

RECORD OF MEDICINAL JEW'S (*Auricularia auricula-judae* (Bull.) Quél) EAR MUSHROOM GROWING IN THE GREATER ACCRA REGION, GHANA AND ITS POSSIBLE HEALTH VALUES

G. T. ODAMTTEN, J. ADDO* & M. WIAFE-KWAGYAN

(*Department of Plant and Environmental Biology, College of Basic and Applied
Sciences, School of Biological Sciences, University of Ghana, Legon.*)

Corresponding author's email: jaddo009@st.ug.edu.gh

ABSTRACT

Medicinal mushrooms are part of total health delivery system of a nation. A mushroom of recognised health benefits was seen for the first time on a pencil cactus (*Euphorbia turicalli* L.) in the Greater Accra Region (Adentan Municipal Assembly) in September- October 2021. The fruiting body was gelatinous with the shape of a human ear. The basidiomata were either solitary, densely rosette with caestipose habit either astipitate or with vestigial stipe. The general morphological features were akin to that of *Auricularia auricula-judae*. Anatomical and morphometric studies showed that the fruiting body had smooth hymenium with a layer of basidia which were cylindrical or club-shaped. The dimensions of the basidia (70.86 ± 4.27 μm long; 9.54 ± 0.60 μm wide) closely agreed with the range reported for *A. auricula-judae*. The white/greyish basidiospores were generally sausage-shaped (allantoid) ranging in length ($18.47 \pm 0.73 \mu\text{m}$) and width ($7.49 \pm 0.3 \mu\text{m}$) closely to reported range. The economical and medicinal values of the mushroom are described and future commercial exploitation through biotechnological technique highlighted.

Keywords: Jews ear mushroom; *Auricularia auricula-judae*, *Euphorbia turicalli* L., basidium, basidiospores; medicinal values.

Introduction

The genus *Auricularia* consists of mushrooms originally described in Europe and belongs to the Phylum: Basidiomycota; Family: *Auriculariaceae*; Order: *Auriculariales* (Kirk *et al.*, 2008). It is well known in Europe, China and other Eastern Asian countries, especially *Auricularia heimuer* (Wu *et al.* 2014). This fungus, *A. heimuer*, is believed to be a taxon reported 2000 years ago in the Chinese Shennong's Compendium of Materia Medica.

Auricularia auricula-judae (= *A. auricula*) is recorded in the Chinese Icons

of Medicinal Fungi (Ying *et al.* 1987). The sporophore is gelatinous and shallow. The shape of the basidiomata resembles the human ear. When humid, the texture is cartilaginous, or waxy. As fruiting body dries out (desiccate), the gelatinous basidiomata shrinks considerably and becomes very tough (Piepenbring, 2015). The hymenium (fertile layer) on the upper surface is smooth or slightly wrinkled varying in colour from reddish, to golden brown, to dark brown. The lower sterile surface is dark olive brown, hairs short, continuous, more or less flexuous gradually tapering towards the

apex. Basidia are cylindrical to barrel-shaped with about three transverse septa, 50-62 x 3-5.5 μm wide. The spore is hyaline to white, often curved, cylindrical or oblong 9-18 μm long x 5-7.5 μm wide (Ying *et al.*, 1987; NCBI, 2020; Mohanan, 2011).

This mushroom grows either solitary, densely in groves and dead older trees such as oak, elm, poplar, banyan, acacia or rotten wood. In Europe, China and Australia where it is found, it occurs throughout the year but most prevalent in late summer and autumn (Li *et al.*, 2021).

The genus *Auricularia* recorded in Africa are summarised in Table 1. There is hardly any reference in the pertinent literature on the occurrence of *A. auriculata-judae* in Ghana. The only record in Ghana is by Apertorgbor *et al.* (2006). But the exact location where this fungus was found during the survey in Southern Ghana was not stated; neither did they mention the type of wood on which it was found. Mushrooms have become an integral part of traditional cuisine and health practices in households in East, Central and West Africa (Dijk *et al.* 2003; Rammeloo & Wallleyn 1993) as well as China, Europe, Americas and the South East Asian-region (Wu *et al.*, 2015; Oli *et al.*, 2020; Li *et al.*, 2021).

The etymology of *Auricularia* in Latin meaning “ear” and “judae” means Judas- the man who was said to have betrayed Jesus in the Garden of Gethsemane as recorded in the Bible. This legend which dates back more than 400 years suggests that, the fungal ear that emerged from older wood are visible residue of Judas tormented spirit (www.first.nature.com, 2021).

The fruiting bodies of *Auricularia* are waxy, rubbery, cartilaginous and colour ranges widely from purplish-brown, yellow brown to

black especially when dry. In Africa, just as in Europe and elsewhere, the fungus can be seen throughout the year.

