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The genus *Termitomyces*- An appraisal of some basic and applied aspects from India

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Abstract

The mushroom genus *Termitomyces* is a paleotropic exosymbiont forming mutualistic association with *Macrotermitinae*, a group of fungal mycelium eating termites. Because of its intimate mutualistic association with termites, culinary credentials and public preferences for its excellent flavor and meaty texture the genus *Termitomyces* carries great ecological and socio-economic significance. Basidiocarps of *Termitomyces* species develop from fungal combs constructed by termites using substrate, their fecal material and the soil within the termite nests. During rainingraining season the basidiocarp of this mushroom genus are commonly gathered by the local inhabitants for personal consumption as well as for selling to the local consumers both in African and Asian countries including India. Due to their exotic taste termitophilic mushrooms are considered as table delicacy in comparison to other mushrooms. For accurate identification and phylogenetic analysis of termitophilic mushrooms both classical as well multigene molecular sequencing techniques are included worldwide in recent years. In view of the importance of these mushrooms in human welfare on the basis of available information in literature an attempt has been made in this treatise to give an insight into their diversity, morphological variation, mutulistic, association, ethnomycological, sociobiological and therapeutic aspects.

Keywords – Culinary – ethno-mycological – medicinal – sociobiology – *Termitomyces*

Introduction

The genus *Termitomyces* belongs to family *Lyophyllaceae* of order *Agaricales* (*Agaricomycetes*). It was established by Heim (1942), a French botanist. There exist a lot of confusion about the number of recognized taxa under the genus since approximately, 101 different names for species, subspecies, varieties and sub-varieties are documented in different databases (MycoBank 2022, Index Fungorum 2022) although in the available version of Dictionary of Fungi only 30 species of this genus are recognized worldwide (Kirk et al. 2008). Substantially good amount of work on different species of *Termitomyces* is available from Africa and Asia (Heim 1941, 1942, 1951, 1958, Otieno 1968, Singer & Pegler 1978, Pegler & Piearce 1980, Van Der Westhuizen & Eicker 1990, Atri et al. 2005, 2014, Wei et al. 2006, 2009, Tibuhwa et al. 2010, Sawhasan et al. 2011, Kumari et al. 2012b, 2013, Kuja et al. 2014, Mossebo et al. 2017, Koné et al. 2018, Hsieh & Ju 2018, Ye et al. 2019, Dabolkar & Kamat 2020, De Souza & Kamat 2021) in comparison to the other parts of the world including American and European countries (Gomez 1994, Vesala et al. 2017).

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As per the available information in literature the farming of termitophilic fungi by macro termite is reported to have started about 30 million years ago. More than 330 species of termites including *Odontotermes obesus, O. feae, O. wallonensis, O. redemanii, O. malabaricus, O. brunneus* besides *Macrotermes* and *Microtermes* sp. are reported to be associated with the cultivation of these fungi (Aanen et al. 2002, Kamat 2016). The termites are known to cultivate these fungi on special structures within nest called "fungal combs" and are reported to eat them to obtain enzymes and nitrogen (Sangvichien & Taylor-Hawksworth 2001, Kamat 2016). Both termites and termitophilic fungi are reported to constitute monophyletic groups and termites are considered as "specialized farmers engaged in the cultivation of specialized crops" of termitophilic mushrooms (Aanen et al. 2002).

The species of *Termitomyces* are preferred table delicacy due to their flavor, texture and palatability because of which these are highly valued amongst the food items (Oso 1977, Parent & Theon 1977, Ogundana & Fagade 1981). Only source for these mushrooms is nature. During rain ingraining season these mushrooms are hunted by local inhabitants for consumption and income generation by selling these in the local markets (Ghorai et al. 2009, Kumari et al. 2012a, Kamat 2016, 2021b, c). When compared with other edible mushrooms the termitophilic mushrooms though are unique in taste but are equally comparable in nutritional properties (Gbolagade et al. 2006, Ferreira et al. 2009, Sargunam et al. 2012, Kumari et al. 2012a, Nakalembe et al. 2015). From nutraceutical and therapeutic point of view also termitophilic mushrooms are reported to offer numerous health benefits to the consumers (Rahi & Malik 2016). *Termitomyces* along with termites are also reported to play a great role in carbon mineralization, recycling process, nitrogen fixation, soil fertility and decomposition of leaf litter (Abbadie & Lepage 1989, Jones 1990). The entire life cycle of termitophilic mushrooms is considered as the ecological magic by local termite-hill goddess worshippers in Goa (Kamat 2016). Fungus growing termites are reported to consume up to 30% of the above ground leaf litter the world over (Wood 1976) in savannas, Africa and India (Collins 1983).

Diversity of *Termitomyces*

The genus *Termitomyces* is widely distributed in the equatorial region, from southern Africa to southern and southeastern Asia (Heim 1977, Otieno 1968, Van Der Westhuizen & Eicker 1990, Rouland-Lefevre et al. 2002, Atri et al. 2005, Johjima et al. 2006, Kumari 2012, Karun & Sridhar 2013). Oyetayo (2012) identified 18 species of *Termitomyces* from Nigeria by employing the molecular sequencing technique. Nine species of *Termitomyces*, namely *T. albiceps, T. bulborhizus, T. clypeatus, T. cylindricus, T. entolomoides, T. fuliginosus, T. microcarpus,* and *T. radicatus* are reported to be widely distributed in Thailand (Sangvichien & Taylor-Hawksworth 2001). From Tanzania as many as 25 species of *Termitomyces* were documented by Tibuhwa et al. (2010) using distinguishing morphological traits. Folk taxonomy of nine species of *Termitomyces* was also reported by Tibuhwa (2012a). Koné et al. (2018) elaborated the diversity and distribution of 16 species of termitophilic mushrooms from Côte d'Ivoire, West Africa. Ye et al. (2019) conducted a survey on *Termitomyces* in China and reported 16 specimens of *Termitomyces* species. Jannual et al. (2020) classified 6 species of *Termitomyces* from Thailand on the basis of both morphological and molecular characterization. Tang et al. (2020) described two new species of *Termitomyces* from China and Thailand (Fig. 1).

As for the diversity of these mushrooms in India is concerned, as many as 22 species are reported from different parts. Region wise 16 species of *Termitomyces* are documented from Punjab, 15 species from Kerala, 10 species from Himachal Pradesh, 35 species from Goa, 20 species from Western Ghats, 2 species from Tamil Nadu, 3 species from Maharashtra, 3 species from Odisha and 9 species from Karnataka and West coast of India (Natarajan 1979, Atri et al. 1995, 2005, Kumari et al. 2012b, Farook et al. 2013, Karun & Sridhar 2013, Kamat 2016) (Table 2). Singh (1965) reported *T. albuminosus* in association with *Odontoteremes obesus* from Dehradun.

Fig. 1 – Global distribution of *Termitomyces* species.

Sharma et al. (1977) recorded *T. clypeatus* from Chambaghat, Solan. Patil et al. (1979) documented number of mushrooms including *T. albuminosus*, *T. cartilaginous*, *T. clypeatus*, *T. mammiformis*, *T. microcarpus*, and *T. robustus* from Poona in Maharashtra. Thite et al. (1976) reported *T. mammiformis* from Kolhapur. Patil & Thite (1978) recorded *T. robustus* on termite nests from Kolahpur then in Maharashtra State. Bhavani Devi et al. (1980) also recorded *T. robustus* from Vellayani in Kerala. Chakravarty & Khatua (1979) reported *T. microcarpus* from Kalyani in West Bengal. Earlier this species was also listed by Ramakrishnan & Subramanian (1952) in Fungi of India from West Bengal. Purkayastha & Chandra (1975) documented *T. eurrhizus* from Calcutta in West Bengal. Natarajan (1975, 1977a, b, 1979) reported and described *T. badius*, *T. clypeatus*, *T. heimii*, *T. indicus* and *T. rabourei*, from Madras and *T. radicatus* from Jammu. Atri et al. (1995, 2005) while investigating the termitophilic mushrooms of Punjab reported *T. badius*, *T. clypeatus*, *T. microcarpus*, *T. mammiformis* forma *albus*, *T. medius*, *T. heimii*, *T. indicus*, *T. radicatus*, *T. rabourii*, *T. striatus* var. *annulatus*, and *T. eurrhizus* from different parts of Punjab. Kumari et al. (2012b) described *T. reticulatus* and *T. schimperi* from North India. Janardhana & Pahlevanlo (2012) documented eight different species of *Termitomyces*, namely *T. microcarpus*, *T. clypeatus*, *T. cylindricus*, *T. globules*, *T. heimii*, *T. indicus*, *T. mammiformis* and *T. eurhizus*, from Kodagu region of Karnataka and stressed for conservation of this one of the rare example of symbiosis on the earth. While investigating mushroom biodiversity of Goa (Kamat 2013) documented, *T. gomantakiensis*, *T. petaloides* and *T. santerei* as unique to Goa. *Termitomyces microcarpus* is known by number of local names in Goa including Xiti olamis, Shiti olamis/Chhiti/Shitol/Xitol/Xitov, etc. which is cultivated by *Microtermes* species. It is a very common mushroom of which as many as 7 morphological variants are reported to be present in Goa (Kamat 2021a). In the "Documentary of Agaricomycetous mushrooms of India" Upadhyay et al. (2017) listed 25 valid species of *Termitomyces* published from different parts of India from time to time by different authors. Karun & Sridhar (2017) documented 18 species of *Termitomyces* from Western ghats. Mani & Kumaresan (2009) considered India to be one of the major gene pool of termitophilic mushrooms. Verma et al. (2019) described number of termitophilic mushrooms from Madhya Pradesh. Srivastava et al. (2012) reported and described 4 species of *Termitomyces*, namely *T. clypeatus*, *T. heimii*, *T. mammiformis* and *T. microcarpus* using morphological taxonomic criteria. Borkar et al. (2015) reported 5 species of *Termitomyces* from Konkan region of Maharashtra. Vrinda & Pradeep (2009) prepared a key to the identification of 17 species of termitophilic mushrooms. De Souza & Kamat (2017) documented *T. bulborhizus* for the first time from India. Thakur et al. (2017) reported the predominant occurrence of *Termitomyces* sp. from

Chattisgarh. Chandrawati et al. (2014) recorded from 3 species of *Termitomyces* from Ksumbhi forest of Gorkhpur. Some other reports on the documentation of *Termitomyces* species from different parts of India are by Bose (1923), Butler & Bisby (1931), Batra & Batra (1966), Natarajan & Raman (1981), Sathe & Deshpande (1980), Roy & Samajpati (1982), Leelawathy et al. (1983), Rawla et al. (1983), Vrinda & Pradeep (2009), Mohanan (2011), etc.

