COLLECTION, IDENTIFICATION AND MORPHOLOGICAL CHARACTERIZATION OF INDIGENOUS MUSHROOMS IN COASTAL KENYA

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ABSTRACT

Mushrooms are consumed all over the world as part of the regular diet. They are consumed for their ample nutrition, medicinal value and enticing flavour. In Kenya, both cultivated and wild mushrooms are consumed, the latter forming an integral part of a long standing cultural practice. However, many people shy off from such wild sources due to fear of poisoning. That notwithstanding, these wild resources risk extinction due to climate change, over exploitation and wanton destruction of their natural habitat. To improve on their utilization, a survey was conducted in coastal Kenya to document the edible species which are known by communities but completely unknown to science. Species collected were identified and characterized using habitat, morphological features and any phenotypic features easily identifiable and categorized as edible hence a food source, poisonous or ornamental. The edible included *Ganoderma* spp, *Cantharellus* spp, *Agaricus* spp, *Pleurotus* spp, *Russula* spp, *Auricularia* spp and *Termitomyces* spp; poisonous species included the deadly *Amanita* spp, *Lactarius* spp and stinkhorn spp while ornamental included the beautiful ringed *Microporous* spp. The survey revealed a rich diversity of economic importance especially for food security if well exploited. Information obtained can be used as a baseline for future studies on genetic diversity, trends associated with climate change and on species for domestication. This information can also be used to improve the management strategy on sustainable utilization of edible species from the forests. However, further studies using modern methods of characterization involving molecular tools are required to improve on such strategies.

Keywords: indigenous mushrooms, edible species, poisonous species, ornamental species, sustainable utilization.

INTRODUCTION

Mushrooms are consumed all over the world as part of the regular diet. While some are cultivated, some are just collected from the wild and consumed. In Kenya, majority of the locals depend on wild mushrooms to spice their diets as cultivated species are exorbitantly expensive and unaffordable to many. Of the 42 tribes living in the country, 38 are known to consume them [1]. They form an integral part of a long standing cultural practice which is passed on from generations to generations[2]. Extensive consumption is however hampered by cultural bias in some communities and lack of adequate knowledge on edible and poisonous species.

According to Hawksworth [3] and Bates [4] the estimated number of fungal species worldwide is 1.5 million species and less than 5% have been described. Fungi producing conspicuous sporocaps are collectively called macrofungi and include gilled fungi, bracket fungi, coral fungi, jelly fungi, stinkhorns, birds nest fungi and puffballs [5]. A mushroom is defined by Chang [6] as a macrofungi with a distinctive fruiting body large enough to be seen with the naked eye and to be picked by hand. Each mushroom has its own special ecological niche and occurs only in certain habitats. They are found growing prolifically all over the world [7] and have been used since time immemorial as part of human diet. To date, they are collected and sold in over 80 countries and collections amount to several million tones with a minimum value of USD 2 billion [8].

Mushrooms can solve world's food shortage problem because of the fact that they occupy a place above vegetables and legumes but below the first class proteins in meat, fish and poultry [9]. They can also solve most of the world's health problems because they are endowed with bioactive compounds that are of medicinal value [10]. Due to their good nutrition and medicinal values, mushrooms are considered ideal for vulnerable groups in the society such as children, breast feeding mothers, the old and the sick especially those suffering from diabetes, heart diseases, cancer and HIV/aids.

In Kenya, several exotic varieties are cultivated which include *Agaricus bisporus*, *Pleurotus* spp, *Lentinula edodes* and *Ganoderma lucidum* [11,12]. However, there is preference for wild species as expressed during a KARI's stake holders work shop held in February 2007 [13]. But they risk extinction due to climate change and wanton destruction of their natural habitat which also poses a threat to biodiversity conservation. The wide spread practice of collecting wild mushrooms

for consumption among local communities also poses the danger of illnesses and possible deaths from poisonous species. Cultivated mushrooms are therefore the only safe and sustainable source of this delicacy, necessitating domestication of these wild types.

However, there exists scarce knowledge for these types of mushrooms in Kenya. Many different kinds are consumed from the wild and though well known by the local communities, they are completely unknown to science. Studies on the taxonomy and diversity of the same are gaining importance as many are facing extinction due to global warming, habitat destruction and or overexploitation. The present study was undertaken to collect, identify and characterize important indigenous mushrooms (both edible and poisonous) of Kenya, conserve specimens in a gene bank and document indigenous technical knowledge (ITK) about them from the locals. This paper highlights the identification and morphological characterization of the mushroom species collected during the study.

