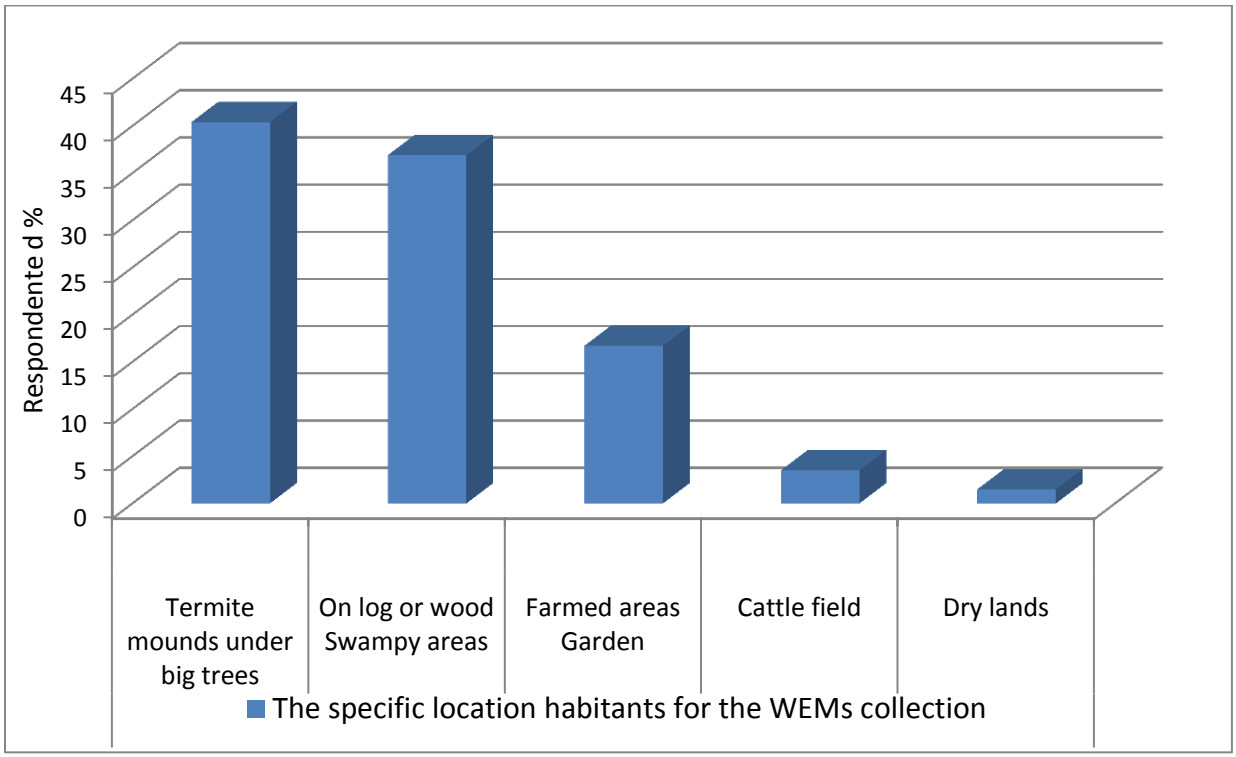


Figure 14. the specific location for the mushrooms collection

According this ethnomycological study mushrooms were collected mainly from the farmlands particularly from the maize and sorghum are cultivated and areas where most of the termite comb found the respective *Termitomyces* species were that observed. However, the investigation showed that these habitats are that subjected to anthropogenic influences due to the practice of using insecticides to eliminate the termite from the farm.

According to report of (Kik *et al.*, 2013; Teferi Yenealem *et al.*, 2013; Osarenkhoe *et al.*, 2014) consequently results in decreasing size of mushroom harvest from such habitat. Misuse of habitats was also that observed as the main factor that decrease wild mushrooms distribution and the amount of harvest.

According to figure 15 showed regarding to the ways of Metu inhabitants collect wild edible mushrooms, 44.4%, 25.3%, 18.2%, 7.1% 5.1% of them responded that they were collected by chance randomly during they simple walking in the fields for different purposes, by observing muddy of soil when they are keeping cattle and walking in field for others objectives, searched deliberately in where they found. In addition, according to interviews data showed, majority of respondents confirmed that WEMs were collected by a chance randomly during they are simple moving in forests/green area and others specific areas. However, they were collected rarely by deliberate searching of the wild edible mushrooms in the area.

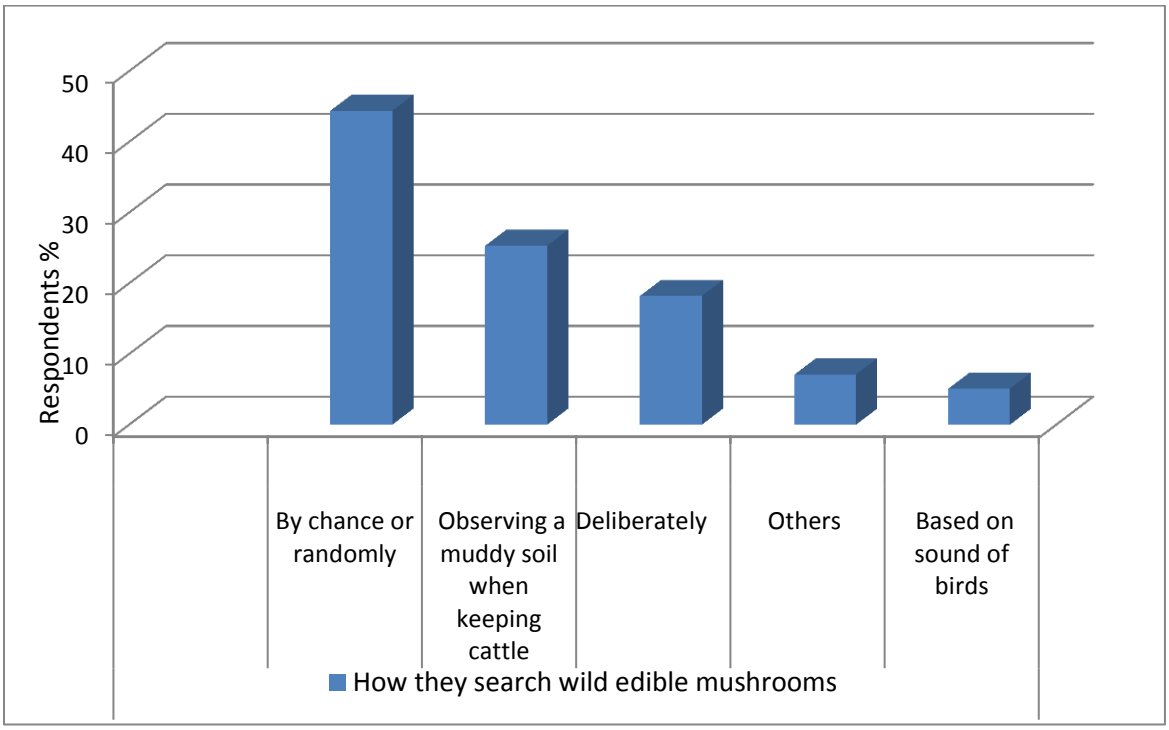


Figure 15. how inhabitants searching mushrooms in their collection

Similarly, according to other reporting of (Tuna, 2001) indicated that, from the total 164 (61.59%) of them responded that mushrooms were the collected sometimes, (33.41%) of the

respondents indicated that mushroom could be gathered, when needed and the remaining (5.71%) of them reported that mushrooms gathered every day.