Variation in Macroscopic and Microscopic characters

Different species of genus *Termitomyces* offers lot of variation in external morphology including variation in size (large/small, fleshy/not fleshy), colour, perforatorium (spiniform, acute, obtuse, broad, color on the umbo), pseudorrhiza (presence/absence, color, length) and veil (presence/absence, relative position on the stipe, persistence). Amongst the known *Termitomyces* species, *T. titanicus* has the largest sized carpophores which is reported from Zambia and Katanga province of Democratic Republic of Congo. It has a cap size of 1 meter in diameter and a stipe size of 57 cm in height (Wikipedia). Janardhana & Pahlevanlo (2012) reported the occurrence of this species from Kodagu region in Karnataka, South India. The observation recorded in this manuscript is based upon our experience of working with North Indian termitophilic mushrooms.

Variation in basidiocarp size and texture

In different species of *Termitomyces* the size of the basidiocarp ranges from 2 cm in *T. medius* to as large as 38.6 cm including pseudorrhiza (33 cm long) in *T. reticulatus*. Even in *T. microcarpus* (2.5–4 cm) and *T. badius* (4.2 cm) the basidiocarps are relatively smaller in size in comparison to those having larger basidiocarps (Fig. 2). Other such mushrooms with larger basidiocarps are *T. tylerianus* (20 cm), *T. striatus* var. *annulatus* (21–34 cm), *T. heimii* (20–25 cm), and *T. schimperi* (26 cm). Texture wise also the basidiocarps in case of *T. microcarpus*, *T. indicus* and *T. badius* is soft, membranous and fragile in comparison to those with larger basidiocarps which are having comparatively fleshy, cartilaginous and tough consistency (*T. heimii*, *T. mammiformis*) (Atri et al. 1995, 2005, Kumari 2012).

Fig. 2 – Variation in size. A *Termitomyces microcarpus.* B *Termitomyces heimii.*

Variation in basidiocarp colour

There is not much variation in the colour of the pileus, lamellae and stipe in different species of *Termitomyces*. It may be white, yellowish white, creamish, grayish white, brownish grey, light

pale, or in some varied shades of light and dark colours extending from pileus margin to umbo (Atri et al. 1995, 2005, Kumari 2012).

Variation in pileus

The pileus is convex to expanding with or without depressed center harbouring variously shaped umbo which may be spiniform, acute, obtuse, or even broad (Fig. 3). The pileus diameter ranges from 1 cm (*T. microcarpus* and *T. medius*) to 10 cm (*T. heimii* and *T. tylerianus*). Umbo in the center of the pileus may be concolorous with the pileus or it may be differently colored. It is expanding broad in *T. rabouri* (grayish brown), acute in *T. tylerianus* (pale brown), broadly conical in *T. striatus* var. *annulatus* (pale orange), broadly roundish in *T. heimii* (pale yellow), obtusely rounded in *T. eurrhizus* (buff colored), spiniform in *T. indicus* (creamish white), prominently pointed conical in *T. badius* (brown), long spiniform in *T. medius* (brownish grey), pronounced spiniform in *T. clypeatus* (grayish brown), conical in *T. mammiformis* forma *albus* (dark brown), broadly rounded in *T. reticulatus* (grayish), broad with appressed scales in *T. schimperi* (brownish orange), etc (Atri et al. 1995, 2005, Kumari et al. 2012b).

Variation in pseudorrhiza

The stipe in majority of the termitophilic mushrooms tapers into pseudorrhiza. In some of the small sized species of *Termitomyces* (*T. badius*, *T. indicus* var. *patialensis*, and *T. microcarpus* there is no pseudorrhiza. While in case of *T. radicatus* (2.5 cm long) and *T. medius* (2.5 cm long) pseudorrhiza is small sized in comparison to *T. striatus* var. *annulatus* (25 cm long), *T. reticulatus* (29.5–33 cm long) and *T. schimperi* (16.3 cm long) in which pseudorrhiza was found to be quite long. As for the surface colour of pseudorrhiza is concerned in some of the species pseudorrhiza is concolorous with the colour of the stipe surface (*T. reticulatus* and *T. schimperi*) while the pseudorrhiza of *T. eurrhizus* is unique in having dark brown to blackish crust on its surface. Also, the pseudorrhiza of *T. striatus* var. *annulatus* is having pale brownish cuticle while the surface of pseudorrhiza in *T. rabouri* and *T. clypeatus* is dark brown (Atri et al. 1995, 2005, Kumari et al. 2012b).

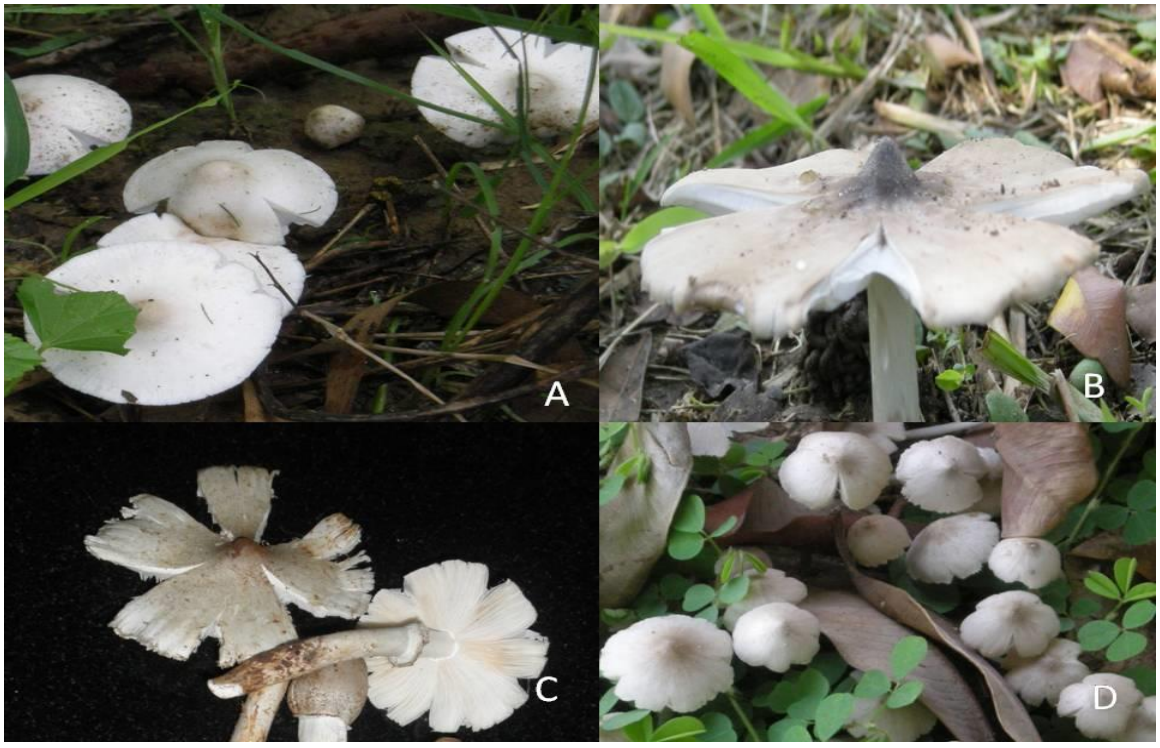

Fig. 3 – Variation in pileus shape and colour. A Nipple shaped. B Spiniform. C Obtuse. D Pointed.

Variation in veil

There are number of *Termitomyces* species which lack veil. These include *T. badius*, *T. clypeatus*, *T. indicus*, *T. microcarpus*, *T. medius*, *T. rabourii* and *T. radicatus*. In case of *T. tylerianus* the annular veil is evanescent while in case of *T. heimii*, *T. mammiformis* var. *albus*, *T. striatus* var. *annulatus* and *T. eurrhizus* the annular veil is persistent (Fig. 4). As compared the annular vein in *T. reticulatus* is represented by closely appressed fibrils forming ridged annular veil on the stipe. In case of *T. schimperi* the squamules of veilar remains are found scattered in a patchy annulate pattern down the stipe. In *T. heimii* the annular veil is double (Atri et al. 1995, 2005, Kumari 2012).

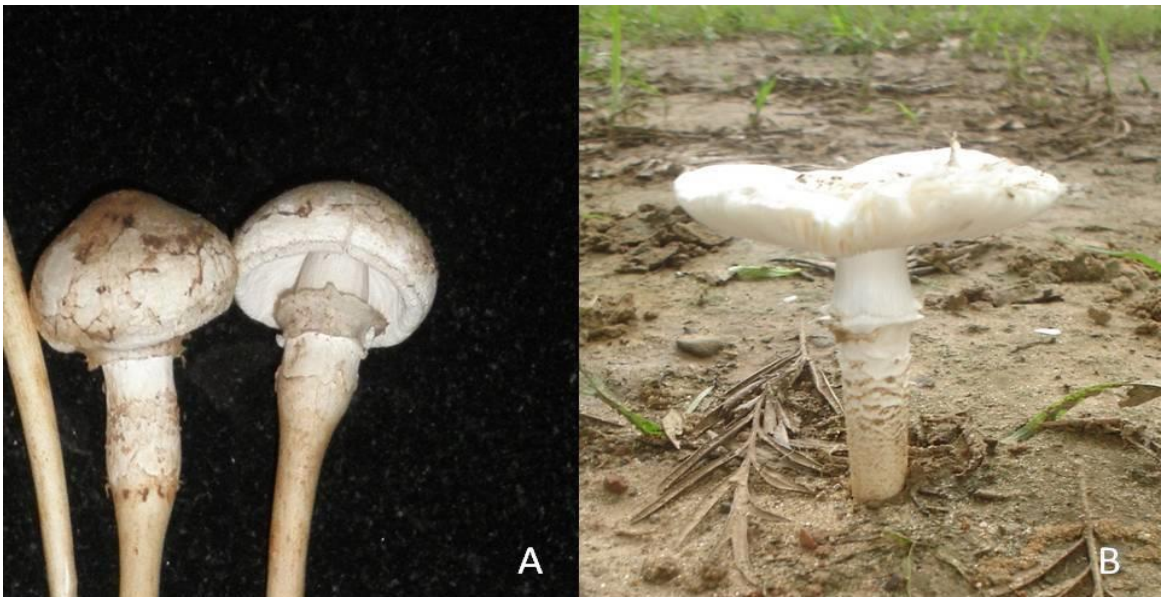

Fig. 4 – Variation in Veil. A Double annulus in *Termitomyces heimii* B Single annulus in *T. mammiformis.*

Variation in Microscopic features

Except for the presence/ absence, and slight variation in the shape and size of cystidia, there is hardly any variation in the microscopic characters pertaining to basidiospores and internal anatomy of different *Termitomyces* species. In case of *T. radicatus* both pleuro- and cheilocystidia are altogether absent. In case of *T. indicus* pleurocystidia are absent but cheilocystidia are present while in case of *T. tylerianus* cheilocystidia are absent and pleurocystia are present. There are number of species including *T. badius*, *T. clypeatus*, *T. eurrhizus*, *T. heimii*, *T. medius*, *T. rabourii*, *T. reticulatus*, *T. schimperi* and *T. tylerianus* both pleuro- and cheilocystidia are present (Atri et al. 1995, 2005, Kumari 2012).