MATERIALS AND METHODS

Field surveys were conducted among the key indigenous mushroom consuming communities in coastal Kenya. Arabuko Sokoke forest in North coast and Kaya Teleza forest shrines at the South coast were surveyed. The forests were the main target but farms were also visited for collections as mushrooms grow everywhere during the rainy season.

A brief description of the sites

Arabuko Sokoke forest is the largest stretch of coastal dry forest extending from south of Somalia to Northern Mozambique. The forest comprises Brachystegia woodlands which are a perfect habitat for Mycorrhizal fungi. It extends 3° 19' 60'' and 39° 52' 0'' in DMS. Average annual precipitation ranges from 900mm in the Northwest to 1100 mm in the East with mean temperature of 31 °C. The elevation is 138 m above sea level. The Kaya Teleza forest shrines are part of Simba Hills which are a naturally rich biodiversity, barely disturbed for many years. The area is situated between 4°10' N and 39°10' S. Elevation is 251 meters above sea level. The annual precipitation ranges between 400 and 1680 mm with about 90% occurring between October-December (short rains) and March-June (long rains). The annual mean air temperature is 25 °C.

Mushrooms survey and sampling

The museums of Kenya and key informants were used in the selection of suitable sites for mushroom collection. The major criteria used for site selection was knowledge and utilization of mushrooms by the local communities. Fruit body surveys were considered for the primary basis of documenting mushroom diversity and were limited to epigeous macromycetes of soil and wood inhibiting fungi that were of appreciable size. Sampling in the forest was done across along transect to a distance of 1000 m x50 m along the forest line. Communities are not able to go deep into the forest for fear of dangerous wild animals. Sampling was done from three communities, two in north coast (from Malindi and Kilifi) and one in south coast (Matuga). Collection of various macro fungi was made and occupational habitat, morphological features and any other phenotypic parameters noted while the mushrooms were still fresh. Where possible, spores prints were also taken for colour. Specimens of fruit bodies were later dried using a field drier at a temperature not exceeding 40 °C. Dried specimens were carefully tagged, packed and tightly sealed in polythene bags for transfer to the museums of Kenya for further identification and characterization.

According to natural habitats, mushrooms were placed in any of the four habitation groups which include

i) Humicolous or Folicolous: humus inhabiting mushrooms which may be either purely saprophytic or growing in symbiotic with green plants without parasitic tendencies.
ii) Lignicolous: wood inhabiting fungi some of which are purely saprophytic but others facultative or obligatory parasitic
iii) Coprophilous: dung inhabiting mushrooms and saprophytic in nature
iv) Fungicolous: fungus inhabiting and saprophytic in nature

Fruit body identification and description

Specimens were initially marched with descriptions in books to facilitate classification. Identification was based on their reproductive structures visible to the naked eye above the ground. Specimens were later described for morphological characters such as size, shape, odour, texture and colour. Other morphological characters such as the ornamentation on the surfaces of the pileus and stipe, the presence of a ring on the stipe and volva at the base of the stipe were also used to describe and identify the mushrooms. As there is very limited reference collection, each specimen was fully described and

where possible, spores print taken for colour to confirm the specific taxon. The listed taxons were according to [14]. The specimens were also preserved in a herbarium at the Museums of Kenya to be used later for spawn production and further studies.

RESULTS

During the survey, several species of mushrooms were collected and described. The photos below provide a sample of the specimens.

Figure 1. *Trametes* spp

Figure 2. *Ganoderma* spp

Figure 3. Stinkhorn spp

Figure 4. *Catherellus* spp

Figure 5. *Auricularia* spp

Figure 6. *Ganoderna* spp

Figure 7. *Termitomyces* spp

Figure 8. *Lactarius* spp

Figure 9. *Microporous* spp

Figure 10. *Amanita* spp

Figure 11. *Russula* spp

Figure 12. *Pleurotus* spp

The survey collected mushrooms from the first three inhabitations (see Table. 1)

Table 1. Shows species collected, their habitation, morphological features noted, local name where applicable and possible usage