A. auricula-judae was previously considered as a single species but has recently been demonstrated to be as species complex using phylogenetic analyses by ITS sequence and combined ITS, LSU and rpb2 sequences (Wu *et al.*, 2015). Seven species were delineated by this method and it included 3 species new to science; *A. angiospermarum*, *A. minutissima*, *A. tibetica*, in addition to *A. heimuer* and *A. villosula*.

Mushrooms have enormous biologically active secondary metabolites of high therapeutic application (Sevindik, 2018; Gebreyohannes *et al.*, 2019a, b; González-Palma *et al.* 2016; Badshah *et al.* 2015; Gargano *et al.*, 2017). These mushrooms also have a wide range of secondary metabolites of high therapeutic value such as antioxidants, antidiabetes, antiviral, antithroboic, anti-inflammatory and anti-tumour properties (Iftekhar *et al.*, 2011; Alves *et al.*, 2012; Waktola & Temesgem, 2018; Bills and Glover, 2016; Onyango *et al.*, 2016). Recent reports indicate that over 136 mushroom extracts also have shown antimicrobial activity against gram positive and gram-negative bacteria (Oli *et al.*, 2020; Deka *et al.*, 2017; Islam *et al.*, 2021).

The genus *Auricularia* and *Termitomyces* are no exceptions (Gebreyohannes *et al.*, 2019, a, b). For example, antifungal action of tris buffer and warm aqueous protein extract was active against ten (10) microbial isolates; gram +ve (*Staphylococcus aureus*, *Bacillus subtilis*), gram -ve (*Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*), yeasts (*Candida albicans*, *C. parapsilosis*) dermatophytes pathogen (*Trichophyton scoenleinii*, *T. mentagrophytes*, *Microsporum*

gyseum and *M. ferugineum*) (Oli *et al.*, 2020; Gabreyhannes *et al.*, 2019 b).

The crude tris buffer and warm aqueous extracts contain the following respectively; carbohydrates (43.15% and 38.30%), protein (23.75% and 23.75%), flavonoids (1.20% and 0.80%), alkaloids (0.60% and 1.0%), saponins (6.00% and 2.40%), tannins (1.65% and 1.57%), cyanide (0.24 and 0.40%), ash (12.40% and 10.40%), moisture content (6.00 and 6.00%), lipids (6.00% and 6.00%), fibre (8.70 and 6.45%) (Oli *et al.*, 2020) in line with the results of Khan *et al.* (2016), Deka *et al.* (2017) and Cai *et al.* (2015).

Polysaccharides present in *A. auricula-judae* makes it qualified to be classified aptly as a functional food. These functional ingredients are greatly beneficial to human health (Lin *et al.*, 2021). It also contains high levels of insoluble fibres with varied bioactivities. *A. auricula-judae* also contains several phenolic compounds including epicatechin and catechin and is also known to exhibit antioxidant properties to prevent free radical induced oxidative damage, balance the blood glucose and lipid levels to alleviate diabetes, hyperlipidaemia, obesity and stimulates macrophage and inflammatory cytokines to prevent inflammation, exhibit anti-cancer properties by stimulating cellular apoptosis and prevents gut microbial dysbiosis by stimulating the frominum of healthy microbiota (Islam *et al.*, 2021). The main sugar components of basidiocarp are mannose, galactose, glucose and also contains wound healing polysaccharides (Mapoung *et al.* 2021).

Auricularia auricula-judae produces two dye decolourising peroxidases (AauDy P1 and AauDy P2) (Liers *et al.*, 2010) which have the potential for industrial applications. Indeed, Büttner *et al.* (2015) found that AauDy

P was able to act on ortho-nitrophenol (ONP), meta-nitrophenol (mNP) and para-nitrophenol (pNP) and convert these compounds into dinitrophenols, quinones and polymers. The strain of *A. auricula-judae* used to study dye decolourising peroxidases was DSM 11326 (Strain: SXM9-CO 21) originating from Shaanxi, China putatively named *A. auricula* (Liers *et al.*, 2010; 2011).

According to the Icons of Medicinal Fungi from China (Yin *et al.*, 1987) every 100g of dry material of the fruiting body of *A. auricula-judae* contains 10.690g protein, fat 0.2g, carbohydrates 65g, fibre 7.0g, ash 5.8g, calcium 373mg, phosphorus 201mg, iron 185mg, carotene 0.03mg and energy 303 kilo calories.