Molecular phylogenetic studies

As for the available references on molecular phylogenetic data on different species of *Termitomyces* is concerned not much has been done in this regard. Rouland-Lefevre et al. (2002) employed molecular sequencing for confirming the monophyletic origin by reconstruction of their phylogeny in African species of *Termitomyces*. Froslev et al. (2003) also worked out the phylogenetic relationships of *Termitomyces* species using nLSU-rDNA and the mitochondrial small subunit ribosomal DNA. Oyetayo (2012) genomically identified 18 species of *Termitomyces* in Nigeria using Internal transcribed spacer (ITS) region and suggested their monophyletic origin. Using molecular sequencing techniques Froslev et al. (2003) concluded that *Sinotermitomyces carnosus*, *S. griseus* and *S. rugosiceps* are the synonyms of *T. mammiformis* and *Sinotermitomyces cavus* and *S. taiwansis* are conspecific with *T. heimii* and *T. clypeatus.* Sawhasan et al. (2011) on the basis of molecular phylogenetic analysis of 13 *Termitomyces* strains in Thailand for an inferred

phylogenetic tree reconstruction reported huge variation from morphological identification. Mossebo et al. (2017) studied the phylogenetic relationship and taxonomic revision of *Termitomyces* using combined nuclear ribosomal large subunit and mitochondrial small subunit of ribosomal DNA. Ye et al (2019) identified 16 species of *Termitomyces* in China using ITS sequence data.

Mutualistic association

Termites are mostly found in tropical areas and sometimes in the cold regions as well (Krishna & Weesner 1970). Termites in family *Macrotermitinae* are reported to establish an obligate symbiosis with *Termitomyces* on fungus comb inside the nest (Janardhana & Pahlevanlo 2012). The Termite-fungus mutualistic association is reported to be initiated after the nuptial flight of Royal Pair. This is followed by their settling down on a suitable substratum in a nest within the royal chambers where the Queens produces first brood, the members of which after maturing are reported to start foraging around so as to establish the fungal garden having fungal combs containing pseudofaces formed from plant material and degraded lignin, cellulose, etc. Construction of fungal combs in the termite nests is reported to be designed in a unique way in the semi enclosed gallery either above or below the ground (Korb 2011). On such fungal combs the foraged spores of *Termitomyces* on germination help in the formation of nutritious fungal compost which is used by termites for their consumption. *Termitomyces* in fungal garden constantly gets highly suitable growth environment while the termites get nutritious compost for feeding (Stephenson 2010, Korb 2003, 2011). The ecological system of "fungal gardens" or fungal combs" is reported to provide all the necessary nutrition for the growth of different species of *Termitomyces* (Zeleke et al. 2013). The mycelia of *Termitomyces* are reported to release some enzymatic metabolites which degrades the complex substances into simpler ones which are reported to be assimilated by the termites (Khowala et al. 1992, Aanen et al. 2007). Makonde et al. (2013) reported the coexistence of *Macrotermes* and *Microtermes* species in the termite mounds. *Macrotermes* is reported to help *Termitomyces* to colonize at the bottom part while *Microtermes* are reported to help in the development of basidiocarps on the top parts of termite mounds (Makonde et al. 2013).

Leuthold et al. (1989) reported that the continuous seeding of termitaria with the spores released from the mature basidiocarps which allow vertical transmission of termites in which workers consume nitrogen rich fungal nodules growing in fungal combs. Such nodules containing asexual spores are reported to serve as inoculum for newly constructed comb substrate (Figs 5, 6). After the establishment of newly built fungal combs the colonies are reported to start dividing (Rouland-Lefèvre & Bignell 2001). The basidiocarps of *Termitomyces* start emerging immediately after first rainingraining showers. Small termites construct interiors of the termite mounds or fungal combs which are quite rich in nutritious food and play an important role in the creation of a selective environment favourable for the development of *Termitomyces* fruiting bodies.

Culturing and cultivation of *Termitomyces* species

Domestication and artificial cultivation of *Termitomyces* species is one of most challenging venture for the researchers. Many investigators raised the pure culture of *Termitomyces* mycelium and also undertook fermentation studies. Gong & Gaun (2019) worked out the growth conditions for the cultivation of *T. albuminosus*. Zeleke et al. (2013) raised the pure culture of *Termitomyces* species by successive sub culturing from nodules of fresh fungal comb and confirmed that the growth of *Termitomyces* culture largely depends upon its supplementation using comb extract. There are reports regarding the cultivation of *Termitomyces* species in China using different substrates by creating a fungal comb environment (Chang & Miles 2004, Shao-Yu 2006). In India attempts are being made but not much has been done in this regard so far.

Ethnic uses and overindulgence

For thousands of years mushrooms are known as an important source of food and folk

medicines (Atri et al. 2010b, Kumari & Atri 2012). The genus *Termitomyces* is one of mushroom genera representing a unique group of edible species which are superior in taste to every other edible mushroom (Pegler & Piearce 1980, Atri et al 2010a). Because of their unique taste and exotic flavor termitophilic mushrooms are frequently gathered by low income groups in bulk from the forested and roadside termitaria during raining season in different parts of the world including India, Tanzania, Nepal, Côte d' Ivoire, Cameroon, etc. (Atri et al. 2010a, Tibuhwa 2012b, Aryal & Budathoki 2016, Kamat 2016, Koné et al. 2018, Teke et al. 2018). Besides edibility, there are number of references about ethnic uses of *Termitomyces*. Tibuhwa (2012b) documented the use of *Termitomyces* as food, tonic and against various gastro-intestinal ailments by different communities of Tanzania. Aryal & Budathoki (2016) while investigating the ethnic aspects highlighted the different cultural practices associated with use of different *Termitomyces* species in Nepal (Aryal & Budathoki 2016). Teke et al. (2018) also documented ethnomycological uses of different mushrooms including *Termitomyces* species in Cameroon (Teke et al. 2018). Kalaba et al. (2013) reported the bulk selling of *T. titanicus* by the local tribals at the roadside market in Katanino in Zambia.

In India termitophilic mushrooms are collected in different regions such as Punjab, Goa, Chhattisgarh, Karnataka, Kerala, Maharashtra, Gujarat, Tamil Nadu, Nagaland, Madhya Pradesh etc. (Natarajan 1979, Lahiri et al. 2010, Bhaben et al. 2011, Kamat 2013, Verma et al. 2019) and sold alongside village roads and local markets. Atri et al. (2005, 2009, 2010a, b, Kumari et al. 2012 a) reported the occurrence and edibility of number of termitophilic mushrooms from different parts of Punjab. These include *T. badius*, *T. clypeatus*, *T. eurrhizus*, *T. heimii*, *T. mammiformis* forma *albus*, *T. medius*, *T. microcarpus*, *T. radicatus*, *T. rabourii*, *T. reticulatus*, *T. schimperi*, *T. striatus* forma *annulatus* and *T. tylerianus*. Atri et al. (2005) reported the selling of fruitbodies of *T. heimii* and *T. mammiformis* @ Rs 50- 60/-per Kg in the local markets of Punjab. The population of these mushrooms is reported to be dwindling because of being under constant target of mushroom hunters (Atri & Lakhanpal 2002, Atri et al. 2009, 2010a). The knowledge of use of termitophilic mushrooms is quite high in ethnic tribes of Kodagu region in Karnataka. These tribes are reported to be well aware of the seasonal availability and utility of various mushrooms growing on termite mounds including *T. clypeatus*, *T. eurhizus*, *T. globulus*, *T. heimii*, *T. mammiformis*, *T. titanicus* etc. (Janardhana & Pahlevanlo 2012). Karun & Sridhar (2013, 2017) while investigating the mushrooms of western ghats reported number of termitophilic mushrooms and documented their edibility and ethnic utility by the locals. Verma et al. (2019) also reported the livelihood support of these mushrooms amongst the tribal population of Madhya Pradesh. Semwal (2014) documented indigenous information about edible mushrooms including species of *Termitomyces* from North West Himalayas. In Goa many interesting taboos and folk-beliefs are reported to be associated with the mushrooms growing on termitaria. Here the termite hills are closely guarded and revered as the abode of a popular local goddess 'Santeri'. The termite hill goddess is reported to be venerated in Konkan, Goa and Kanara regions of this tiny state which is also named as Bhumika, "Shantala" or "Shantadurga". Every temple in this region is reported to have a holy termite in the sanctum sanctorum (Kamat 2016). The People of Goa during the festival of Mundris "Ritual mage Parab" consider the holy soils of termitaria as full of supernatural powers. Kamat (2021b), while analyzing the Goa's booming illegal wild mushroom trade reported that the trade of wild edible termite hill mushrooms increased from Rs 5 lakhs per annum in 1980 to Rs 1500 lakhs/annum by 2019 and on account of this during Nagapanchmi in Panaji (Goa) a single wild mushroom seller is reported to earn Rs. 30,000–50,000/- a day (Kamat 2021b). In Ponda (Goa) a person has been reported to sell packets containing 25–30 mushrooms @ Rs 100/ per packet and just in one hour he is reported to earn Rs 50,000/-(Kamat 2021c). Because of the excessive exploitation of these mushrooms since 1986, Goa is reported to have lost number of commonly occurring species including *T. albuminosus, T. antruziensis, T. aurantiacus, T. bulborrhizus, T. dudhsagarensis, T. gomantakiensis, T. entolomoides, T. fuliginosus, T. longiradicatus, T. medius, T. robustus, T. santerei, T. striatus,* etc. (Kamat 2021c).

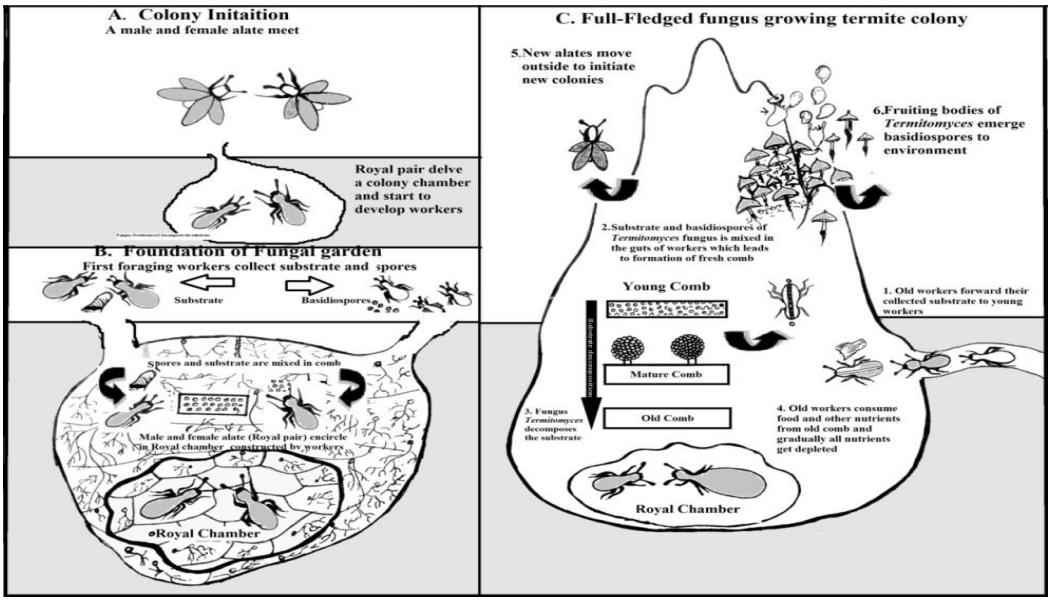

Fig. 5 – Diagrammatic representation of Life cycle of Termite fungus association (Modification of Poulsen 2015).