4.7 Ecology of the wild edible mushrooms

From those respondents, about 34.3% of the respondents confirmed that mushrooms were collected from Soor green area, 26.3% from the Cokki, 23.3% from the Medalu and 16.2% from the Bishary/Tullube green area. According to data of investigation observations was showed, relatively there is high diversify of edible mushrooms in the Medalu green area than others parts of the green area. Both genus Termitomyces and Agaricus species were dominated in the Medalu green area that located southwestern part of Metu town than the others area.

4.8 An indigenous knowledge transfer

Dissemination of the indigenous knowledge of the wild edible mushrooms among the Metu inhabitants is relatively just sharply on decreasing in the area because of different factors. Based on data of interviews showed that an indigenous knowledge of the inhabitants on the wild edible mushrooms has been transferred orally from parents to new generations. In addition to that, there is few an indication that it has been disseminated through folk taxonomy from parents, elders, agricultural experts and educational experts (teachers) to the new generations in study area.

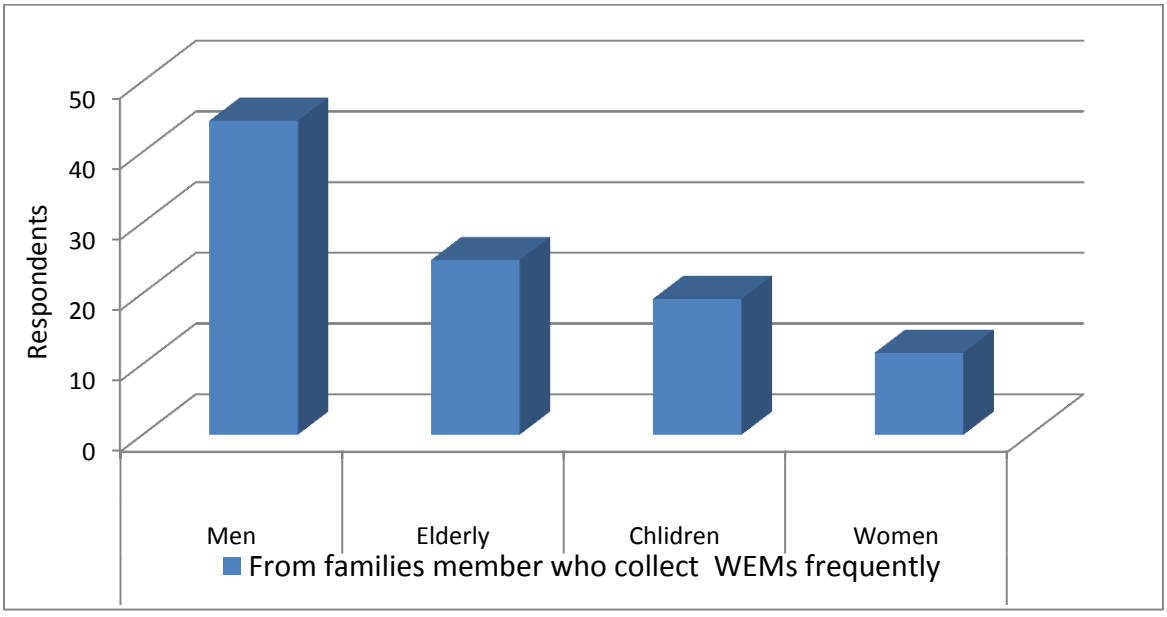


Figure 16. from the families who frequently collect mushrooms

According to figure 16 showed, about 44.4%, 25%, 19% and 12% of respondents confirmed that WEMs were collected frequently by men, elders, children and women in respectively (figure 16). In contrast, according to (Miriam *et al.*, 2006; Garibay-orijel *et al.*, 2012; Treu and Adamson, 2006; Yongabi *et al.,* 2004) ethnomycological study was reported that women and children are more involved in collecting of wild edible mushrooms either for food preparation or sale at local markets, dye extraction for rural cosmetics or for religious rites.

Based on data of this ethnomycological study observation regarding to the ways of they prepare mushrooms for the meal as in different forms such Tibsi, Salad and Wet. From those form of meal Tibsi was a form of meal which commonly practice in the area. From those interviewers, majority of them were referred to a process of preparing meat for a Tibsi (in Amharic language).

Mushrooms Tibsi can be prepared in the following process of a step: these are after it's have been collected from the fields should be washed thoroughly and then peeled properly and remove unnecessary things from the surface of mushrooms and also cutting the peeled mushroom into small pieces as well as cutting of meat for Tibsi. Take and mix with the substances that already prepared and then putdown on a fire. Finally, after 5-7 minute, the made Tibsi of mushrooms shall be removed and it transfer to bread and injera for the consumption.

Termitomyces spp, Mushrooms collecting field, and Preparation of the Mushrooms for a meal.

Figure 17. Field and home observation

4.9 Preservation of the wild edible mushrooms

According to those respondents showed regarding to an experience of inhabitants in preservation practice of the edible mushrooms for future generations and next time, majority (79.8%) of respondents confirmed that mushrooms were not preserved in their area that might be due to lack of an experience sharing among their pre-parents in the area, lack of well development of indigenous knowledge of edible mushrooms in the area and etc. However, only few (20.2%) of respondents confirmed they have been with an experience of preserving of wild edible mushrooms. Therefore, according to this ethnomycological study, mushrooms not well preserved in study area for their new generations.

In contrast, according to (Garibay-orijel *et al.,* 2012; Tibuhwa, 2012b) report, though in some part of the world people prefer the dried form of mushrooms. It is because the moisture content of most mushrooms fruit bodies are more than 80% and it requires immediate drying before it deteriorate and (Lampman, 2004). many other ethnomycological studies have showed the preferred use of fresh WEMs as food.

4.10 Marketability of the wild edible mushrooms

Based on this ethnomycological study was conducted regarding to the marketability of the wild edible mushrooms, they were not practiced as well as the others wild edible plants in study area. Similarly, majority (81.8%) of respondents argued that mushrooms were not practice to bought/sold in local market that might be due to a gap of knowledge and positive attitude for importance of the mushrooms for consumption among inhabitants, but only (18.2%) of respondents were argued with the marketability of edible mushrooms in the Metu area (figure 18).

Similarly, according to (Garibay-orijel *et al.,* 2012; Tibuhwa, 2012b) report, majority (78%) of respondents revealed that mushrooms were preferred in fresh form, but 22% of them preferred in dried form. In contrast, according to the report revealed that mushrooms are in some part of the world people prefer the dried form of mushrooms.

In other hand, overall of key respondents were confirmed to not experienced in selling/buying of the wild edible mushrooms in the area. However, few of them were suggested that mushrooms

were marketed for medicinal purpose than for the consumption. Furthermore, mushrooms were bought/sold in both fresh and dried form for the medicinal value. In contrary, according to some of the ethnomycological studies reported in Ethiopia, there are some an indications of marketing mushrooms for food purpose and medicinal value in different parts of Ethiopian country.

Similarly, according to (Teferi 2013 *et.al*) reported, about 10.37% of respondents indicated that poor economic status could be a reason for discouraging mushroom consumption (in case mushrooms were sold in very few local open markets) and similarly, (20.37%) of respondents also felt education/knowledge level negatively contributes. On the other hand, few (3.66%) of respondents mentioned that religion was a reason to be considered as obstacle to constraint mushroom consumption.