In terms of medicinal value this mushroom is good for the treatment of piles, is a good stomach tonic which regulates the flows of vital energy (Ying *et al.*, 1987). The sporophore enriches energy mild to sweet tart and nourishes lungs, stops haemorrhage and invigorates blood circulation; has the effect of embellishment and invigorating bowel movement. The Chinese use it for rheumatic pains in the legs and lumbago, for weakness after childbirth, cramp and numbness, for pains and injury of wound, obstruction in arteries and veins, and tetany (Ying *et al.*, 1987). Furthermore, the Chinese and Europeans use it to treat malignant dysentery, and enteritis, for menorrhagia with leucorrhoea, for haemation and haemorrhoids and uterine bleeding, for gastric disorders causing nausea and excessive phlegm. (Ying *et al.*, 1987).

In West Africa this mushroom *A. auricula-judae* is used in folk medicine for complaints of illnesses including sore throat, sore eyes, jaundice, astringent etc. (m.wikipedia, org). In Chinese restaurants, it is used to prepare dishes such as hot and

sour soup which is also available in Ghana. In Ghanaian folklore medicine, it is used as a blood tonic (m. wikipedia, org; Apetorgbor *et al.*, 2006).

There has not been any study of morphological, anatomical features and phytochemistry of the fungus which will delimit *A. auricula-judae* in Ghana and indeed Africa for future biotechnological cultivation and exploitation for the pharmaceutical industry and to our health benefits. This paper provides some vital morphometric and anatomical diagnostic features which could act as a springboard for future biotechnological cultivation and exploitation of its bioactive compounds for health delivery improvement in Africa.

Experimental

Location of study area

This edible mushroom was spotted in a house at a residential area, Lakeside Estate, in a rock garden within the Ga, Greater Accra, Adentan Municipality with coordinates N4°33' 28° E 0° 55' 56" Latitude 4.5576511, Longitude 0.99322071.

The fruiting body/ basidiomata

When fresh, the basidiomata was gelatinous, orange brown to vinaceous to reddish brown. (Figs. 1a and b). The fruiting body was either solitary, gregarious, rosette or cespitose (growing in dense clusters) (Figs. 2a and b), sessile or sub stipitate, discoid or auriculate with lobbed margin projecting up to form an ear-like lobe. The fruiting body was 2-6mm thick when moist (Figs. 1a and b) becoming greyish upon drying smeared with white spores (Fig. 3a-c).

Anatomical studies

The anatomy of hymenium was studied by cutting a longitudinal section by hand and sliding microtome (Reichart Nr.15917, Austria) and staining with lactophenol and mounting on a glass slide with a cover slip using conventional anatomical methods.

Photographs were taken under photomicroscope (Computer Model Leica ICC50W) with a software (Leica LAS EZ Version 1.8.0).

Dimensions of at least 30 basidiospores and 30 basidium were estimated by stage micrometre and eyepiece graticule measurements and then confirmed with a measuring software ImageJ Version 1.53. (NIH/LOCI, University of Wisconsin, USA).

Host plant for the edible mushroom

The host plant for this mushroom *A. auricula-judae* is commonly known as naked lady, aveloz, milk bush, pencil cactus or fire sticks (Anon, 2010). Its botanical name is *Euphorbia tirucalli* Linn. (Euphorbiaceae, Malpighiales). It is a tree which grows in semi-arid and tropical climates. It is usually used to feed cattle or as a hedge especially in the savanna zones (Haevermans, 2017). In Ghana, it is used as a hedge or decorative plant. This plant is a hydrocarbon plant which produces a poisonous latex milk can cause temporary blindness if not handled properly (Wikipedia, anon 2017). According to the ICUN it is placed in category 3.1 of least concern Conservation status (Haevermans, 2017). *Euphorbia tirucalli* is a plant that has been promoted as an anti-cancer agent (Aveloz, 2015). *Euphorbia tirucalli* has a wide distribution in Africa in black clay soils, being prominently present in Northeastern, Central and Southern Africa. It has been introduced to many other tropical regions, such as Brazil, India, Vietnam, the Philippines and Ghana. (Haevermans, 2017).

Results

Fruiting body/ basidiomata

The initial stages of the development of the mushroom were cryptic under the hard-older bark of the host plant was not visible until its prolific appearance on 4th- 5th October 2021 after a heavy downpour of rain in Accra. The gelatinous orange brown to vinaceous reddish-brown gelatinous fruiting body was seen on the host in the rock garden (Figs. 1a and b). There was an intervening dry spell of 10-12 days which caused the basidiomata to shrivel by losing moisture attended by discharge of copious amounts of basidiospores (Figs. 3b and c). Fig. 3a shows microecological surroundings creating a humid condition with palm trees and pencil cactus in the foreground. Figs. 2a and b show the morphology of the fruiting body as seen in front and behind with the sessile attachment.