Fig. 6 – A Delved Termite hill showing Termites in termite chambers. B, C *Termitomyces microcarpus* and *Termitomyces heimii* growing on termitaria.

Table 1 Medicinal and ethnological uses of *Termitomyces* spp.

Sl. No.	Species	Usage/Ethano-botanical uses	References
1.	*Termitomyces albuminosus*	Possess termitomycesphins that improves neural development	Qi et al. (2001)
		Possess analgesic and anti-inflammatory activities	Lu et al. (2008)
		Used to treat haemorrhoids	Lu et al. (2008)
		Used for the remedy of measles, yellow fever, Inappetance, Diarrhoea, muscular pain, indolence	Aryal & Budathoki (2016)
		Contains polysaccharides that possess antihyperlipidemic effects	Zhao et al. (2016)

Table 1 Continued.

Sl. No.	Species	Usage/Ethano-botanical uses	References
2.	*Termitomyces clypeatus*	Cibacron blue affinity eluted protein present in fungus possess anti-proliferative property against tumor cell	Maiti et al. (2008)
		Used in treatment of pox. Paste of fruit-body is applied in effected area	Dutta & Acharya (2014)
		High antioxidant properties	Pattanayak et al. (2015)
		Serine protease (AkP) showed selective inhibition of growth of cell line consisting human liver carcinoma cells	Majumder et al. (2016)
		Antioxidant, anticancer and antitumor properties	Mondal et al. (2016)
		Antibacterial activity and immuno-stimulatory effects	Mahamat et al. (2018)
		Used as medicine against fever and measles	Atri & Mridu (2018)
		As a hypolipidemic properties used in lowering cholesterol level	Oyetayo (2006)
		Paste of fruiting body applied to healing chicken pox by Santals	Manna et al. (2014)
3.	*Termitomyces microcarpus*	Lowers the total serum cholesterol, LDL-cholesterol and triglycerides in rats	Nabubuya et al. (2010)
		Used to treatment of gonorrhea	Oyetayo (2011)
		Used in wound healing	Venkatachalapathi & Paulsamy (2016)
		Used in treatment of Diarrhoea, muscular pain, delivery pain, stomachache, laziness, stiffness of joints, cough/cold, venereal diseases	Aryal & Budathoki (2016)
		Used for fever treatment and bone strengthening	Teke et al. (2018)
4.	*Termitomyces eurrhizus*	Gastric ulcer healing property of soluble polysaccharide-rich fraction	Chatterjee et al. (2013)
		Antioxidant and antibacterial potential	Singdevsachan et al. (2014)
		Effective for skin diseases used with *Cynodon dactylon*	Aryal & Budathoki (2016)
		Used as medicine against fever and measles	Atri & Mridu (2018)
		Used in treatment of gastrointestinal problems	Tibuhwa (2012a)
		Paste used in treatment of Chicken pox	Manna et al. (2014)
5.	*Termitomyces heimii*	Used in wound healing	Venkatachalapathi & Paulsamy (2016)
		Syrup used in diarrhea, jaundice, measles, yellow fever	Aryal & Budathoki (2016)
		Paste used in treatment of Chicken pox.	Manna et al. (2014)
		Used as blood tonics, healing wounds and helps in blood coagulation	Chandrawati et al. (2014)
6.	*Termitomyces globules*	Believed to cure Leucorrhoea. Used in remedy as when crushed with another fungus *Daldinia concentrica* and mixed with the African black soap	Oso (1977)
		Strongly believed to prevent pregnancy in Nigeria	Oso (1977)
7.	*Termitomyces robustus*	Anaemia and high blood pressure	Okigbo & Nwatu (2015)
8.	*Termitomyces striatus*	Splenocyte activation resulting enhancing immune system	Mondal et al. (2006)
		Used to treat measles	Aryal & Budhathoki (2016)
9.	*Termitomyces titanicus*	Termitomycamides found in fungus reduces endoplasmic reticulum stress which is involved in Parkinson's, Alzheimer's, and prion disease	Choi et al. (2010)

Table 1 Continued.

Sl. No.	Species	Usage/Ethano-botanical uses	References
		Used in abdominal pain, constipation, stomachache and ulcers	Tibuhwa (2012a)
10.	*Termitomyces reticulatus*	Used in rheumatism and lowering high blood pressure	Panda & Tayung (2015)
11.	*Termitomyces schimperi*	Aqueous and ethanolic extracts is cytotoxic for leukemia cells and Human Prostate Cancer Cell Line	Boadi (2017)

Table 2 List of different species *Termitomyces* in different regions of India with main distinguishing morphological characteristics.

Sr. No.	Name of Fungus (India)	Vernacular names (Indian names)	Cap colour	Cap Size	Annulus	Pseudorhiza
1	*Termitomyces microcarpus*	Katola kum/Akki kum, Nuchikum, Pullaekum, Uei Chhatu, Choto karane, (Kerala & Karnatka) Bhat Pihari, (Nei kalan, Ari Kumizh, Arishi Kalan (Tamil Nadu), Bada bali chatu (Odisha), Jhari chewn, Mulchewn (Uttrakhand), Kanki Phutu, Chowk Phutu, Chapat phutu (Chattisgarh), Shiti or Shitol olamis (Goa), Inyak (Arunachal pradesh), Balu khukhdi (Jharkhand), Mikhumu khapolok (Tripura) Bhatoli, Mohtran (Himachal Pradesh)	Silky White, creamish	S	Ab	Ab
2	*Termitomyces heimii*	Alandi Kum/Heggala alambu/Heggala anabae, Bedurumuna, beru anabe (Karnataka) Tatmour (Himachal Pradesh), Alukum, Sib chhatu, Dumbersathi Raj Bindo Pihari, (MP) Olmi, Putru Kumizh, Putru kalan, Ejova (Tamil Nadu), Parbana chatu, Ind Chati, Nada Chatu (Odisha), Satya (Maharastra), Cheyun (UK), Roen Olmi, Roenichim (Goa), Rupucie (Ang) (Nagaland), Chiphungyar (Manipuri), Isak munda, Chirko, Bada khukhri, Patiyari, Taknos mushroom (Jharkhand), Pa sawntlung (Mizorum), Muplong, Maikhun, Legum, Uri mwikhun (Assami), Kaloongae cheaoe (Sikkimi), Mikhumu khapolok (Tripura) Taanna, Sutri and Nadu (J&K)	Silky white, creamy greyish to light brownish at maturity	M	Double, Persistent	P
3	*Termitomyces mammiformis*	Amme kodae kum, Bedurumuna, beru anabe (Western ghats) Dumbersathi, Olmi, Cheyun (UK), Bhadwahi, Bhundu, Dusherra phutu, Bhimbhora phutu, Goncha phutu, Dengur phutu, Bhigora phutu, Khukhadi, Kanki phutu (Chattisgarh), Roen olmi (Goa), Mohikhun (Assami) Jharae cheaoe (Sikkim) Mikhumu khapolok (Tripura), Taanna, Sutri and Nadu (J&K) Tatmour (Himachal Pradesh)	Whitish, greyish to brownish at maturity	M	Persistent	P
4	*Termitomyces clypeatus*	Naikodae, Pillukum, Hullu anabe, Nethale Kum (Karnataka), Baali Chhatu, Kalunge chiyu, Chirko Pihari, (Madhya Pradesh) Patera Phutu, Bhigora phutu (Chattisgarh), Varlang (Tangkhul) (Manipur) Mikhumu khapolok (Tripura), Taanna, Sutri and Nadu (J&K)	Greyish becomes dark brown at maturity	M	Ab	P

Table 2 Continued.

Sr. No.	Name of Fungus (India)	Vernacular names (Indian names)	Cap colour	Cap Size	Annulus	Pseudorhiza
5	*Termitomyces eurrhizus*	Gonnae kodae Kum (Western ghats), Bhindo Pihari, (Madhya Pradesh), Desi Chhattisgarhiya Phutu, Bhigora phutu (Chattisgarh), Narin Chenggum (Meitei), Shipungvar (Tangkhul), Palhung (Kuki), Piirapa, Epriapa (Naga) (Manipur), Mikhumu khapolok (Tripura), Taanna, Sutri and Nadu (J&K)	Greyish brown, dark brownish at maturity	M	Peronate/ evanescent	P
6	*Termitomyces fuliginosus*	Kundu Kodae kum (Western ghats)	Ochraceous to orangish brown	M	Ab	P
7	*Termitomyces globulus*	Urutu kodae kum, Hullu anabe (Western ghats)	Pale brown with pale margin	M	Ab	P
8	*Termitomyces indicus*	Nuchi Kum (Kerala), Kullu anabe (Karnataka) Bhatoli, tamohtran(H.P.)	Whitish, creamy, with dark brown umbo	S	Ab	A
9	*Termitomyces lanatus*	Karadi kodai kum, Joolu Kodae kum (Western ghats)	Greyish	M	Wooly veil	P
10	*Termitomyces le-testui*	Gantae kodae kum (Western ghats)	Creamish to light brown	L	P	P
11	*Termitomyces robustus*	Tholu/ Nar kodae kum (Western ghats)	Brownish with Maroon tinge	M	P in young stage	P
12	*Termitomyces schimperi*	Baeru alambu, Baeru anabe, Beeru kodae kum (Western ghats) Tatmour (H.P.)	Whitish, creamish, with large patches of brownish colour	M-L	Membranous velar patches	P
13	*Termitomyces spiniformis*	Nai nethalekum (Western ghats), Tatmour (H.P.)	Greyish	M	P	P
14	*Termitomyces striatus*	Pullae/Puthu kum (Western ghats), Tatmour (H.P).	Whitish to greyish brown	M-L	P	P
15	*Termitomyces titanicus*	Baari balliya, Kodae kum (Western ghats)	Greyish with dark brown patches	L	P	P
16	*Termitomyces tylerianus*	Kaad kodae kum (Western ghats)	Greyish white to smoky white with dark brown umbo	M	Ab	P
17	*Termitomyces umkowaani*	Naikodae alambu, Patera Phutu, Chirko Khukhadi (Chattisgarh)	Creamish grey to brown buffy	M-L	Ab	P
18	*Termitomyces badius*	Batoli, Tamotran (H.P.)	Cremish to brownish	S	Ab	AB
19	*Termitomyces rabourii*	Khukh(H.P.)	Ochraceous orange	M	Ab	P
20	*Termitomyces saggittiformis*	Khukh(H.P.)	Greyish sepia with faded margin	M	Ab	P

Table 2 Continued.