Species of mushroom	Habitation	Morphological features	Local name	Possible usage
Ganoderma spp (Bracket mushroom) Fig. 2, 6	Lignicolous-Found growing on decaying logs and stumps of hardwood	Cap thick, hard, flat and shinny, kidney-bean shaped. creamy white margin, yellowish in the middle orange to red at the center. Pileus large (6-10cm). Pores on the underside. Spore print brown.		Medicinal
Cantharellus spp (Gilled mushroom) Fig. 4	Foliculous- Found growing on forest floor on roots of Brachystagia trees	Cap (3-5cm), smooth, yellow or orange, funnel shaped and depressed at the centre. Gills forked and run all the way down to the stipe (decurrent). Stipe fleshy and centrally placed. Same colour on entire fruit body. Smells nice and has a mildly peppery taste. Spore print white	Choga Kapilipili	Food
Agaricus spp (Gilled mushroom)	Carpophilous- Found growing on the forest debri.	Cap, thick, conic, white in colour and button shaped. Stalk hollow and short with a ring. Dark brown hymenium with gills. Spore print brown		Food
Pleurotus spp (Gilled mushroom) Fig. 12	Lignicolous- Found growing ondecidous trees	Carps are spongy, funnel shaped and white growing in clusters. Stipe reduced and off centre. Gills white in colour and decurrent. Spore print white. Have fishy smell		Food
Russula spp (Gilled mushroom) Fig. 11	Hemicolous- Found growing on the forest floor on roots of hardwoods	Cap pinkish to purplish, convex to flat (5cm). Gills white to cream, forked near the margin. Fresh white and skin easily peels. Stipe long and white in colour. Spore print white	Hakoranyani	Food
Amanita spp (Gilled mushroom) Fig. 10	Humicolous- grown on forest floor on roots of trees	Cap greyish covered with pyramid like warts, thick and conical. Stalk well visible with a ring and volva at the base.	Choga Nyere	Poisonous-Industrial
Microporous spp Fig. 9	Lignicolous- found growing on fallen woody branches of trees either one or two close together	Cap hard and corky with beautiful concentric rings which assume various colours. Margin sharp Pileus round 3-5cm with stipe centrally placed. Very beautiful		Ornamental

Species of mushroom	Habitation	Morphological features	Local name	Possible usage
Lactarius spp (Gilled mushroom) Fig.8	Humicolous grown on forest floor on roots of deciduous trees	Caps (5 - 6 cm), white, convex to flat. Gills white, decurrent and exude a milky substance with a peppery taste. Stipe long and white without a ring. Spore print white.	Choga Mazia	Poisonous-Industrial
Auricularia spp (Jelly mushroom) Fig. 5	Lignicolous- found growing on dead decaying wood, many clustered together	Caps ear shaped and smooth. Flesh jelly-like, elastic texture. Caps dark brown with a purplish tint. No gills. Stalk very short or absent.		Food
Termitomyces spp – (Gilled mushroom) Fig. 7	Coprophilous- found growing on soil with termites	Caps very large and white in colour. Stipe is long with a subterranean elongation	Choga Nyama	Food
Trametes spp Fig. 1	Lignicolous-found growing on fallen woody logs	Caps thin but tough. Flat and round. Show concentric zones of different colours with a conspicuous brown zone. Pores on the underside. Mushrooms grow in tiled layers lacking a stipe.		Ornamental
Stinkhorn spp *Phallaceae* Fig.3	Humicolous – found growing on wooden decomposing debri	Cap pink and spherical. White coloured stalk with a volva at the base. Mushroom covered in a foul smelling slime with insects		Poisonous

DISCUSSION

Species found utilized by the communities included *Cantharellus* spp (Fig. 4), *Pleurotus* spp (Fig.12), *Russulla* spp (Fig. 11), *Auricularia* spp (Fig. 5) and *Termitomyces* spp (Fig. 7). Among them the *Cantharellus* is the most prominent especially in North Coast, having been harvested and traded locally and internationally [15]. The mushroom has also been reported by [16] to be popular in Tanzania where it is harvested from the Miombo woodlands. Despite its good prospects, the mushroom cannot be grown artificially because of its dependency on a living plant host. The same goes for the *Rusulla* spp which is also mycorrhizal. The *Pleurotus* spp and *Auricularia* spp are promising as they can be artificially grown. These two mushrooms were only found in South Coast and are not popular with the locals because they are not abundant. Their occurrence depends largely on the presence of decaying logs in the forests. The description of the *Auricularia* spp from south coast match the description of that collected from Kakamega forest, which has been fully described by [17]