Anatomic studies

The hymenium (fertile layer) on the upper surface of the basidiomata (fruiting body) was smooth, wrinkled varying in colour from reddish brown to golden brown to dark brown. All the basidia were seen as cylindrical or club-shaped creamy white in colour at various stages of development (Fig. 4a). The basidia were variable in size. Table 2 summarizes the dimensions of basidia ($70.86 \pm 4.27 \mu\text{m}$ long; $9.54 \pm 0.60 \mu\text{m}$ wide). The spore prints on the fruiting body were white to greyish white in colour (Figs. 3b and c); generally, sausage-shaped (allantoid) to oval ranging in the length ($18.47 \pm 0.73 \mu\text{m}$) and $7.49 \pm 0.3 \mu\text{m}$ in width (Table 2). Figs. 4a and 4b show the morphology of the basidia and basidiospore respectively in the hymenium layer of the fruiting body.

Record of Auricularia in Africa

Table 1 shows the occurrence of *Auricularia* species in Africa. These include *A. auricula-judae*, *A. delicata*, *A. fuscococcinea*, *A. mesenterica*, *A. polytricha* and *A. tenuis*. There is a preponderance of *A. auricula-judae* over the other species in Africa (Table 1).



Fig. 1a and b: Photograph showing the fruiting basidiomata growing on the pencil cactus *Euphorbia tirucalli* L. among other plants after heavy rains (x1/3)



Fig. 2a and b: Photograph of *Auricularia auricula-judae* (front portion) and backside with short stipe.



Fig. 3a-c: Photograph of the mushroom on the host plant under very dry conditions 10-12 days after the rain (x1/3)

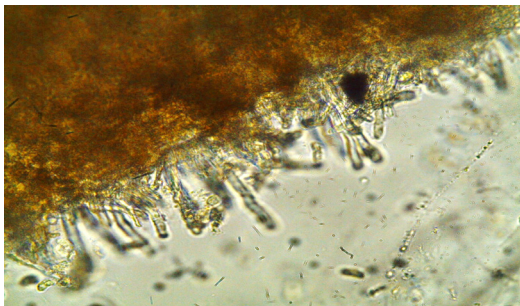


Fig. 4a: Photomicrograph of the longitudinal section of the fruiting body of *Auricularia auricula-judae* showing septate basidia at various stages of development (x400).

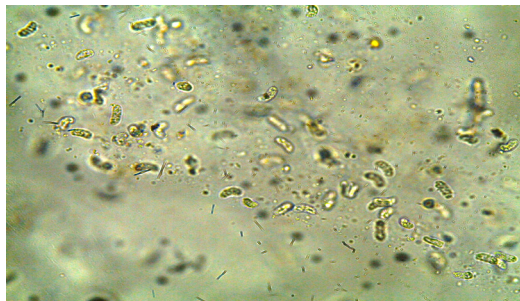


Fig. 4b: Photomicrograph of the longitudinal section of the fruiting body of *Auricularia auricula-judae* showing collection of the sausage shaped spores (allantoid) (x400).

TABLE 1

Record of Auricularia species occurring in Africa.

Name of species	Country/ Region in Africa	Reference(s)
<i>Auricularia auricula-judae</i> (Bull.) Quel	East Africa	Hennings (1895)
	Cameroon	Hennings (1897, 1901,1905)
	Central African Republic	Heim (1963)
	Gabon	Walker (1931)
	Democratic Republic of Congo	Gillet and Paque (1910)
	Malawi	Williamson (1975), Morris (1987,1990)
	Ghana	Apetorgbor <i>et al.</i> (2006),
	South Africa	Gorter & Eicker (1988), Levin <i>et al.</i> (1985)
Nigeria	Zoberi (1973;1979), Akwaji (2015)	
<i>A. delicata</i> (Fr) Henn.	DR. Congo	Morris (1990)
	Malawi	Rammeloo and Walley, (1993)
<i>A. fuscococcinea</i> (Mont) Ferlow	Malawi	Rammeloo and Walley, (1993)
	DR. Congo	Rammeloo and Walley, (1993)
	East Africa	Lowy (1952)
<i>A. mesenterica</i> (Dicks) Fr.	East Africa	Lowy (1952)
<i>A. polytricha</i> Mont.	Tanzania	Eichelbaum (1906)
	DR. Congo	Gillet and Paque (1910)
<i>A. tenuis</i> Lev.	DR. Congo	De Greef <i>et al.</i> (1991)
		Musibono <i>et al.</i> (1991)

TABLE 2
*Morphometric and some physical characteristics of fruiting body of
 A. auricula-judae in Ghana and in the literature.*

Parameter	SPORE		BASIDIUM	
	Literature*	Current Paper	Literature*	Current Paper
Length(μm)	16-18	18.47 \pm 0.73	60-72	70.86 \pm 4.27
Width (μm)	6-8	7.49 \pm 0.30	4.0-7.50	9.5 \pm 0.60
Colour	White	White	Creamy White	Creamish White
Shape	Sausage, Reniform, Allantoid	Sausage, Reniform, Allantoid.	Club-shaped, cylindrical.	Club-shaped, cylin- drical.