Sr. No.	Name of Fungus (India)	Vernacular names (Indian names)	Cap colour	Cap Size	Annulus	Pseudorhiza
21	*Termitomyces albuminosus*	Khukh (H.P.)	Greyish brown	M	Ab	P
22	*Termitomyces entolomoides*	Tatmour (H.P.)	Buffy brown with bluish black	M	A	P
23	*Termitomyces perforans*	Tatmour (H.P.)	Whitish creamish to slightly greyish brown	M	P	P
24	*Termitomyces radicatus*	Bhatoli (H.P.)	White, creamy with brownish umbo	S	Ab	P
25	*Termitomyces reticulatus*	Tatmour (H.P.) Parabana Ada Chatu (Odisha)	Creamish to whitish with with greyish brown patches	M	P	P
26	*Termitomyces medius*	Bhatoli (H.P.) Bihida chatu (Odisha)	Cremish to greyish with a cute umbo	S	Ab	P
27	*Termitomyces umkowaan*	Kodae alambu (Western ghats)	Yellowish brown to greyish brown	M	Ab	P
28	*Termitomyces bulborhizus*	Tatmour (H.P.)	Pale brown to brownish with dark chocklaty brown umbo	M	Ab	P
29	*Termitomyces cylindricus*	Tatmour (H.P.)	Greyish brown	M	Ab	P

Where S = Small, M = medium, L = Large, Ab = absent, P = present

Nutritional and medicinal properties

Termitophilic mushrooms are quite rich in various nutritional and nutraceutical components such as proteins, fibers, carbohydrates, low amount of fats, minerals, phenolics, flavonoids, ascorbic acid, β carotene, lycopene, alkaloids, etc. (Kumari et al. 2013, Kumari & Atri 2012, Atri et al. 2014). Nutritional and culinary medicinal potential of termitophilic mushrooms is primarily because of their richness in nutritionally and nutraceutically important constituents which basically account for their superior taste and preference by local people which provide many health care benefits to the consumers (Atri et al. 2012, Kumari et al. 2013, Atri 2020). The nutritional and hypocholesterolemic properties of *T. microcarpus* were investigated from Africa by Nabubuya et al. (2010). Yourba tribes of Nigeria are reported to use African varieties of *T. microcarpus* for medicinal purposes (Kamat 2021a). Pattanayak et al. (2015) reported the high antioxidant properties of heteroglycan from *T. clypeatus* thereby accounting for its nutraceutical potential. Janardhana & Pahlevanlo (2012) while investigating the diversity of termitophilic mushrooms in Kodagu region of Karnataka discussed the ecological significance of termites and *Termitomyces* and use of these mushrooms as preferred food item by the local communities.

Table 3 Occurrence of termitophilic mushrooms within different states and its ethnomyclogical information (References: Farook et al. 2013, Florence & Yesodharan 2000, Kavishree et al. 2008, Leelavathy et al. 1983, Mohanan 2011, Kamat 2013, Natarajan 1979, Purkayastha & Chandra 1976, Vrinda et al. 2002, Vrinda & Pradeep 2009).

Scientific names	**Name of State**	**Ethnomycological Information**
Termitomyces heimii, T. clypeatus, T. eurrhizus, T. striatus	Jammu & Kashmir	Consumed as highly delicious food and sold@ 40/- Kg in local markets of Jammu.
Termitomyces microcarpus	Jammu & Kashmir	Consumed as food by villagers.
Termitomyces microcarpus	Himachal Pradesh	Womens, elders and children often collect these mushrooms from termite mound in bulk in their dupattas and baskets and eaten with rice mostly.
Termitomyces heimii	Himachal Pradesh	In plains of region villagers consume these mushrooms with great interest.
Termitomyces microarpus	Tamil Nadu	Palamalai and Kaani tribes of area considered them a tasty rich medicinal food as immune booster and for controlling diabetes.
Termitomyces heimii, T. mammiformis	Tamil Nadu	Mushrooms are frequently sold by local vendors in local markets of Tiruneveli and Thirivananthapuram and known to cure healing wounds.
Termitomyces microcarpus, T. heimii, T. eurrhizus	Uttrakhand	Consumed as favorite food in Pauri and Dehradoon region of UK.
Termitomyces spp. (*T. heimii, T. microcarpus, T. clypeatus*)	Maharastra	Consumed as energetic food by locals of Gadchiroli forest and also sold at higher rates in local markets.
Termitomyces medius	Odisha	Poor people consume these mushrooms from wild.
Termitomyces	Odisha	Tribe community consumed as delicious food and regarded them to reduce blood pressure.
Termitomyces heimii	Odisha	One of favorite mushrooms in region with high market value @ 150-250/kg in urban areas. Tribal community consumed as delicious food and regarded them to reduce blood pressure.
Termitomyces eurhizus	Odisha	Frequently consumed as delicious food and sold by poor community @250 per bundle and believed to be lowering high blood pressure rheumatism, and diarrhea.
Termitomyces microcarpus	Chattisgarh	In Bastar and Korea distt. Of Chattigarh these mushrooms are used to treat chicken pox by inhaling its ashes. Tribal people wrap these mushrooms with Ajwain seeds in banana leave and smoked and its fumes considered to relive pain after delivery.
Termitomyces heimii, T. mammiformis	Chattisgarh	In Raipur, Kanker, Korea, Gariyaband, Jagdalpur, Kawardha, Ambikapur, Jagdishpur region, tribals collected and sold @600-1000/- per kg and also used to treat measles, viral fever, diarrhea, constipation, pain, injury, sickle cell diseases, cold and skin infections. In Bastar and Korea distt. of Chattisgarh these mushrooms known to cure chicken pox by inhaling its smoked mushrooms and its fumes considered to relive pain after delivery.
Termitomyces heimii and *T. mammiformis, T. entolomoides*	Goa	Mushrooms were earlier sold in leafy material in local or city markets by Goaenkar people @150 /per bundle but harvesting of these mushrooms are banned by state govt to conserve these mushrooms.
Termitomyces eurrhizus	Nagaland	Collected mainly in Canacona Sattari, Valpoi region in bulk and sale along roadsides and locals market in bundals@250-1000/- per 50 pieces or 700-7000 per kg. A special dish Xcuti is prepared from these mushrooms.

Table 3 Continued.

Scientific names	Name of State	Ethnomycological Information
Termitomyces heimii	Nagaland	Consumed in the form of soup, chutney, salads, dishes and sold @ up to 250 per kg dried or fresh in Kohima, Tuensang and Phek distt of Nagaland.
Termitomyces microcarpus	Nagaland	Consumed as food in Kohima, Tuensang and Phek distt of Nagaland.
Termitomyces eurhizus	Manipur	One of delicious mushroom considered to be in area and collected in bulk for sale along road sides @ 200 /- and cooked along meat and other gradients.
Termitomyces clypeatus	Manipur	Consumed as food with fish and sold @ 200/- per bundle.
Termitomyces heimii	Manipur	One of favourite mushrooms frequently hunted in rainy season in bulk for consumption and sold in bundles along road sides, streets, city markets at high rates.
Termitomyces microcarpus	Arunachal Pradesh	Fruiting bodies are used for making delicious dish by boiling, squeezed then fried with other gradients and sold @ up to 500 /- per kg.
Termitomyces heimii, T. mammiformis, T. albuminosa, T. clypeatus	Jharkhand	One of most consumed mushroom and sold along road sides and in local markets @ 800-1000/- per kg.
Termitomyces microcarpus	Jharkhand	Collected in bulk for consumption and Regarded them as very tasty mushroom.
Termitomyces heimii	Panjab	Consumed by people of Punjab plains & other states like Chattisgarh and Uttrakhand collect and eat these mushrooms and Local vendors sold @ up to 60 /- per kg.
Termitomyces heimii, T. microcarpus, T. clypeatus, T. fuliginosus, T. indicus	Karnataka	Locals of region sale these mushrooms along roadsides (Kushalnagar) and local market (Madikeri) in kodagu region of Karnataka.

Some species of *Termitomyces* in Western Ghat and West Coast including *T. clypeatus*, *T. globules* and *T. umkowaan* are reported to possess low lipid, high protein, high fibre and many essential amino acids to cater the needs of human nutrition and health (Sudheep & Sridhar 2014, Karun et al. 2018, Ghate & Sridhar 2019). Zhao et al. (2016) investigated the antihyperlipidemic activities of enzymatic and acidic intracellular polysaccharides produced by *T. albuminosus*. De Souza et al. (2018) reported the formation of a dark melanin like pigment in *T. albuminosus* mycelia colonies which is reported to provide protection from extreme environmental conditions such as UV light, ionising radiation, resistance to heat or cold, phagocytosis, heavy metals, oxidants and provides cell wall rigidity (Money et al. 1998, Plonka & Grabacka 2006, Casadevall et al. 2017). Sai & Basavarju (2020) evaluated the antioxidant potential of *T. heimii* using methanolic extract.

The real potential of these mushrooms as a source of medicinally significant bioactive constituents needs to be evaluated and validated as has been done in case of number of mushrooms including *Cordyceps militaris*, *Ganoderma lucidum*, *Grifola frondosa*, *Tramates versicolor*, etc. Some of the available information gathered from different sources about the medicinal and ethno-mycological usage of different species of *Termitomyces* is summarized in Tables 1, 3.

Conclusion

Indian plains and foothills provide perfect environment and ecological niches for the growth of termitophilic mushrooms. Due to their ecological and multiple health benefits these needs to be explored and evaluated. The presence of nutraceutically important constituents in them makes these mushrooms ideally suited for recommendation as food supplements. Strategies need to be worked out to stop their bulk collection from natural locations and work for conserving this unique symbiotic association between termites and these mushrooms. To meet the requirements, there is a need for their bulk cultivation for which attempts are on in different institutes. The various aspects associated with cultivation of these mushrooms needs to be evaluated and packages can practice with technological know-how in this regard made available to the entrepreneurs to take up this challenging task.

Disclosure

The authors declare no conflict of interest. The manuscript is neither published nor under consideration for publication elsewhere.