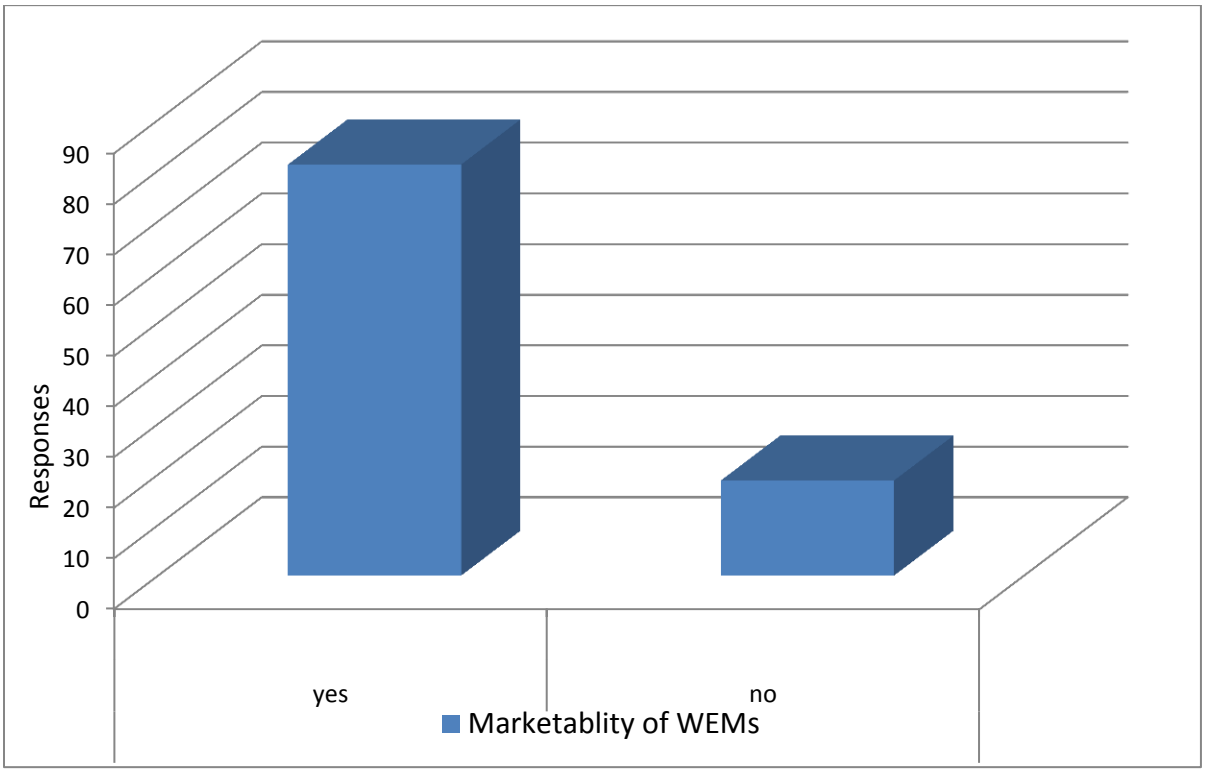


Figure 18. Marketability Mushrooms in area

Moreover, (Miriam *et al.*, 2006; Boa, 2004) was reported in most east, west and central Africa and south East Asia, marketability could also show that the WEMs might be overharvested and as a result are under pressure as they are purposefully collected from wild for economic reasons.

4.11 Preference of Wild Edible Mushrooms

Wild edible mushrooms were not equal needed in the community because of their mushrooms value are varies. Marketability of wild edible mushrooms was sold/bought by 10-20 birr per full of hand hold (1/2kg) in the area. However, mushrooms such as genus of Termitomyces, Agaricus and Laetiporus sulphureus (polypore) were the most expensive and highly wanted of mushrooms among inhabitants of the Metu area.

According to key respondents revealed, termitomyces have been the most expensive and wanted among the community. Among those respondents suggested that regarding to the reasons why some mushrooms were more expensive than the others, about 35% of them confirmed that mushrooms were expensive among the communities due to its meaty flavor, 30% medicinal values, 22% good smell and also 10% of them confirmed that in case of its delicacy for food consumption in their area. In contrast, according to (Yehuala, 2010), Wild mushrooms are generally not among NTFPs for sale in Ethiopia.

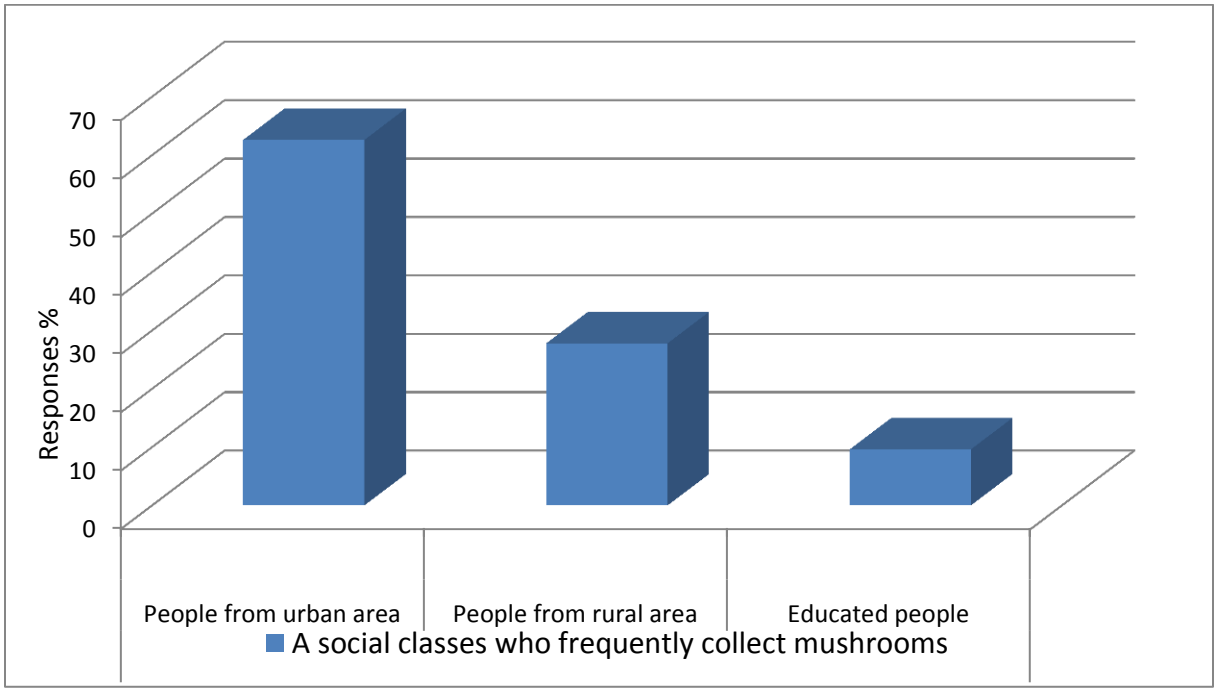


Figure 19. a social group who frequently collect mushrooms

Among those respondents revealed regarding among the social group that frequently buying wild edible mushrooms, significant (62%) of respondents confirmed that mushrooms were frequently bought by the urban inhabitants, (27.6%) and (9.5%) rural social group and by educated peoples in respectively in the Metu area (Figure 18).

Majority (92.4%) of respondents confirmed that mushrooms were transported by human carrying to their home and everywhere its needed, but about (7.6%) of them argued that mushrooms were transported by domestic animals such as by donkey. However, according to key respondents, all of them confirmed that mushrooms were transported by human carrying to take everywhere its needed in Metu area. Similarly, from 198 respondents confirmed that majority (85.9%) of them argued that they had not confirm with the poisonous person was occurred in Metu area. However, few (14.1%) of participants confirmed with it.