*Literature: Mohanan (2011), Ying *et al.* (1987).

NCBI (National Center for Biotechnology Information) <https://ncbi.nlm.nih.gov> Taxonomy ID

NCBI: txid29892

Discussion

The fruit body of this mushroom found in Accra resembles that of *Auricularia auricula-judae* and is waxy and cartilaginous, resembling human ear with a wide range of colours ranging from purplish brown, yellow brown, vinaceous to sometimes black (Figs. 1-3). This is akin to what is stated in the pertinent literature as having wide occurrence in Africa (Table 1) and is the first record of its occurrence in the Adentan Municipal Assembly, in the Greater Accra Region, in a residential house within the Lakeside Estate, Ashalley Botwe. Previous record was reported by Apetorgbor *et al.* (2006), in an unnamed location of Southern Ghana. They also did not state the host plant. This is the first record of *A. auricula-judae* on dried older wood of pencil cactus, *Euphorbia turicalli* L. or fire sticks. This data also extends the list of host plants supporting the growth and development of the *A. auricula-judae*. It has been previously recorded growing solitary, or densely in groves, rosette, caestipose on the dead wood such as oak, elm, poplar, bayan, sycamore, acacia, eucalyptus etc. in Europe,

South East Asia, Australia and England (Li *et al.*, 2021). The shape of the basidiomata which resembles human ear shrunk considerably and became very tough (Fig. 3) as occurred in this study under drought conditions. This agrees with the findings of Piepenbring (2015) and Li *et al.* (2020) for the same fungus under drought conditions.

The longitudinal section of the hymenium (Figs. 4a and b) shows that the basidia were at various stages of development and were club shaped or cylindrical with at least three transverse septa. The basidia length was 70.86 \pm 4.27 μm long and 9.54 \pm 0.60 μm wide (Table 2). These values fairly agree with the reported values in the pertinent literature by Ying *et al.* (1987), Mohanan (2011) and NCBI (2020). They stated a range of 60-72 μm long and 4.0-7.5 μm wide (Table 2). The spore print of the hymenium was hyaline to white in colour (Fig. 3) and were often curved sausage shaped (or allantoid) (Fig. 4b). This observation agrees with that of other workers (Ying *et al.*, 1987; NCBI 2021; Mohanan, 2011).

This mushroom occurs throughout the

year in Africa and Ghana (Apetorgbor *et al.* 2006) and agree with what obtains in Europe, Asia and Australia (Oli *et al.* 2020; Li *et al.* 2021).

The perennial nature of flushing and occurrence of this mushroom should lend the fungus the opportunity for cultivation. However, before developing the local techniques for commercial cultivation in Africa and Ghana in particular, there should be some preliminary biotechnological screening of the local isolates. This group has never been studied in the detail in Africa and most of the literature data are probably based on macroscopic resemblances (Rammelo & Walley, 1993). It will be instructive to study the local isolated using phylogenetic analyses by ITS sequence and combined ITS and 150 and rpb2 sequences as was done by Wu *et al.* (2015) for the Chinese and European species. This aforementioned study is more relevant as mushroom have a plethora of biologically active secondary metabolites of high therapeutic applications (Sevindik, 2018; Bahshah *et al.*, 2015; González- Palma *et al.*, 2016; Gargano *et al.*, 2017; Gebreyahannes *et al.*, 2019a, b) and may differ in concentration of active ingredients based on genetic lines. It is also well known that *Auricularia* also have a wide range of secondary metabolites of high therapeutic value such as antioxidants, anti-diabetic, antiviral, antithrombotic, anti-inflammatory and anti-tumor properties worthy of exploitation for health improvement (Bill and Glover, 2016; Gryango *et al.*, 2016; Iftehekhar *et al.*, 2011; Alves *et al.*, 2012; Walktola & Temesgen, 2018). Recent studies indicate that, over 136 mushroom species extracts have also been shown to have antimicrobial activity against gram positive and gram-negative bacteria (Islam *et al.*, 2021; Oli *et al.*, 2020; Deka *et al.*, 2017). The genera

Auricularia and *Termitomyces* are prominent among these mushrooms with biologically active secondary metabolites of high therapeutic applications (Gebeyohannes *et al.*, 2019a, b) as well as antimicrobial activity against both gram negative and gram-positive bacteria (Islam *et al.*, 2021; Oli *et al.*, 2020; Deka *et al.*, 2017).