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References

Aanen DK, Eggleton P, Rouland-Lefevre C, Guldberg-Frøslev T et al. 2002 – The evolution of fungus-growing termites and their mutualistic fungal symbionts. Proc Natl Acad Sci USA 99: 14887–92. Doi 10.1073/pnas.222313099

Aanen DK, Ros VI, de Fine Licht HH, Mitchell J et al. 2007 – Patterns of interaction specificity of fungus-growing termites and *Termitomyces* symbionts in South Africa. BMC Evol Biol 7: 115. Doi 10.1186/1471-2148-7-115

Abbadie L, Lepage M. 1989 – The role of subterranean fungus comb chambers (isoptera, macrotermitinae) in soil nitrogen cycling in a preforest savanna (côte divoire). Soil Biol Biochem 21: 1067–1071. Doi 10.1016/0038-0717(89)90045-X

Aryal HP, Budathoki U. 2016 – Ethnomycology of *Termitomyces* R. Heim in Nepal. J Yeast Fungal Res 7: 28–38. Doi 10.5897/JYFR2015.0154

Atri NS. 2020 – Exploration, sociobiology and conservation of Mushrooms-My experience. Kavaka 54: 1–9. Doi 10.36460/Kavaka/54/2020/1-9

Atri NS, Lakhanpal TN. 2002 – Conservation of Mushroom Biodiversity. Ind. J. Mush. 19: 1–9.

Atri NS, Kaur A, Kour H. 2005 – Systematics and sociobiology of termitophilous mushrooms from Punjab. In: The fungi-diversity and conservation in India (Eds.: Dargan, J.S., Atri, N.S. and Dhingra, G.S.). Bishen Singh Mahendra Pal Singh, Dehra Dun, UA (India).

Atri NS, Kaur M, Kour H, Kaur A et al. 2010a – Mushroom diversity in Punjab: Application, prospects and conservation. In: Prospecting fungal diversity, conservation and applications in biotechnology (Eds.: Singh, S.K. and Rao, V.S.). Anamaya Publications, New Delhi, India.

Atri NS, Kour H, Kaur A, Saini MK. 2009 – Mushroom wealth of north eastern Punjab-their ecology, conservation and screening. In: Germplasm diversity and evaluation Algae, Fungi and Lichens (Eds.: Atri, N.S., Gupta, R.C, Saggoo, M.I.S. and Singhal, V.K.). Bishen Singh Mahendra Pal Singh, Dehra Dun, U.K. (India). pp. 59–74.

Atri NS, Kumari Babita, Upadhyay RC. 2014 – Taxonomy, sociobiology, nutritional and nutraceutical potential of termitophilous and lepiotoid mushrooms from North West India. Proceedings of the 8th International conference on mushroom biology and mushroom products (ICMBMP8) (Eds.: Singh Manjit, Upadhyay, R.C., Sharma, V.P, et al.). Publisher ICAR-DMR, Solan, H.P. & WSMBMP. pp. 479–489.

Atri NS, Kumari B, Upadhyay RC, Sharma SK. 2012 – Nutritional and sociobiological aspects of culinary-medicinal termitophilous Mushrooms from north India. Int J Med Mushrooms. Doi 10.1615/IntJMedMushr.v14.i5.50

Atri NS, Mridu. 2018 – Mushrooms – Some *ethnomycological* and sociobiological aspects. Kavaka 51: 11–19.

Atri NS, Saini MK, Gupta AK, Kaur Amanjeet et al. 2010b – Documentation of wild edible mushrooms and their seasonal availability in Punjab. In: Taxonomy and ecology of Indian fungi (Eds.: Mukerji, K.G. nad Manoharachary, C.). I.K. International Publishing House Pvt. Ltd.

Atri NS, Saini SS, Kaur G. 1995 – Taxonomic studies on the north Indian agarics-the genus Termitomyces Heim. Mushroom Res. 4: 7–10.

Batra LR, Batra SWT. 1966 – Fungus-growing termites of tropical India and associated fungi. J. Kansas Entomol. Soc. 39: 725–738

Bhaben T, Lisha G, Chandra SG. 2011 – Wild edible fungal resources used by ethnic tribes of Nagaland, India. Indian J Tradit Knowl 10: 512–515

Bhavani Devi S, Nair MC, Menon MR. 1980 – *Termitomyces robustus*, an addition to Indian edible mushroom. Kavaka 8: 53–54.

Boadi O. 2017 – Antioxidant and selective cytotoxic activities on cancer cell lines by bioactivatable compounds in extracts of *Termitomyces schimperi* (Lyophyllaceae). University of Ghana.

Borkar P, Doshi A, Navathe S. 2015 – Mushroom diversity of Konkan region of Maharashtra, India. J Threat Taxa 7: 7625–7640. Doi 10.11609/jott.o4283.7625-40

Bose SR. 1923 – The fungi cultivated by termites of Burkuda. Res. Indian Mus. 25: 253–258.

Butler EJ, Bisby GR. 1931 – The fungi of India. Imp. Coun. Agr. Res. India Sci. Mono.-I, 18: 233 p, Calcutta.

Casadevall A, Cordero RJ, Bryan R, Nosanchuk J, Dadachova E. 2017– Melanin, radiation, and energy transducton in fungi. Microbiol Spectr. 5(2): FUNK-0037-2016.

Chakravarty DK, Khatuva DC. 1979 – *Termitomyces microcarpus*- a new edible mushroom from India. Curr. Sci. 48: 364–365.

Chandrawati, Singh P, Kumar N, Tripathi NN. 2014 – Macrofungal wealth of kusumhi forest of Gorakhpur UP, India. Am Int J Res Form Appl Nat Sci 5: 71–75.

Chang S, Miles GP 2004 – Mushrooms: cultivation, nutritional value, medicinal effects and environmental Impact (p. 436). Boca Raton, Fl: CRC Press. Doi 10.1201/9780203492086.

Chatterjee A, Khatua S, Chatterjee S, Mukhrjee S et al. 2013 – Polysaccharide-rich fraction of *Termitomyces eurhizus* accelerate healing of indomethacin induced gastric ulcer in mice. Glycoconj J 30: 759–768. Doi 10.1007/s10719-013-9479-5.

Choi J-H, Maeda K, Nagai K, Harada E et al. 2010 – Termitomycamides A to E, Fatty acid amides isolated from the mushroom *Termitomyces titanicus*, Suppress Endoplasmic Reticulum Stress. Org Lett 12: 5012–5015. Doi 10.1021/ol102186p

Collins NM.1983 – Utilization of nitrogen resources by termites (Isoptera). JA Lee, S McNeill, IH Ronson (Eds.), Nitrigen as an ecological factor, Blackwell Scientific, Oxford (1983). pp. 381–412.

Dabolkar S, Kamat N. 2020 – Application of digital colorimeter for preliminary characterization of gold nanoparticle swarms produced by *Termitomyces heimii* using a noval Bioinspired Microfluidics assay. Kavaka 55: 50–57. Doi 10.36460/Kavaka/55/2020/50-57

De Souza RA, Kamat NM. 2017 – First report of *Termitomyces bulborhizus* holomorph from Goa, India. 49: 32–37.

De Souza RA, Kamat NM. 2021 – Chemical creativity of *Termitomyces* mushrooms. In: New and future developments in microbial biotechnology and bioengineering. Elsevier. pp. 233–244.

De Souza RA, Kamat N, Nadkarni VS. 2018 – Purification and characterisation of a sulphur rich melanin from edible mushroom *Termitomyces albuminosus* Heim. Mycology 9(4): 296–306. Doi 10.1080/215012032018.1494060

Dutta A, Acharya K. 2014 – Traditional and ethno-medicinal knowledge of mushrooms in West

Bengal, India. Asian J Pharm Clin Res 7: 36–41.
Farook V, Khan S, Manimohan P. 2013 – A checklist of agarics (gilled mushrooms) of Kerala State, India. Mycosphere 4: 97–131. Doi 10.5943/mycosphere/4/1/6
Florence EJM, Yesodharan K. 2000 – Macrofungal flora of Peechi-Vazhani wildlife sanctuary. KFRI Research Report No. 191. Kerala Forest Research Institute, Peechi, Kerala, India.
Ferreira I, Barros L, Abreu R. 2009 – Antioxidants in wild Mushrooms. Curr Med Chem 16: 1543–1560. Doi 10.2174/092986709787909587
Froslev TG, Aanen DK, Laessøe T, Rosendahl S. 2003 – Phylogenetic relationships of *Termitomyces* and related taxa. Mycol. Res. 107: 1277–1286. Doi 10.1017/S0953756203008670
Gbolagade J, Ajayi A, Oku I, Wankasi D. 2006 – Nutritive value of common wild edible mushrooms from southern Nigeria. Glob. J. Biotechnol. Biochem. 1: 16–21
Ghate SD, Sridhar KR. 2019 – Nutritional attributes of two wild mushrooms of Southwestern India. In: Advances in macrofungi: Diversity, ecology and biotechnology (Eds.: Sridhar, K.R and Deshmukh, S.K.). CRC Press, Boca Raton. pp. 105–120.
Ghorai S, Banik SP, Verma D, Chowdhury S et al. 2009 – Fungal biotechnology in food and feed processing. Food Res Int 42: 577–587. Doi 10.1016/J.FOODRES.2009.02.019
Gomez PL. 1994 – Una nueva especie neotropical de *Termitomyces* (Agaricales: Termitomycetaceae). Rev. Bio.l Trop. 42: 439–441. Doi 10.15517/rbt.v42i3.23218
Gong M, Guan Q. 2019 – Growth conditions of *Termitomyces albuminosus*. In: AIP Conference Proceedings. American Institute of Physics Inc., p 020021
Heim R. 1941 – Etudes descriptives et experimentales sur les agarics termitophiles d'Afrique tropicale. Memoire de'Academie des Sciences 64: 25–29.
Heim R. 1942 – Nouvelle setudes descriptivessur les agarics termitophiles d'Afrique tropicale. Archives du Museum Nationale d'Histoire Naturelle Paris, Serie 6,18: 107–166.
Heim R. 1951 – Les Termitomyces du Congo Beige recueillis par Mme M. Goossens-Fontana. Bulletin JardinBotanique de I'Etat a Bruxelles 21: 205–222.
Heim R. 1958 – Flore iconographique des champignons du Congo, Fasc. 7: Termitomyces. 208 Jard. Bot. Nat. Belgique: 209: 139–151.
Heim R. 1977 – Termites et Champignons. Les champignons termitophiles d'Afrique Noire etd'Asiemeridionale. Societete Novelle des Edition, p. 205, Boubee. Paris.
Hsieh HM, Ju YM. 2018 – Medicinal components in *Termitomyces* mushrooms. Appl. Microbiol. Biotechnol. 102: 4987–4994.
Index Fungorum. – http://www.indexfungorumorg/names/Names.asp (Retrieved on April 18, 2022).
Janardhana GR, Pahlevanlo A. 2012 – Diversity of *Termitomyces* in Kodagu and need for Conservation. J. Adv. Lab Re. s Biol. 3: 54–57.
Jannual N, Nipitwattanaphon M, Hasin S, Kaewgrajang T. 2020 – Morphological and molecular characterization of *Termitomyces* (Lyophyllaceae, Agaricales) in Thailand. Biodiversitas 21(6): 2481–2491.
Jones JA. 1990 – Termites, soil fertility and carbon cycling in dry tropical Africa: A hypothesis. J. Trop. Ecol. 6: 291–305. Doi 10.1017/S0266467400004533
Johjima T, Taprab Y, Noparatnaraporn N, Kudo T et al. 2006 – Large-scale identification of transcripts expressed in a symbiotic fungus (*Termitomyces*) during plant biomass degradation. Appl. Microbiol. Biotechno. l 73: 195–203. Doi 10.1007/s00253-006-0570-8
Kalaba FK, Quinn CH, Dougill AJ. 2013 – Contribution of forest provisioning ecosystem services to rural livelihood in the Miombo woodlands of Zambia. Popul. Environ. 35: 159–182. Doi 10.1007/s11111-013-0189-5
Kamat NK. 2013 – Goa's mushroom biodiversity. (Science Column New Frontiers-July 7). Navhind Times, https://www.navhindtimes.in
Kamat NM. 2016 – Cover story: Mushroom biowealth of Goa. Goa Today, Goa's finest magagine (October). 51(3): 22–27.