4.12 The diversity of wild edible mushrooms at Metu Area

In the Metu area there are high diversity of WEMs, but only some of them are well recognized in the community that just stated as following with their local names, species, genus, family and habitat that categorized into the Palatability (P) and non-palatability (NP**).**

Table 5 list of the diversity of wild edible mushrooms in study area

No	Species	Vernacular Name	(P/NP)	Habitat and Substrate
1	Termitomyces	Hukkoo	P	Farm Land, Termite Nests
2	Termitomyces	Tilaa jaarsaa	P	Farm Land, Termite Nests
3	Termitomyces	Uddaan jarsaa	P	Grazing Land, Termite Nests
4	Termitomyces	Dhuufuu jaarsaa	p	Grazing Land, Termite Nests
5	Termitomyces	Tilaa jaarsaa	P	Grazing Land, Termite Nests
6	Termitomyces	Tilaa jaarsaa	P	Grazing Land, Termite Nests
8	Termitomyces	Coommee	P	Grazing Land, Termite Nests
9	Laentiporus sulphureus	kereroo	P	Forest, on log of tree
10	Agaricus spp	Dalachoo		

According to data of **Table 4** illustrated that non-edible mushrooms are not name vernacularly as well as edible mushrooms that might be due to lack of well significant attention, but sometimes they were general called “dhuufuu jaarsaa” (fart of elders men).From those the following mushrooms have been collected during this field observation of ethnomycological study. These are included three genus of edible mushrooms:

Figure 20 Termitomyces species

This species Termitomyces relatively has convex shape of pileus and surface cream to light brown becoming dark brown and Margin incurved, splitting radially at maturity and Lamellae free, cream to pinkish, thin, crowded with numerous lamellae broad, Taste mild, and odor strong and pleasant.

Figure 21 Termitomyces species

This a photography Termitomyces has the convex pileus of the mushroom and broad convex, often umbonate, upper surface whitish to cream in the premature, darkening at the center, dry and distinctive characteristics of this species is small size, occurrence in dense troops and the absence of pseudorrhiza. Similarly, its association with termite, the presence of pinkish spore and other micro morphological characters that it shares with other species in the genus lead mycologists to put it under this genus.

Figure 22. *Termitomyces* species

This Termitomyces is a conical and convex, pointed to perforatorium, surface grey crowded wide and, ivory/creamy. Stipe is thick, white, solid, central, and cylindrical slightly tapering down wars. Taste and Odor mild the fruiting body appear after good rains from mid-July until the end of September.

Figure 23. Termitomyces species

This Termitomyces is convex that covered with thick large persistent scales concentric and forming plate-like covering at disc, surface white. This is that well known for its large robust fruiting body. It is rough scaly cap and stem, the brown scales of the cup (Figure 23).

Figure 24. Agaricus species

This species Agaricus has been one of the wild edible mushroom that commonly collecting from grazing land particularly at decayed wood trees during the rainy seasons. Similarly, the occurrence of mushrooms in these forests is widespread during the rainy season in area **(**Figure 24).

Figure 25. Laetiporus sulphureus

This is Laetiporus sulphureus a mushrooms that is grows on the wood of trees and had yellowish color. It has been rarely consuming, but highly wanted for medicinal purpose in the study area. Laetiporus sulphureus is also relatively hard than the Termitomyces and Agaricus species. According to (Woldegiorgis *et al.,* 2015a), the fatty acid profile: antioxidant property (Woldegiorgis, *et al.,* 2014) of some wild edible mushrooms and cultivated edible mushrooms and medicinal property of Laetiporus sulphureus, collected from Ethiopia have been an evaluated.

Therefore these mushrooms are which commonly found in study area. However, majority of the mushrooms have been did not explored for the food consumption due different factors.

There are different factors that can be negatively discouraged inhabitants in involving for benefit of wild edible mushrooms. These are such as poorly transferring of the indigenous knowledge and negatively perception of inhabitants for mushrooms characters like all that grew at a dirt area, smaller size of mushrooms, with mild taste, not good smell and watery, which have red, yellowish and too blackish, which gave burning sensation on tongue, grew around dung, deep white mushrooms are generally considered as they are the non-edible mushrooms.

In addition, misinformation about mushrooms and negatively interpretation/perception for the mushrooms like, it is a rural residents food and relate with modernity that can discourage Metu inhabitants for the edible mushrooms. Moreover, there is some traditional taxonomy (folk's name) of mushrooms, which might be discouraged for the positive attitude of them. These are such as "fincaan booyyee" (a product of the pigs urine), "miidhaan seexanaa" (a crops of an

evil), “dhuufuu jaarsaa” (fart of elders), “qaama seexanaa” (organ of evil) are also the others challenges. Furthermore, there are also the others untangeable information, like such as mushrooms are causative agent of diseases (source of diseases), that are the product of the others things/animals, they are useless nutrients and they have not given for us as the edible by the God.

According to this ethnomycological study, mushrooms are not on cultivating due to the reasons of the lack of the institution that involved in an actively promote of the agricultural ministries of the developing countries and neglecting of the individual of the inhabitants due to the lack of technical capacities for the production mushrooms and with the poorly equipped government supported advisory services resulting in interested farmers having to seek technology on their own; comparatively few studies on tropical mushrooms; and a lack of technical skills to produce spawn with suitable strains often hard to find. However, there suitable temperature, humidity, and light for the cultivation of mushrooms.

On the other hand, cultivations of require which require aspects of sterile handling technology are much more technically demanding. Mushroom cultivation is both a science and an art. The science is that developed through research; the art is that perfected through curiosity and practical experience. Mushrooms growth dynamics involve some technological elements that are in consonance with those exhibited by our common agricultural crop plants.

Based on data of figure 26 showed regarding to coverage status of wild edible mushrooms in the area, about 50.3% of respondents confirmed that coverage of mushrooms are decreasing through trends of a years, 24.9% of them argued that they could not decide their suggestion whether either the coverage increased or decreased in the area and 20.8% of respondents confirmed that with not changed. However, all the key respondents confirmed that they were sharply decreased in the area.