There are other economically beneficial compounds in *A. auricula-judae* such as polysaccharide serving as functional food for human health (Liu *et al.*, 2020; Miao *et al.*, 2020), insoluble fibres with varied bioactivities not excepting sugars (mannose, galactose, glucose etc.) as well as wound-healing polysaccharides (Mapoung, 2021). In summary, this mushroom is such a potent source of pharmaceutical factory for bioactive healing compounds in the health delivery system that it cannot be discounted.

This paper has provided morphological and anatomical evidence that this mushroom occurs in Ghana and future studies should aim at ascertaining its biotechnological physiology and molecular characteristics with the view to providing a spring board for its commercial cultivation, as explained, for better health.

References

- ALVES, M. J., FERREIRA, I. C., DIAS, J., TEIXEIRA, V., MARTINS, A. & PINTADO, M. (2012) A review on antimicrobial activity of mushroom (Basidiomycetes) extracts and isolated compounds. *Planta Medica* **78** (16), 1707 – 1718. <https://doi.org/10.1055/s.0032-1315370>.
- ANON (2010) *Euphorbia tirucalli* L. Germplasm Resources Information Network (GRAIN). Agricultural Research Service 9ARS) United States Dept. of Agriculture. USDA. Retrieved 18/10/21.
- APETORGBOR, M. M., APETORGBOR, A. K. & OBODAI, M. (2006) Indigenous Knowledge and utiliza-

- tion of edible mushrooms in parts of Southern Ghana. *Ghana J. Forestry* **19** and **20**, 20 - 34.
- BADSHAH, H., ULLAH, F., KHAN, M. U., MUMTAZ, A. S. & MALIK, R. N. (2015) Pharmacological activities of selected wild mushrooms in South Waziristan (FATA), *Pakistan. South African Journal of Botany* **97**, 107 – 110. doi:10.1016/j.sajb.2014.12.002.
- BILLS, G. F. & GLOER, J. B. (2016) Biologically Active Secondary Metabolites from the Fungi. *Microbiology Spectrum* **4** (6), 10.1128/microbiolspec.FUNK-0009-2016. https://doi.org/10.1128/microbiolspec.FUNK-0009-2016
- BÜTTNER, E., ULLRICH, R., STRITTMATTER, E., PIONTEK, K., PLATTNER, D. A., HOFRICHTER, M. & LIERS, C. (2015) Oxidation and nitration of monotrophenols by a DyP-type peroxidase. *Archives of Biochemistry and Biophysics* **574**, 86 – 92. https://doi.org/10.1016/j.abb.2015.03.003
- CAI, M., LIN, Y., LUO, Y. L., LIANG, H. H. & SUN, P-L, (2015) Extraction, antimicrobial and antioxidants of crude polysaccharides from the wood ear medicinal mushroom, *Auricularia auricula-judae*. *Int. J. Medicinal Mushrooms* **17** (6), 591 - 600.
- DE GREEF, J., MALAISSE, F., RAMMELOO, J. & BAUDART, É (1991) Edible mushrooms of Zambesian woodland area: a nutritional and ecological approach. *Proceedings XIII AETFAT Congress Malawi*, 2 - 11 April, 1991.
- DEKA, A. C., SARMA, I., DEY, S. & SARMA, T. C. (2017) Antimicrobial properties and phytochemical screening of some wild macrofungi of Rani-Garbhangra reserve forest area of Assam, India. *Advances in Applied Science Research* **8** (3), 17 - 22.
- DIJK, V. H., ONGUENE, N. A. & KUIJPER, T. W. (2003) Knowledge and utilization of edible mushroom by local populations of the rain forest of south Cameroon. *Ambio* **32**(1), 19 - 23.
- EICHELBAUM, F. (1906) Beiträge zur Kenntnis der Pilzflora des Ostusambargebirges. *Verh. Naturw. Ver.Hamb.* **14**, 1 - 92.
- GARGANO, M. L., VAN GRIENSVEN, L. J. L. D., ISIKHUEMHEN, O. S., LINDEQUIST, U., VENTURELLA, G., WASSER, S. P. & ZERVAKIS, G. I. (2017) Medicinal mushrooms: Valuable biological resources of high exploitation potential. *Plant Biosystems* **151** (3), 548 - 565. https://doi.org/10.1080/11263504.2017.1301590
- GEBREYOHANNES, G., NYERERE, A., BII, C. & SBHATU, D. B. (2019a) Investigation of Antioxidant and Antimicrobial Activities of Different Extracts of *Auricularia* and *Termitomyces* Species of Mushrooms. *The Scientific World Journal* **19**, 1 – 10. doi:10.1155/2019/7357048.
- GEBREYOHANNES, G., NYERERE, A., BII, C. & BERHE SBHATU, D. (2019b) Determination of Antimicrobial Activity of Extracts of Indigenous Wild Mushrooms against Pathogenic Organisms. *Evidence-Based Complementary and Alternative Medicine* **2019**, 1 – 7. doi:10.1155/2019/6212673.
- GILLET, J. & PAQUE, E. (1910b) Plantes Principales De La Region De Kisantu, leur nom indigene, leur nom scientifique, leur usages. *Ann Mus Congo Se. Bot.* **5** (4), 1 - 20.
- GONZÁLEZ-PALMA, I., ESCALONA-BUENDÍA, H. B., PONCE-ALQUICIRA, E., TÉLLEZ-TÉLLEZ, M., GUPTA, V. K., DÍAZ-GODÍNEZ, G. & SORIANO-SANTOS, J. (2016a) Evaluation of the Antioxidant Activity of Aqueous and Methanol Extracts of *Pleurotus ostreatus* in Different Growth Stages. *Frontiers. Microbiol.* **7**, 1099. doi: 10.3389/fmicb.2016.01099.
- GORTER, G., MA, J. & EICKER, A. (1988) Gewone Afrikaanse en Engelse name vir die meer algemene Suid-Afrikaanse sampioene en anere makroswamme. *South Afr: Tydsk Natuur and Teng.* **7**, 55 – 64.