Kamat NK. 2021a – Why Xiti olamis facinate people. (Science Column New Frontiers – August 22). Navhind Times, https://www.navhindtimes.in
Kamat NK. 2021b – Goa's booming wild mushroom trade. (Science Column New Frontiers – June 20). Navhind Times, https://www.navhindtimes.in
Kamat NK. 2021c – Save Goa's *Termitomyces* species. (Science Column New Frontiers – July 4). Navhind Times, https://www.navhindtimes.in
Karun NC, Sridhar KR. 2013 – Occurrence and distribution of *Termitomyces* (Basidiomycota, Agaricales) in the western ghats and on the west coast of India. Czech. Mycol. 65: 233–254. Doi 10.33585/cmy.65207
Karun NC, Sridhar KR. 2017 – Edible wild mushrooms of the western ghats: Data on the ethnic knowledge. Data Br 14: 320–328. Doi 10.1016/j.dib.2017.07.067
Karun NC, Sridhar KR, Ambarish CN. 2018 – Nutritional potential of Auricularia auricula-judae and Termitomyces unkowaan- The wild edible mushrooms of southwestern India. In: Microbial Functional Foods and Nutraceuticals (Eds.: Gupta, V.K., Treichel, H., Shapaval et al.). John Wiley & Sons Ltd., New Jersey. pp. 281–301.
Kavishree S, Hemavathy J, Lokesh BR, Shashirekha MN et al. 2008 – Fat and fatty acids of Indian edible mushrooms. Food Chemistry, 106(2): 597–602.
Khowala S, Ghosh A, Sengupta S. 1992 – Saccharification of xylan by an amyloglucosidase of Termitomyces clypeatus and synergism in the presence of xylanase. Appl. Microbiol. Biotechnol. 37: 287–292. Doi 10.1007/BF00210979
Kirk PM, Cannon PF, Minter DW, Stalpers JA. 2008 – Dictionary of the Fungi. CAB International, Wallingford, Oxon, UK.
Koné NA, Soro B, Vanié-Léabo LPL, Konaté S et al. 2018 – Diversity, phenology and distribution of *Termitomyces* species in Côte d'Ivoire. Mycology 9: 307–315. Doi 10.1080/21501203.2018.1500498
Korb J. 2003 – Thermoregulation and ventilation of termite mounds. Naturwissenschaften 90: 212–219
Korb J. 2011 – Termite mound architecture, from function to construction. In: Biology of termites: A Modern Synthesis. pp. 349–373.
Krishna K, Weesner FM. 1970 – Biology of termites (Vol. II). Academic Press, New York, NY, XIV + [i] + 643 pp.
Kuja JO, Boga HI, Matiru V, Makonde HM. 2014 – Diversity, properties and ecological significance of the genus *Termitomyces* associated with fungus farming termites in Africa. Int. J Microbiol. Mycol. IJMM 2: 2309–4796.
Kumari B. 2012 – Diversity, sociobiology and conservation of lepiotoid and termitophilous mushrooms of northwest India. Ph. D thesis.
Kumari B, Atri NS. 2012 – Evaluation of alkaloids of north Indian wild edible termitophilous mushrooms. Libian Agriculture Research Center Journal International 3(5): 229–232.
Kumari B, Atri NS, Upadhyay RC. 2012a – Culinary status and sociobiology of termitophilous and lepiotoid mushrooms of north west India. World J Agric Sci 8: 415–420. Doi 10.5829/idosi.wjas.2012.8.4.1681
Kumari B, Atri NS, Upadhyay RC. 2012b – Two new records of the genus *Termitomyces* from North India. Mushroom Res. 21(1): 11–16.
Kumari B, Upadhyay RC, Atri NS. 2013 – Evaluation of nutraceutical components and antioxidant potential of North Indian wild culinary-medicinal termitophilous mushrooms. Int J of Med Mush (2): 189–195.
Lahiri SS, Shukla MD, Shah MB, Modi HA. 2010 – Documentation and analysis of certain macrofungal traditional practices from western-India (Gujarat). Ethnobo.t Leafl. 2010: 9.
Leelavathy KM, Flower SL, Suja CP. 1983 – The genus *Termitomyces* in India. Science and Cultivation Technology of Edible Fungi. pp. 402–406.
Leuthold RH, Badertscher S, Imboden H. 1989 – The inoculation of newly formed fungus comb with *Termitomyces* in Macrotermes colonies (Isoptera, Macrotermitinae). Insectes Soc 36:

328–338. Doi 10.1007/BF02224884
Lu Y-Y, Ao Z-H, Lu Z-M, Xu Z et al. 2008 – Analgesic and anti-inflammatory effects of the dry matter of culture broth of *Termitomyces albuminosus* and its extracts. J. Ethnopharmacol. 120: 432–436. Doi 10.1016/J.JEP.2008.09.021
Mahamat O, André-Ledoux N, Chrisopher T, Mbifu AA et al. 2018 – Assessment of antimicrobial and immunomodulatory activities of termite associated fungi, *Termitomyces clypeatus* R. Heim (Lyophyllaceae, Basidiomycota). Clin. Phytoscience 4: 28. Doi 10.1186/s40816-018-0089-4
Maiti S, Bhutia SK, Mallick SK, Kumar A et al. 2008 – Antiproliferative and immuno stimulatory protein fraction from edible mushrooms. Environ. Toxicol. Pharmacol. 26: 187–191. Doi 10.1016/j.etap.2008.03.009
Majumder R, Banik SP, Khowala S. 2016 – AkP from mushroom *Termitomyces clypeatus* is a proteoglycan specific protease with apoptotic effect on HepG2. Int. J. Biol. Macromol. 91: 198–207. Doi 10.1016/J.IJBIOMAC.2016.05.03
Money NP, Caesar-TonThat TC, Frederick B, Henson JM. 1998 – Melanin synthesis is associated with changes in hyphopodial turgor, permeability, and wall rigidity in *Gaeumannomyces graminis* var. *graminis*. Fungal Genet. Biol. 24(1–2): 240–251.
Makonde HM, Boga HI, Osiemo Z, Mwirichia R et al. 2013 – Diversity of *Termitomyces* associated with fungus-farming termites assessed by cultural and culture-Independent methods. PLoS One 8: e56464. Doi 10.1371/journal.pone.0056464
Mani S, Kumaresan V. 2009 – Occurrence of macrofungi on the Coromandel coast of Tamil Nadu, southern India. J. Threat Taxa 1: 54–57. Doi 10.11609/jott.o1773.54-7
Manna S, Ray D, Roy A. 2014 – Tribal relation to spatio-temporal variation of wild mushrooms in eastern lateritic part of India. Ethnobot. Res. Appl. 12: 15–24. Doi 10.17348/era.12.0.015-024
Mohanan C. 2011 – Macrofungi of Kerala. Forest research Institute, pp 597.
Mondal A, Banerjee D, Majumder R, Maity TK et al. 2016 – Evaluation of *in vitro* antioxidant, anticancer and *in vivo* antitumour activity of *Termitomyces clypeatus* MTCC 5091. Pharm Biol 54: 2536–2546. Doi 10.3109/13880209.2016.1168854
Mondal S, Chakraborty I, Rout D, Islam SS. 2006 – Isolation and structural elucidation of a water-soluble polysaccharide (PS-I) of a wild edible mushroom, *Termitomyces striatus*. Carbohydr. Res. 341: 878–886. Doi 10.1016/J.CARRES.2006.02.004
Mossebo DC, Essouman EPF, Machouart MC, Gueidan C. 2017– Phylogenetic relationships, taxonomic revision and new taxa of *Termitomyces* (Lyophyllaceae, Basidiomycota) inferred from combined nLSU- and mtSSU-rDNA sequences. Phytotaxa 321: 71–102. Doi 10.11646/phytotaxa.321.1.3
MycoBank. 2022 – https: //www.myobank.org/page (Retrieved on April 18, 2022)
Nabubuya A, Muyonga J, Kabasa J. 2010 – Nutritional and hypocholesterolemic properties of *Termitomyces microcarpus* mushrooms. African J .Food Agric. Nutr. Dev. 10: 2235–2257.
Nakalembe I, Kabasa JD, Olila D. 2015 – Comparative nutrient composition of selected wild edible mushrooms from two agro-ecological zones, Uganda. Springerplus 4: 433. Doi 10.1186/s40064-015-1188-z
Natarajan K. 1977a – A new species of *Termitomyces* from India. Curr. Sci. 46: 679–680.
Natarajan K. 1977b – South Indian Agaricales-III. Kavaka 5: 35–39.
Natarajan K. 1975 – South Indian Agaricales-I. *Termitomyces*. Kavaka 3: 63–66.
Natarajan K. 1979 – South Indian Agaricales V: *Termitomyces heimii*. Mycologia 71: 853. Doi 10.2307/3759201
Natarajan K, Raman N. 1981 – South Indian Agaricales-VI. Nova Hedwigia 34: 163–176.
Ogundana SK, Fagade OBA. 1981 – The nutritive value of some Nigerian edible mushrooms. Mushroom Science 11: 123–131.
Okigbo RN, Nwatu CM. 2015 – Ethnostudy and usage of edible and medicinal mushrooms in some parts of Anambra State, Nigeria. Niger. Nat. Resour. 6: 79–89. Doi 10.4236/nr.2015.61008