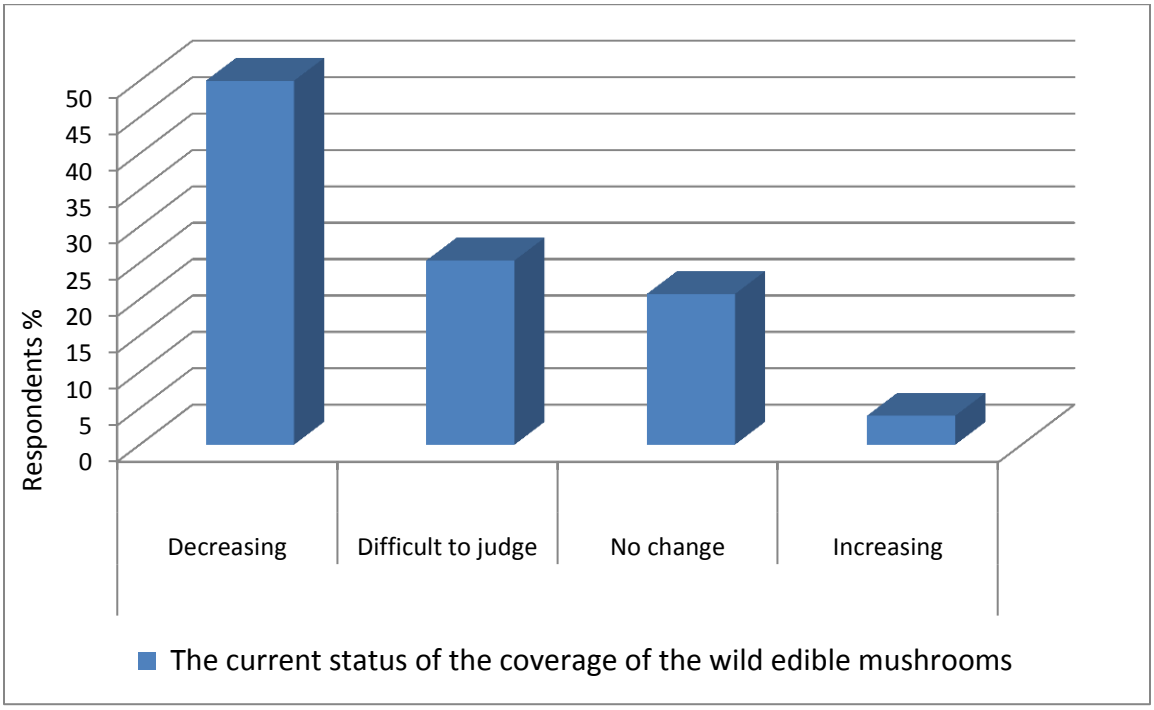


Figure 26. the coverage status of mushrooms

According to several literatures were revealed that mushrooms were sharply on decreased particularly in the developing countries including Ethiopia. Similarly, the requirement of mushrooms was increased among the communities of the world for the consumption due to their high chemical composition of the protein, vitamins and fiber contents and having certain medicine properties in the world because they could be enhance to build human immunity, use to reduce cholesterol accumulation in the blood, would healing of the some infections, for healing some types of the allergies and tumor retarding effects etc.

On the other hand, in developed countries such as Europe, North America, Japan, Korea, and the Russian, not only the tradition of eating wild edible fungi but also a wise use of these resources is much stronger and appears to have resisted the problem experienced elsewhere (Arora and Hepard, 2008; Miriam et al., 2006). Similarly, in countries like Japan, the Republic of Korea, China, and the Russian Federation, the tradition of eating wild edible fungi is much stronger and appears to have withstood the changes experienced elsewhere as stated by Boa (2004).

Based on the data of figure 27 showed that about 50.8%, 21.3%, 16.2% and 10.7% of respondents confirmed that mushrooms were decreased in the area due to the deforestation,

habitat destruction, overgrazing and populations pressure in respectively. Similarly, according to (Teferi *et.al* 2013) report that there has been significant trend of decreasing mushroom in the past years as confirmed from the residents of Wacha kebele mainly due to decline in forest coverage in the area. Since there has been expansion of agricultural land around the study area in the past years due to human population pressure, it was clear that deforestation is the main factor to reduce such essential non-timber forest product. It is also logical that chemicals (particularly agrochemicals) were additional factors to seriously affect the mushroom distribution as farmers use the chemicals to boost crop production. Moreover, (Guissou *et al.*, 2008) alarming decline in wild edible mushroom populations has been reported from central part of Burkina Faso which was closely linked to disappearing forest habitats.

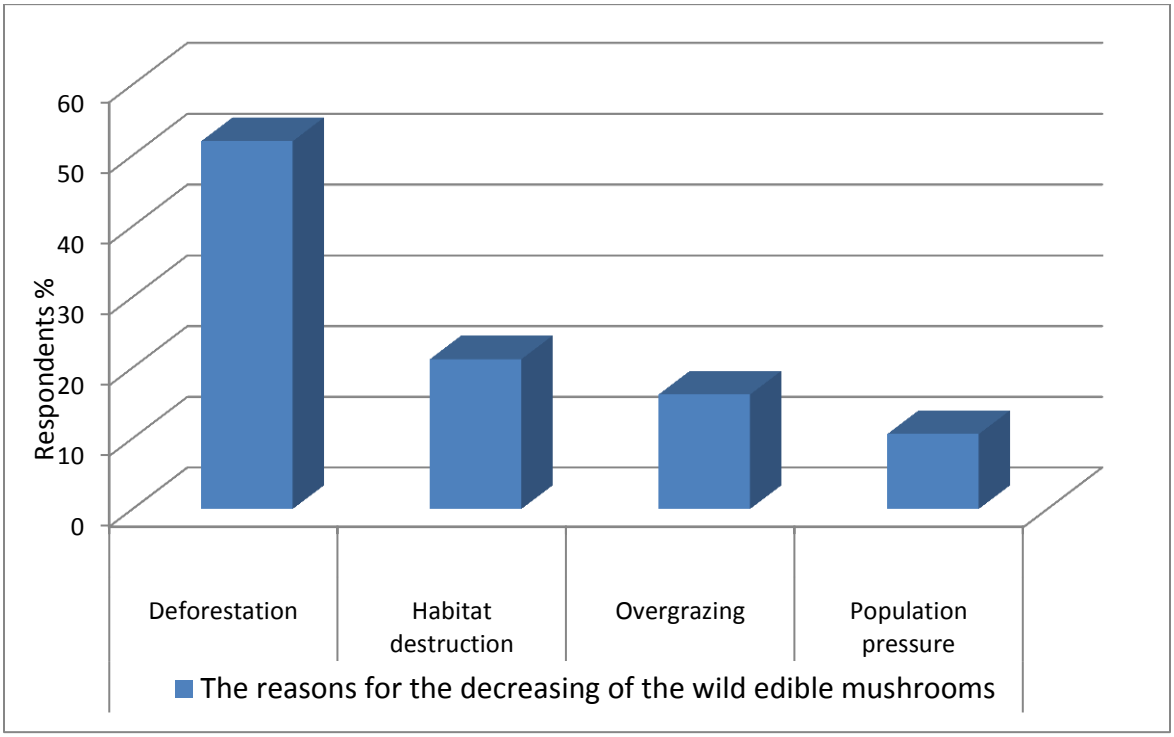


Figure 27. the reasons for the decreasing of wild edible mushrooms

In general, mushrooms have been decreasing due to increase of the urbanization, climate change occur, loss of mushrooms habitats for mushrooms diversity, increase of the population growth, change of inhabitants for their consumption habit, exotic plants and agrochemical effect in the area are the main factors. Similarly, according to the other report, the tradition of collecting and consuming WEMs among rural populations in countries such as India is on the decline because

of growing urbanization and the associated changes in food habits (Agrahar-Murugkar and Subbulakshmi, 2005).