- HAEVERMANS, J. (2017) *Euphorbia tirucalli* L. IUCN Red list of Threatened species 2017; e. T44452A117034216. Retrieved 5th June 2021.
- HEIM, R. (1963) La nomenclature mycologique de Lissosongos. *Cah Maboke* **1**, 77 - 85
- HENNINGS, P. (1895) Fungi: Camerunensis I. *Bob. Jahrb Syst.* **22**, 72 - 111.
- HENNINGS, P. (1897) Fungi: Camerunensis II. *Bob. Jahrb Syst.* **23**, 537 - 558.
- HENNINGS, P. (1901) Fungi: Camerunensis novi III. *Bob. Jahrb Syst.* **30**, 39 - 57.
- HENNINGS, P. (1905) Fungi: Camerunensis I. *Bob. Jahrb Syst.* **22**, 72 - 111.
- IFTEKHAR, A. F. M. H., CHOUDHRY, Z. K., KHAN, M. I. & SALEH, A. A. (2011) Comparative study of antibacterial activity of wood-decay fungi and antibiotics. *Bangladesh Journal of Pharmacology* **6** (1). doi:10.3329/bjp.v6i1.7907.
- ISLAM, T., GANESAN, K. & XU, B. (2021) *Insights into health-promoting effects of Jew's ear (Auricularia auricula-judae)*. *Trends in Food Science & Technology* **114**, 552 – 569. doi: 10.1016/j.tifs.2021.06.017.
- KHAN, A. A., JAHANGIR, M. M., SAMIN, G., ALI, M. A., ZIAF, K., KHAN, A., KARIM, W. & ZAHI, A. (2016) Nutritional and chemical profiles of auricularia mushrooms: A Review. *Int. J. Agric. Environ. Res.* **2** (3), 225 - 233.
- LEVIN, H. & BRANCH, M. (1985) *A Field guide to the mushrooms of South Africa*. 168pp. Cape Town Struik Publishers.
- LI, J., LI, Z., ZHAO, T., YAN, X. & PANG, Q. (2021) Proteomic Analysis of *Auricularia auricula-judae* Under Freezing Treatment Revealed Proteins and Pathways Associated with Melanin Reduction. *Front. Microbiol.* **11**, 610173. doi: 10.3389/fmicb.2020.610173.
- LIERS, C., ARNSTADT, T., ULLRICH, R. & HOFRICHTER, M. (2011) Patterns of lignin degradation and oxidative enzyme secretion by different wood- and litter- colonizing basidiomycetes and ascomycetes grown on beech-wood. *FEMS Microbiology Ecology* **78** (1), 91 – 102. <https://doi.org/10.1111/j.1574-6941.2011.01144.x>
- LIERS, C., BOBETH, C., PECYNA, M., ULLRICH, R. & HOFRICHTER, M. (2010) DyP-like peroxidases of the jelly fungus *Auricularia auricula-judae* oxidize nonphenolic lignin model compounds and high-redox potential dyes. *Appl Microbiol Biotechnol* **85**, 1869 – 1879. <https://doi.org/10.1007/s00253-009-2173-7>
- LIU, E. J. I. Y., ZHANG, F., LIU, B. & MANG, X. (2021) Review of *Auricularia auricula-judae* as a functional food: Growth Chemical composition and Biological Activities. *J. Agric. Food Chem.* **69** (6), 1729 - 1750.
- LOWY, B. (1952) The Genus *Auricularia*. *Mycologia* **44**, 656-692.
- MAPOUNG, S., UMSUMARNG, S., SEMMARATH, W., ARJSRI, P., THIPPRAPHAN, P., YODKEEREE, S. & LIMTRAKUL DEJKRIENGKRAIKUL, P. (2021) SkinWound-Healing Potential of Polysaccharides from Medicinal Mushroom *Auricularia auricula-judae* (Bull.). *Journal of fungi (Basel, Switzerland)* **7** (4), 247. <https://doi.org/10.3390/jof7040247>
- MOHANAN, C. (2011) *Macrofungi of Kerala*. Kerala Forest Research Institute p.90 - 93 ISBN 978-81-85041-73-5.
- MORRIS, B. (1987) *Common mushrooms of Malawi*, 108p.8pl.Oslo Fungi Flora.