Oso BA. 1977 – Mushrooms in Yoruba mythology and medicinal practices. Econ. Bot. 31: 367–371. Doi 10.1007/BF02866888
Otieno N. 1968 – Further contributions to a knowledge of termite fungi in east Africa: The Genus *Termitomyces* Heim. Sydowia 22: 60–65.
Oyetayo FL. 2006 – Responses of plasma lipids to edible mushroom diets in albino rats. African J. Biotechnol. 5: 1263–1266. Doi 10.5897/AJB06.213
Oyetayo OV. 2011 – Medicinal uses of mushrooms in Nigeria: towards full and sustainable exploitation. African J. Tradit. Complement Altern. Med. AJTCAM 8: 267–74.
Oyetayo VO. 2012 – Wild *Termitomyces* species collected from Ondo and Ekiti states are more related to African species as revealed by ITS region of rDNA. Sci. World J. 2012. Doi 10.1100/2012/689296
Panda MK, Tayung K. 2015 – Documentation and ethnomedicinal knowledge on wild edible mushrooms among ethnic tribes of northern Odisha, India. Asian J. Pharm. Clin. Res. 8: 139–143.
Parent G, Theon D. 1977 – Food value of edible mushrooms from upper Shaba region. Eco.Bot. 436–455.
Patil MS, Thite AN. 1978 – Some fleshy fungi from Maharashtra-II. Botanique 9: 194–202.
Patil SD, Nair LN, Kapandis BP. 1979 – studies on fleshy fungi of Western India. J. Univ. Poona Sci. & Technol. 52: 349–354.
Pattanayak M, Samanta S, Maity P, Sen IK et al. 2015 – Heteroglycan of an edible mushroom *Termitomyces clypeatus*: structure elucidation and antioxidant properties. Carbohydr. Res. 413: 30–36. Doi 10.1016/J.CARRES.2015.05.005
Pegler DN, Piearce GD. 1980 – The edible mushrooms of Zambia. Kew Bull. 35: 475. Doi 10.2307/4110017
Plonka PM, Grabacka M. 2006 – Melanin synthesis in microorganisms- biotechnological and medical aspects. Acta Biochim. Pol. 53: 429–443.
Poulsen M. 2015 – Towards an integrated understanding of the consequences of fungus domestication on the fungus-growing termite gut microbiota. Environ. Microbiol. 17: 2562–2572.
Purkayastha RP, Chandra A. 1975 – *Termitomyces eurhizus*, a new Indian edible mushroom. Trans. Brit. Mycol. Soc. 64: 168–170.
Purkayastha RP, Chandra A.1976 – Indian edible mushrooms. Firma Klonput. Ltd Culcutta, India pp. 105.
Qi J, Ojika M, Sakagami Y. 2001 – Neuritogenic cerebrosides from an edible Chinese mushroom. Part 2: Structures of two additional termitomycesphins and activity enhancement of an inactive cerebroside by hydroxylation. Bioorganic. Med. Chem. 9: 2171–2177. Doi 10.1016/S0968-0896(01)00125-0
Rahi DK, Malik D. 2016 – Diversity of mushrooms and their metabolites of nutraceutical and therapeutic significance. J Mycol 2016: 1–18. Doi 10.1155/2016/7654123
Ramakrishnan K, Subramanian CV. 1952 – The fungi of India-A second suppliment. J. madras Univ. 22 (B): 1–65.
Rawla GS, Arya S, Sarwal BM. 1983 – Species of Termitomyces Heim from Chandigarh, India. Bibliotheca Mycologica 91: 13–21.
Rouland-Lefèvre C, Bignell DE. 2001 – Cultivation of symbiotic fungi by termites of the subfamily Macroternitinae. In: Seckbach J (ed) Symbiosis. Kluwer Academic Publishers, Dordrecht. pp. 731–756.
Rouland-Lefevre C, Diouf MN, Brauman A, Neyra M. 2002 – Phylogenetic relationships in *Termitomyces* (Family Agaricaceae) Based on the Nucleotide Sequence of ITS: A First approach to elucidate the evolutionary history of the symbiosis between fungus-growing termites and their fungi. Mol. phylogenet. evol. 22: 423–429. Doi 10.1006/MPEV.2001.1071
Roy R, Samajpati N. 1982 – Edible mushroom of west Bengal-IX: Termitomyces letestui (Pat.)

Heim, a new Indian edible mushroom. Mushroom Newsletter for Tropics 3: 1013.
Sharma AD, Jandaik CL, Munjal RL. 1977 – Some fleshy fungi from Himachal Pradesh. Ind. J. Mushroom 3: 12–15.
Sai I, Basavarju R. 2020 – Antioxidant properties of two wild edible mushrooms from Andhra Pradesh. Kavaka 54: 107–114. Doi 10.36460/Kavaka/54/2020/107-114
Sangvichien E, Taylor-Hawksworth PA. 2001 – *Termitomyces* mushrooms: A tropical delicacy. Mycologist 15: 31–33. Doi 10.1016/S0269-915X(01)80058-6
Sargunam D, Johnsy G, Samuel AS, Kaviyarasan V. 2012 – Mushrooms in the food culture of the Kaani tribe of Kanyakumari district. 11(1): 150–153.
Sathe AV, Deshpande S. 1980 – Agaricales (Mushrooms) of south west India Series-1Research Institute Monograph No. 1: 9–42.
Sawhasan P, Worapong J, Vinijsanun T. 2011 – Morphological and molecular studies of selected *Termitomyces* species collected from 8 districts of Kanchanaburi Province, Thailand.
Semwal K. 2014 – Edible mushrooms of the northwestern Himalaya, India: a study of indigenous knowledge, distribution and diversity. Mycosphere 5: 440–461.
Shao-Yu J. 2006 – Cultivation of Termitomyces albuminosus and its taste quality and evolution of physiological activities. National Chung Hsing University, Taipei.
Singdevsachan SK, Patra JK, Tayung K, Sarangi K et al. 2014 – Evaluation of nutritional and nutraceutical potentials of three wild edible mushrooms from Similipal Biosphere Reserve, Odisha, India. J für Verbraucherschutz und Leb 9: 111–120. Doi 10.1007/s00003-014-0861-4
Singh S. 1965 – *Termitomyces albuminosus*. (Berk.) Heim on active mounds of *Odontotremes obesus* (Rambur) Holmgren. J.T.D.A. 11: 4.
Singer R, Pegle DN. 1978 – A preliminary agaric flora of east Africa. Mycologia 70: 476. Doi 10.2307/3759053
Srivastava B, Dwivedi AK, Pandey VN. 2012 – Sociobiology and natural adaptation of termite and *Termitomyces* in different forest division of Gorakhpur Region.
Stephenson SL. 2010 – The Kingdom fungi: The biology of mushrooms, molds, and lichens – Steven L. Stephenson – Google Books
Sudheep NM, Sridhar KR. 2014 – Nutritional composition of two wild mushrooms consumed by the tribals of the western ghats of India. Mycology 5: 64–72. Doi 10.1080/21501203.2014.917733
Tang S-M, He M-Q, Raspe O, Luo X et al. 2020 – Two new species of Termitomyces (Agaricales, Lyophyllacae) from China and Thailand. Phytptaxa 439(3): 231–242.
Teke NA, Kinge TR, Bechem E, Nji TM et al. 2018 – Ethnomycological study in the Kilum-Ijim mountain forest, northwest region, Cameroon. J. Ethnobiol. Ethnomed. 14: 25. Doi 10.1186/s13002-018-0225-8
Thakur MP, Shukla CS, Jha D. 2017 – Occurrence of mushroom diversity in Chhattisgarh plains, northern hilly regions and bastar plateau of Chhattisgarh state. Int. J Res. Biosci. Agric. Technol. Doi 10.29369/ijrbat.2017.05.ii.0002
Thite AN, Patil MS, More TN. 1976 – Some fleshy fungi from Maharashtra. Botanique 7 (2&3): 77–78.
Tibuhwa DD. 2012a – Folk taxonomy and use of mushrooms in communities around Ngorongoro and Serengeti National Park, Tanzania. J. Ethnobiol. Ethnomed 8. Doi 10.1186/1746-4269-8-36
Tibuhwa DD. 2012b – *Termitomyces* species from Tanzania, their cultural properties and unequalled basidiospores. J .Biol. Life Sci. 3. Doi 10.5296/jbls.v3i1.1723
Tibuhwa DD, Kivaisi AK, Magingo FSS. 2010 – Utility of the macro-micromorphological characteristics used in classifying the species of *Termitomyces*. Tanzania J Sci. 36: 31–45.
Upadhyay RC, Verma B, Sood S, Atri NS et al. 2017 – Documentary of agaricomycetous mushrooms of India. Jaya Publishing House, Delhi, India.
Van Der Westhuizen GCA, Eicker A. 1990 – Species of *Termitomyces* occurring in South Africa. Mycol. Res. 94: 923–937. Doi 10.1016/S0953-7562(09)81306-3

Venkatachalapathi A, Paulsamy S. 2016 – Exploration of wild medicinal mushroom species in Walayar valley, the southern western ghats of Coimbatore District Tamil Nadu. Mycosphere 118–130.

Verma RK, Pandro V, Mishra SN, Raj D et al. 2019 – Sal Forest: A Source of wild edible mushrooms for livelihood support to tribal people of Dindori District, Madhya Pradesh, India. Int. J.Curr. Microbiol. Appl. Sci. 8: 563–575. Doi 10.20546/ijcmas.2019.801.063

Vesala R, Niskanen T, Liimatainen K, Boga H et al. 2017 – Diversity of fungus-growing termites (*Macrotermes*) and their fungal symbionts (*Termitomyces*) in the semiarid Tsavo Ecosystem, Kenya. Biotropica 49: 402–412. Doi 10.1111/btp.12422

Vrinda KB, Pradeep CK. 2009 – *Termitomyces sagittiformis*- a lesser known edible mushroom from the Western Ghats. Mushroom Res 18: 33–36

Vrinda KB, Pradeep CK, Abraham TK. 2002 – *Termitomyces umkowaani* (Cooke & Mass.) Reid- an edible mushroom from the Western Ghats. Mushroom Research 11(1): 7-8.

Wei TZ, Tang BH, Yao YJ. 2009 – Revision of *Termitomyces* in China. Mycotaxon 108: 257–285

Wei TZ, Tang BH, Yao YJ, Pegler DN. 2006 – A revision of Sinotermitomyces, a synonym of Termitomyces (Agaricales). Fungal Divers 21: 225–237.

Wood TG. 1976 – The role of termites (Isoptera) in decomposition processes. In: The role of terrestrial and aquatic organisms in decomposition processes. pp. 145–168.

Ye L, Karunarathna SC, Li H, Xu J et al. 2019 – A survey of *Termitomyces* (Lyophyllaceae, Agaricales), including a new species, from a subtropical forest in Xishuangbanna, China. Mycobiology. Doi 10.1080/12298093.2019.1682449

Zeleke J, Gessesse A, Abate D. 2013 – Substrate-utilization properties of *Termitomyces* culture isolated from termite mound in the great rift valley region of Ethiopia. Online.

Zhao H, Li S, Zhang J, Che J et al. 2016 – The antihyperlipidemic activities of enzymatic and acidic intracellular polysaccharides by *Termitomyces albuminosus*. Carbohydr Polym 151: 1227–1234. Doi 10.1016/j.carbpol.2016.06.058.