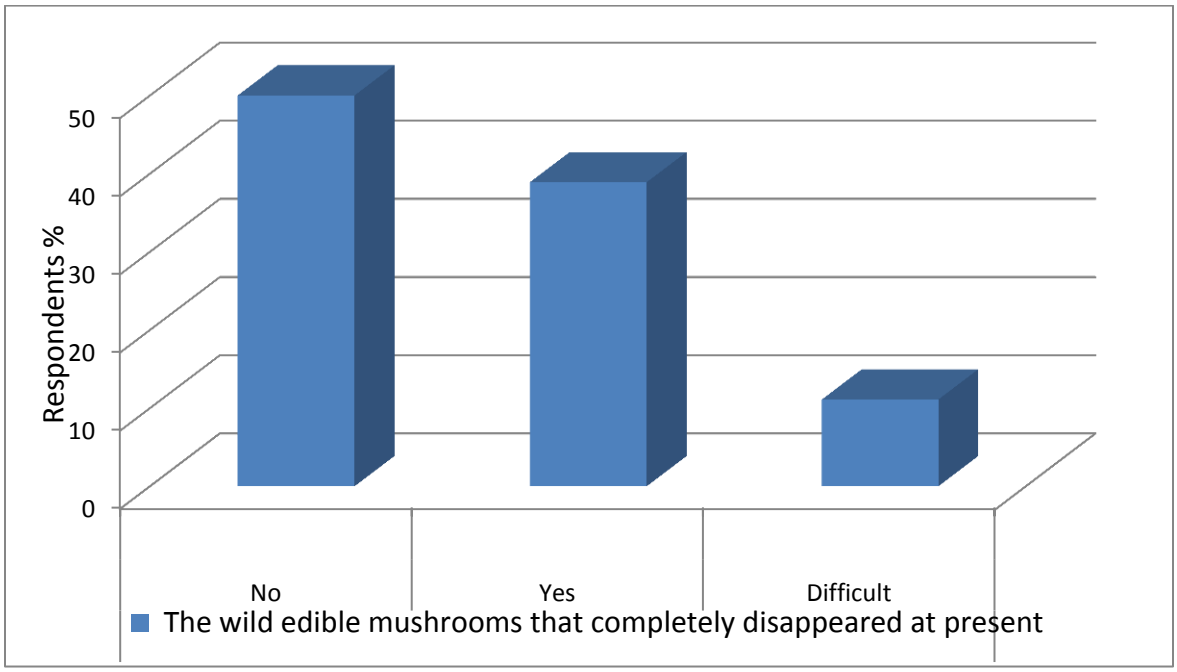


Figure 28. response of mushroom disappearance

Similarly, from 198 of respondents 49.7% of respondents were not argued with the suggestion of the completely disappearance of mushrooms and 39.1% of them argued that they were suggested for occurrences of there are completely disappeared the wild edible mushrooms. However, about 11.2% of them were not decide in the study area. In general, according to data observation and key respondents suggested that some of the mushrooms were completely disappeared, but some of them rarely possible to found in the Metu area.

4.13 Adoption and cultivation of the wild edible mushrooms

Majority (86.8%) were not argued for the possibility of wild edible mushrooms adoption/cultivation in the Metu area, but few (13.2%) of respondents confirmed that they were argued with the possibility of an adopting/cultivating of the WEMs. Similarly, according to other report, in Ethiopia the practice of mushroom cultivation is a recent activity, mostly restricted to urban areas (Yehuala, 2008; Abate, 2014). However, around the world about 60 mushroom species have been cultivated commercially (Chang & Miles, 2004).

According to the key respondents argued that mushroom was not practiced to cultivate in the area. Even majority of them have not had any information about the possibility of cultivation/adoption of the wild edible mushrooms in elsewhere. In contrast, cultivation activities of mushrooms have been observed to serve various purposes in different countries. For instance, in Japan mushroom cultivation is an income generating activity both in rural and urban areas (Daba *et al.,* 2008). Similarly, the most common species include Agaricus bisporus, Lentinula edodes, Pleurotus ostreatus, Flammulina velutipes, Volvariella volvacea, Grifola frondosa, and Pholiota nameko (Gizaw, 2010).

In other hand, majority of respondents had high interesting to involve in the activities of adopting/cultivating wild edible mushrooms in the Metu area. However, according to (Yehuala, 2008; Gebrelibanos *et al.,* 2016) and P. florida (Gebrelibanos *et al.,* 2016), agricultural and agro-industrial wastes have been used at a small scale to produce four most commonly cultivated mushrooms: A. bisporus, L. edodes, and P. ostreatus in other part of the Ethiopia.

An operating and maintaining environmental controls require a certain degree of technical expertise and it need culture of adoption of wild edible mushrooms. Pest control is also critical because some insect pests, such as fungus gnats, flourish under the same conditions that favor mushrooms and with high yields and short production cycles, harvest windows are short, so, institute and civil organization have great responsibility to engage the inhabitants to involve in the process of cultivation and adopting wild edible mushrooms which is a science and an art.

Mushroom growth dynamics involve some technological elements that are in consonance with those exhibited by our common agricultural crop plants. Mushrooms adoption and cultivation are very important to improve the consumption habit of the Metu inhabitants to benefit human kind to conserve indigenous knowledge and positive attitude to edible mushrooms, to improve food security and to benefit health from the nutritional value of the edible mushrooms.

4.14 The folks of the Metu inhabitants for the wild mushrooms

Indigenous knowledge of some things can conserve oral in the form of the folks among the communities. There are different a folks of wild edible mushrooms in Metu area including such as:

“Coomaa fi coommee irraa maaltu goraa?” literally meaning, is nobody who away from eating of mushrooms. This indicated that both white meat and mushrooms are equal important for the

consumption. This concept is indicated that mushrooms had good want for food consumption as well as to a meat.

“Nyaatni coomaa namarraa hin baasu arraa coommee!” is consumption of white meat (coomaa) could not respond for the person who was stimulated for a mushrooms. According to this above folk, the consumption of the mushrooms was more preferred than the consumption of the white meat among the inhabitants.

“Coomaaf mititii commeefu hin nanu! etc.” It mean, not for the white meat, even we don`t care for a mushrooms. So, this is indicating that mushroom have been preferred than the white meat for consumption in the Metu area.

Mushrooms have different folk name including such as Horronqoo, Habuuttaa, Abba marqoo, Hingudaayee, kararoo, Dhuufuu jaarsaa, Coommee, Waakkoo, Jaarsa marqoo, qondalee, Huukkoo, Zuubii, Qorondallee, Kochaa, Hibibii, futtaa, Amboshillaa etc are a mushrooms name that calls interchangeable among the Metu inhabitants in Afan oromo. However, both the Coommee and Huukkoo are the most commonly used folk name of the edible mushrooms. In addition, some non-edible mushrooms also had shared name with edible mushrooms. Therefore, this condition indicated that none of well did on the ethynomycological study in the area. So that, ethnomycological study especially taxonomic of the mushrooms are highly required in the study area for further study of the wild edible mushrooms.

Moreover, there are some traditional taxonomy (folk’s name) of mushrooms, which could be discouraged negatively Metu inhabitants for WEMs. These are such as “fincaan booyyee” (urine of the pigs), “miidhaan seexanaa” (a food of evil), “dhuufuu jaarsaa” (fart of elders), “qaama seexanaa” (organ of evil) are also the others challenges. Furthermore, there are also the others intangible information, like such as mushrooms are act causative agent of diseases (source of diseases) and they are useless nutrients and not given for us as the edible.

By helping to share indigenous knowledge within and across communities, the development community can learn a lot about the local conditions that affect those communities. Indigenous knowledge should complement, rather than compete with global knowledge systems in the implementation of projects. Moreover, this process can contribute to better cross-cultural understanding and to the promotion of culture in development. However, above all investing in

the exchange of indigenous knowledge and its integration into the development process can help to reduce poverty.

4.15 The threat and Conservation for mushrooms

According to Figure 29 showed, from the 198 of respondents about 44.2% of them confirmed that wild mushrooms development discouraged by both the rain and soil properties and about 29.9% affected by heavy thunder rain roles. However, about 26% affected soil type coupled with heavy rains roles.

Similarly, there are different factors that had great role for the development of the wild edible mushrooms. These are including: vegetation types (plant association or degree of host), precipitation (temperature), succession (when host changed the equality of accessibility of organic matter also changed), geography (diversity of habitat strongest impact because of temperature), seasonality (that limiting by absence of precipitation and excess moisture hinder fruiting of mushrooms), agrochemical input (fungal pesticide that kill microbial and micro flora) and physicochemical properties of soil (bulk density affect porosity that responsible water holding capacity, ph., electron conductivity and organic matter and spent capacity) are influence on the growth of mushrooms.