The *Termitomyces* spp is another popular mushroom among the locals growing near homesteads on areas with termites. It is typified by symbiotic life with termites and therefore quite difficult to grow artificially. The mushroom is a tropical species reported in many parts of Africa. The genus comprises of the largest mushrooms in the world such as *T. titanicus* of West Africa and Zambia whose cap reaches 1m in diameter [18]. The termite mushrooms are a great contributor to the livelihoods of rural communities in Africa through income generation and food security [8]

The precious *Ganoderma* spp (Fig. 2) is utilized by very few in the community perhaps because it is also arare occurrence and the locals have little knowledge of its medicinal benefits. The mushroom is however reported to have a worldwide distribution in both tropical and temperate geographical regions including North and South America, Africa, Europe, Asia and Australia [18]. The *Agaricus* spp whose description matches that of *Agaricus bisporus* is hardly utilized by the locals

for fear of poisoning. The species is said to resemble the *Amanita* species which the locals say is deadly. *Agaricus bisporus* is the world premier mushroom and 95% of Kenyan production comprises this mushroom [11, 12]

Amanita spp (Fig. 10), *Lactarius* spp (Fig. 8) and Stinkhorn spp (Fig. 3) were all labeled poisonous by the local communities. Although *Amanitas* are always feared to be poisonous, Smith [7] indicates that some 81 edible species are reported from 31 countries. For example *A. ceasarea* is reported to be highly valued in Mexico, Turkey and Napal. The *Lactarius* spp also has several species reported as edible and traded in Europe. The *Lactarius* described above resembles *L. piperatus* (no other *Lactarius* spp exudes a peppery milk substance) which is also reported by Metzler and Metzler [19] as toxic. The Stinkhorn (Fig. 3)which has such an awful smell is difficult to consume and passes out easily as poisonous though it may not be. The locals use smell as one of the ways to identify poisonous species.

The *Trametes* spp (Fig. 1) and *Microporous* spp (Fig. 9) are unpalatable but display unmistaken Beauty. With little value addition, these species can be of economic importance as ornamentals. However, the *Trametes* spp described above which resembles *T. versicolor* could be of medicinal value. There is scientific evidence from the [20] that substances referred to as polysaccharides derived from parts of the mushroom may be useful against cancer. Polysaccharide-K displays anticancer activity in preliminary human research [21]. Careful studies on such species may be very beneficial

It was noted that the communities highly utilize mushrooms either collected from the forest or within the homesteads. This was established to be because of knowledge of edible species as well as methods of preparation of collected mushrooms. Forests closets to homesteads had lowest species richness due to wood collected for fuel and perhaps over exploitation.

CONCLUSION

The survey has demonstrated that Arabuko Sokoke and Kaya Teleza forests provide a habitat for diverse macro fungal species some of which are used by the locals as food. Some of the edible species collected are mycorrhizal and cannot be cultivated necessitating employment of good management strategies for sustainable utilization. The species collected can be recognized for industrial usage, ornamental display, pharmaceutical application or food security. The information obtained can be used as a baseline for future studies including fungal genetic diversity and populations, future trends associated with climate change, indigenous knowledge application to current usage of mushrooms and species likely to go for domestication. The information can also be used to improve the management strategy on sustainable utilization of all the edible mushroom resources from the forests.

RECOMMENDATIONS

Further studies using modern technology of characterization involving molecular tools should be undertaken on economically important indigenous mushrooms among the communities. This is because effective strategies for conservation and utilization of fungal resources require a clear understanding of the populations of the target mushroom species. Population genetic studies of selected edible mushroom species will provide more information about genetic diversity within single species and contribute to improving management strategy on conservation and utilization of indigenous edible fungal resources in Kenya. Genetic studies will also give a mushroom a scientific name which can clearly tell whether mushroom is edible or not and also provide a clue to other important properties. Further research is also required to map out mycorrhizal partners of edible species. A data base linking edible species to tree hosts would also help to develop management strategies for sustainable use. Investigation on culturing, nutrition and pharmaceutical studies of these species should also be undertaken.

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