- MORRIS, B. (1990) An annotated check-list of macro fungi of Malawi. *Kirkia*, **13**, 323 - 364.
- MUSIBONO, E. A., HABARI, M. H. & PAULUS, J. J. (1991) Essai de culture mycélienne de quelques champignons comestibles zairois sur milieu semi-synthétique. *Tropiculture* **9**, 138 - 139.
- NCBI (NATIONAL CENTER FOR BIOTECHNOLOGICAL INFORMATION) (2020) <https://ncbi.nlm.nih.gov>. Taxonomy ID NCBI:txid29892.
- OLI, A. N., EDEH, P. A., AL-MOSAWI, R. M., MBA-CHU, N. A., AL-DAHMOUSHI, H., AL-KHAFAJI, N., EKUMA, U. O., OKEZIE, U. M. & SAKI, M. (2020) Evaluation of the phytoconstituents of *Auricularia auricula-judae* mushroom and antimicrobial activity of its protein extract. *European Journal of Integrative Medicine* **38**, 101176. <https://doi.org/10.1016/j.eujim.2020.101176>
- ONYANGO, B. O., MBALUTO, C. M., MUTUKU, C. S. & OTIENO, D. O. (2016) Molecular characterization of wood ear mushrooms (*Auricularia*) from Kakamega Forest in Western Kenya. *Current Research in Environmental & Applied Mycology* **6** (1), 51 – 60, Doi 10.5943/cream/6/1/6.
- PIEPENBRING, M. (2015) *Introduction to Mycology in The Tropics*. American Phyto pathological Society St. Paul, Minnesota USA, 366pp.
- RAMMELOO, J. & WALLEYN, R. (1993) *The Edible Fungi of Africa South of the Sahara*. Moise National Botanical Garden of Belgium, Domain van Bruchout, Moise, Belgium, E.U. Commission, 62pp.
- SEVINDIK, M. (2018) Investigation of Antioxidant/Oxidant Status and Antimicrobial Activities of *Lentinus tigrinus*. *Advances in Pharmacological Sciences* **2018**, ID 1718025. <https://doi.org/10.1155/2018/1718025>
- WAKTOLA, G. & TEMESGEN, T. (2018) Application of Mushroom as Food and Medicine. *Advances in Biotechnology and Microbiology* **11**, 97 - 101. <https://doi.org/10.19080/AIBM.2018.11.555817>
- WALKER, A. (1931) Champignon comestibles de la Basse-Ngounié (Gabon). *Rev.Inst.Bot.Appl. Agric.Trop* **11**, 240 – 246.
- WILLIAMSON, J. (1975) Fungi: In *Useful Plants of Malawi* (revised and extended edition), 312 - 336, Zomba, University of Malawi.
- WU, F., YUAN, Y., HE, S-H, BANDARA, A., HYDE, K. D., VERA, M., LI, D-W. & DAI, Y-C. (2015) Global diversity and taxonomy of *Auricularia auricula-judae* complex (Auriculariales, Basidiomycota). *Mycological Progress* **14** (10), doi:10.1007/s11557-0151113-4.
- YING, J., MAO, X., MA, Q., ZONG, Y. & WEN, W. (1987) *Icons of Medicinal Fungi from China*. Science Press, Beijing China, 575pp.
- ZOBERI, M. H. (1973) Some edible mushrooms from Nigeria. *Nigerian Field* **38**, 81 - 90.
- ZOBERI, M. H. (1979) Some edible mushrooms from the tropics. *Mushroom Science* **10** (2), 519 - 536.

Received 11 Apr 21; revised 02 Feb 22.