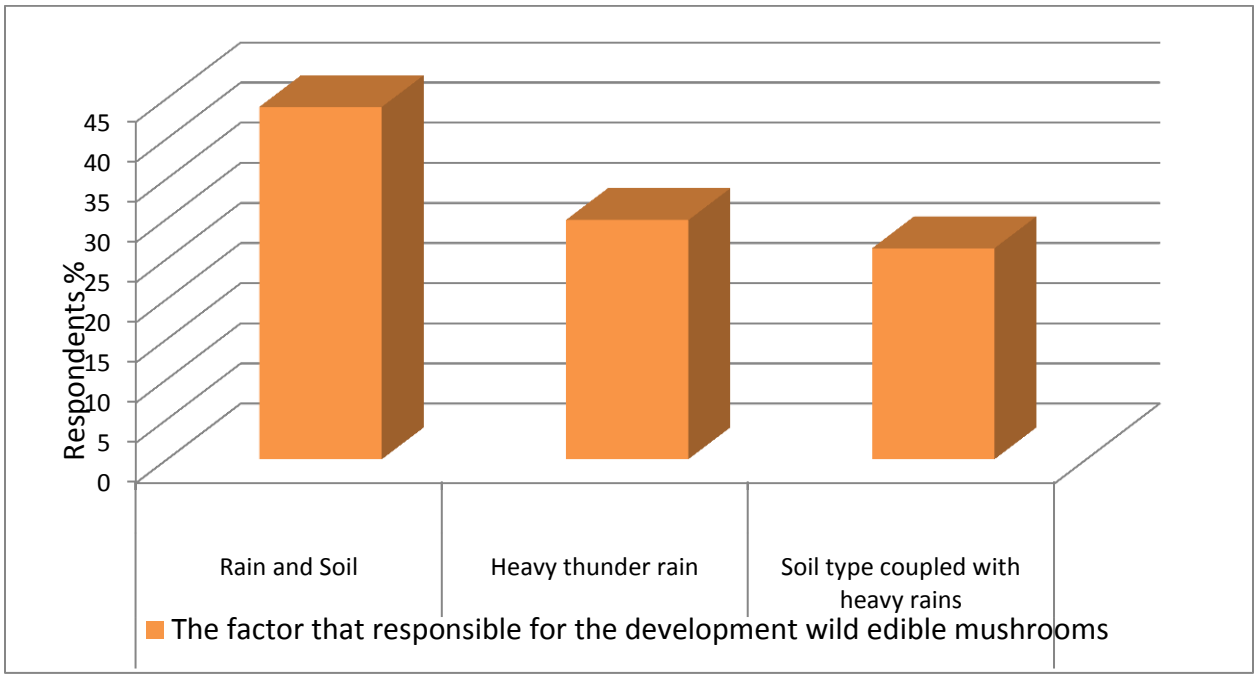


Figure 29 the factors which role in development of the mushrooms

Similarly, according to some earlier studies described about the distribution of macro fungal species (especially ectomycorrhizal fungi) to be correlated with forest type (deciduous trees or conifers), since every fungus shows a certain degree of host or substratum specificity (Anderson *et al.*, 2013). However, in other studies it was believed that precipitation to be better than vegetation type as a predictor of species richness of macro fungi (O'Dell *et al.,* 1999).

In addition to that, other main factors could be effect on wealth indigenous knowledge of wild mushrooms. These are such as deforestation, agricultural expansion, urbanization/population pressure and use of agro-chemicals and also habitat degradation, such as fires, are also affect the mushrooms communities in forest systems which is also a recurrent phenomenon in the natural forest systems. Similarly, many threats affecting wild mushrooms are similar to those that globally affect the biodiversity in Ethiopia (IBC, 2005). Moreover, the most important of all, deforestation, comes because of anthropogenic change to which global environmental and climate change.

Therefore, such as poorly understood, habitat loss, environmental pollution, climate change, under researched and underfunded are the most threaten for the developments of the mushrooms. Therefore, understanding, documenting mushrooms diversity, conserving mushrooms diversity, using mushrooms diversity in sustainable, build capacity for the mushrooms conservation, restoration and adoptive management are the main solutions for the development wild edible mushrooms. In addition to that, local knowledge help for the data of mushrooms collection, provide management plan, design adoptive strategies, and institutional support to put policy into practice for deforestation, anthropogenic change and fire decisions have great role in the sustainable use of the mushrooms.

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Conclusion

According to this study was revealed, there were indications of less involvement of organizations, institutes and civil societies in the disseminating of indigenous knowledge of the wild edible mushrooms in the Metu town.

Dissemination of indigenous knowledge of the mushrooms for consumption could be play significant role for food security and also enable experts to establishment of a center of the mushrooms study particularly regarding to their diversity, associated utility and practice. There are some negative perceptions that might be directly and indirectly discourage the support groups to negatively funding project, communities' loose attention for their edibility and influence experts of researchers to investigate for the furthermore work on the wild edible mushrooms in the country. In general, little use of information dissemination is a clearly indicating to different regarding organ to work hard in promotion and creating awareness in structured ways in order to transform communities among the inhabitants for the future.

Rapid rising of the population growth is a global issue and global threaten factor that can be directly influence livelihood of the communities as whole by increasing the demands for food, domestication and cultivation of indigenous varieties of edible mushrooms to be ensured the alternatives of that might be contributed to nutritional security with comparative small holding and cheap substrates such as agricultural solid wastes, thus leading to reduce environmental pollution, natural conservation, create a job opportunity and encourage communities to sustainable use of natural resources in the country. However, if this population growth is not managed and solved by science and knowledge of technology and by well wisdom may enable to develop problems among the communities.

According to data of different reviewed literature more of them showed that, there are some review literatures of the wild edible mushroom that is gathering of mushrooms for their food value. However, Wild mushrooms were poorly practiced for the generate economic value for the local people in Ethiopia, but it did not assessed in all corners of the country (limited into some regions), particularly all the available ethnomycological notes focused on specific areas

such as the west and southwest parts of the Ethiopia. However, ethnomycological study of mushrooms was not well considered in Oromia region except few of studies that take place in central Oromia region. Therefore, ethnomycological study was not well assessed, documented and explored in the Metu area.

Thus, researchers encourages more research and documentations to reveal the wild edible mushroom in different corner of the country. There are only certain review literatures of the wild edible mushrooms and some lists of mushrooms that commonly used in the country. In addition, there is high diversity of species but its need hard work to distinguishes species of mushrooms, illustrate characters of mushrooms and document diversity of the mushrooms. However, diversity of the mushrooms was decreased highly in the Metu area. Even, some of the species might face to extinction in their habitats because of the being altered by human activities and poorly managed of natural resource in the country. Therefore, indigenous knowledge of edible mushroom was poor considered and under threatens in Ethiopia.

5.2 Recommendation

All the concerned bodies include different organizations, institutes and civil societies should be responsible to establish a center for documentation and teach the traditional knowledge of the mushrooms to carry out furthermore investigation on the wild edible mushrooms and also to sustainable use this natural resource. Researchers should be investigate to identify edible mushrooms from the non-edible mushrooms, introduce edible non-edible mushrooms and take responsible to teach a peoples to aware and transform negative perception and also adopt positive attitude.

Parents' and elders should be having transparency for their new generation to transfer indigenous knowledge or information of wild edible mushrooms in order to they have to use this natural resource in a sustainable ways. As much as possible all the concerned body should be responsible to be create positive attitude among inhabitants towards the adoption and cultivation practices by providing professional support.

Conservation activities of the mushrooms shall be in in-situ and ex-situ need to be a followed by taking measures for protection of the forest from grazing, human interference, and other anthropogenic influences.

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ADDIS ABEBA UNIVERSITY

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Appedix: I

Questionnaire for the Ethnomycological study that associated to assessment of an indigenous Knowledge and Attitude Metu inhabitants Practice on the Wild Edible Mushrooms. These questionnaires were prepared to collect information from selected respondents for the accomplishment of thesis program. The findings of the study will only be used for academic purposes, to make recommendation based on findings in order to improve the system and hence you are kindly requested to forward your views and experiences as carefully as possible. Each of your answer has great contribution for the completeness of the research paper. I would like to thank you in advance for your kind cooperation in responding to this questionnaire. The information generated in the study kept confidential.

I. Instructions:

1. Do not write you name

2. Place a tick mark "X" and circle in the boxes and / or briefly write your response in the space provided. 3. Attempt all questions

A. Demography characters

1. Sex: _____

2. Age: _____

3. Ethnic: _____

3. Level of education: _____

4. Type of work: _____

B. General Knowledge and attitudes about Wild Edible Mushroom

1. Do you know mushrooms?

Yes

No

2. Do you benefit from the wide edible mushrooms?

Yes

No

3. Where do you get knowledge of the wild edible mushrooms?

From School

From local medicinal experts

From religious bodies

From agricultural experts

From NGOs

From others sources

4. What is the importance of wild edible mushrooms collection for the community?

For food and health benefits

For religious purpose

c. Entertainment

d. Others

5. Do you have an experience of mushrooms for food purpose?

Yes

No

6. If yes, which kind of mushroom?

_____

_____

_____

_____

_____

7. Why you like to consume mushrooms?

Its substitute to meat and fish

Its good taste

Its delicacy

Good smell

8. Which of the following functions you get from feeding of mushrooms?

To get heat and energy

To build our body

To get resistance and build immunity

Others

9. Where do you get knowledge regarding collection and importance of the wild edible mushrooms?

From School institutional

From agricultural sector

From the health sector

Mass media

9. Do you use wild edible mushrooms as the medicinal purpose?

Yes

No

10. If yes, for what types of disease?

anti-inflammatory

analgesics

homeostatic

diuretic

nourishment

antibiotic

anti-tumor

11. Why you preferred to use for medicinal purpose?

Easily found in our surrounding

It is too cheap

It is better to cure than modern medicine

Others

12. What the traditional beliefs in your community/tribe concerning mushrooms appearance?

Ceremonial

Religious roles

Hallucinogenic properties

Others

13. Did you involved in the collection of wild edible mushrooms?

Yes

No

14. If your answer is yes, how do you differentiate the wild edible mushrooms from the poisons?

Color

Smell

Taste

16. Would you indicate the abundance period of the wild edible mushroom in your locality?

Summer/ wet seasons

Spring seasons

Autumn seasons

Dry seasons

17. Which is the specific location for wild edible mushrooms collection?

Termite mounds under big trees

On log or wood Swampy areas

Farmed areas Garden

Dry lands

Cattle field

Others

18. How do people go for searching of mushroom?

By deliberately searching when collecting fire wood

By chance or randomly

Birds sound

By observing a muddy soil when keeping cattle

Any other

19. Which is the forest you are collecting wild edible mushrooms?

Bashar

Cokki

Soor

Wuci

20. Who frequently collect wild edible mushrooms?

Women

Men

Children

Elderly

21. How are wide edible mushrooms prepared for the meal? Explain the local recipes or procedures:

_____

_____

_____

_____

_____

_____etc.

22. Do you preserve mushroom for future use?

Yes

No

23. If your answer is yes, how do you preserve?

_____

_____

_____

_____

_____

_____

_____etc.

24. Are wild edible mushroom sold in your local markets?

Yes

No

25. If yes, in what form?

Fresh

Dried

26. Estimate the price of the mushroom per kg_____

27. Which mushroom type/s is (are) the most expensive? _____

28. Why this mushroom is most preferred one? Due to its:

Its delicacy

Meaty flavor

Medicinal value

Easley digestible

Good smell

Others

29. Which social groups buy mushrooms more frequently?

Educated people

People from rural area

People from urban area

30. How do people transport the mushroom to local market?

By human carry

Domestic animal

31. Did any mushrooms poising occur in the area?

Yes

No

32. If yes, because of which mushrooms types _____.

23.Which genus of mushrooms are dominated in the study area?

_____
_____
_____
_____

34. What is the current status of wild edible mushrooms distribution in your locality?

Decreasing

Increasing

No change

Difficult to judge

35. If decreasing, what do you think will be the main reason (s)?

Deforestation

Overgrazing

Population pressure

Habitat destruction

Urbanization

Agro-chemicals (herbicides, fungicides) urbanization

36. Are there wild edible mushrooms, which totally disappeared at present?

Yes

No

Difficult to judge

37. Do you believe for the possibility of cultivating mushrooms artificially?

Yes

No

38. Do you want to adopt mushroom cultivation in your locality?

Yes

No

39. Are there any folklore.

_____
_____
_____
_____
_____
_____
_____

40. Which the factors that responsible for mushrooms development?

Rain and Soil

Heavy thunder rain

Soil type coupled with heavy rains

41. How are indigenous knowledge of the edible mushrooms transferred?

42. what are the threats for sustainable use of mushrooms?

Summary of the collected wild edible mushrooms species in Metu town

Figure 30. 1 ***Termitomyces m. m.***

Figure 30. 2 ***Termitomyces m.***

Figure 30. 3 ***Termitomyces***

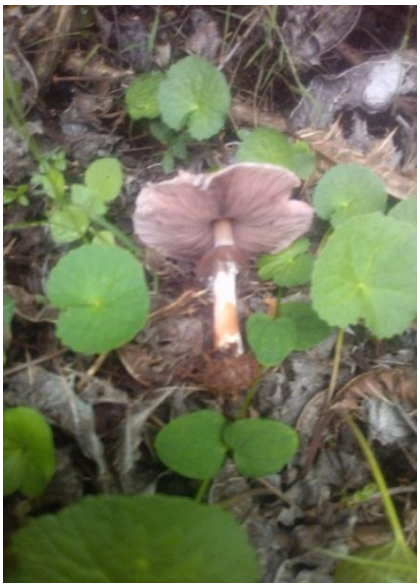

Figure 30. 4 *Termitomyces*

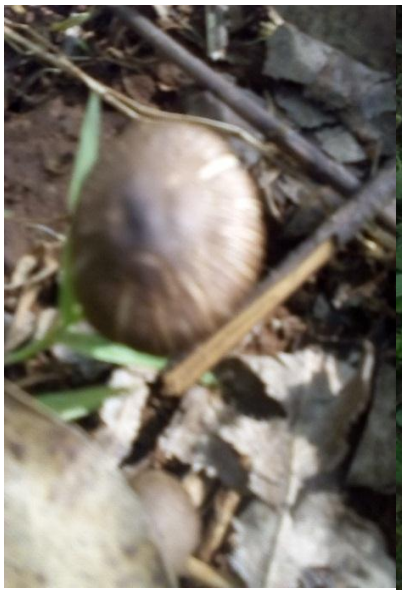

Figure 30. 5 *Termitomyces*

Figure 30. 6 Termitomyces

Figure 30.7 *Termitomyces*

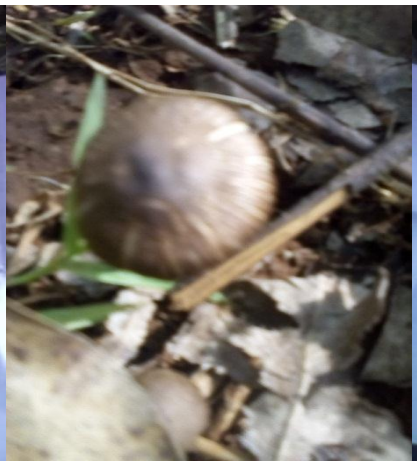

Figure *e* **30.8** *Termitomyces*

Figure 30.9 *Termitomyces*

Figure 30. *10 Termitomyces sulphurous*

Figure 30. *11 Termitomyces*

Figure *30. 12 Leatiporus*

Figure *30. 13 Agaricus*

Figure *30.14 preparing Agaricus for meal*

Figure 30. Summary the most commonly used wild edible mushrooms species