FEDERAL UNIVERSITY OF LAFIA

INAUGURAL LECTURE SERIES NO. 9

FACULTY OF SCIENCE

INDOOR FUNGI: FRIENDS OR FOES?

PROFESSOR ALERUCHI CHUKU

Professor of Medical Mycology

Department of Microbiology

June 22, 2023

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DEDICATION

This work is dedicated to God Almighty, who only by His mercy, I am. For He is my help.
Psalms 121

PROF. ALERUCHI CHUKU

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Professor of Medical Mycology

Department of Microbiology

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Federal University of Lafia

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SALUTATION

The University Council present,
The Vice Chancellor
Deputy Vice-Chancellors,
Registrar and other Principal Officers,
Provost, College of Health Sciences
Dean School of Postgraduate Studies,
Deans of Faculties
Distinguished Professors
Heads of Academic and Administrative Departments,
Colleagues,
Distinguished Guests,
Students,
Cherished Friends,
My beloved Family,
Ladies and Gentlemen.

I welcome you all to this inaugural lecture. I thank you all for making the effort and sacrificing your precious time from far and near to be here for this programme. It is an honour to me and I appreciate each and every one of you present here today.

Mr. Vice Chancellor Sir, I am immensely honoured and grateful to you for the approval given to enable me stand before this great audience as a Professor of Medical Mycology to present the 9th Inaugural Lecture of the University, the 3rd in the Faculty of Science, the 1st in the Department of Microbiology, the 1st female Inaugural Lecture presenter in the Department of Microbiology, in the Faculty of Science and in Federal University of Lafia.

I am eternally grateful to God Almighty for making this day a reality for me. There are no words suitable to describe His blessings upon my life and I can only express my gratitude to God the only way I know best; by singing His praises

All glory must be to the Lord
For He is worthy of our praise
No man on earth should give glory to himself
All gory must be to the Lord

PREAMBLE

For newly promoted Professors, the inaugural lecture provides an opportunity to present what they *profess.* It is the platform to exhibit the progress of their career so far, update colleagues on current and future research plans, and introduce their field of expertise to a wider audience. It is therefore my pleasure this afternoon to stand before you and *profess* my career progress so far in this Inaugural Lecture titled **"Indoor Fungi: Friends or Foes"**

Vice Chancellor Sir, if the destiny of a person were to be in the hands of fellow men and women, mine would have been described as "cut short" or at best "liability". As the first child out of five and first daughter out of four, my upbringing was underlined with setting the pace or example for my siblings, because failure was not an option for me. So it was a devastating blow for me when I had an accident in my J.S.S.1 which involved my eyes and threatened my entire educational future.

I was bullied constantly and subtly, sometimes unconsciously by the bullies but ironically, this only made the stubborn Ikwerre spirit and blood in me more determined to do better and excel, so that if I did not get selected for beauty, then there will be no choice but to be selected for my achievements.

All through the early phase of my education, two issues stood out clearly in my memory. One was my struggle with my eyes,

the numerous surgeries I had to go through both at home and abroad, the hurt and most times innocent but embarrassing questions and stares I had to endure. The second was the complete opposite, which was the unflinching love and support from my parents and siblings. As far as my father was concerned, I could do and be who and whatever I wanted. My parents saw no limitations to what I could become in spite of the challenge I faced and I choose to see myself through their eyes.

The first time I saw the “fisherman's cap” (the Doctoral cap), I called it ugly and at the same time I declared that I would wear one. That was at my first matriculation day at the University of Port Harcourt in 1992. Although I forgot the words I had spoken that day, my mother like Mary the mother of Jesus Christ hid my words in her heart, nursed them and never forgot them as she reminded me of those same words I had spoken, on my graduation day as a Ph.D. holder. Those words signifying the power of spoken words, set me spiritually on the path of a career in academics.

While growing up, I never wanted to be a teacher, even though at an early age I knew I loved and had an affinity for teaching others and an indescribable reverence for my teachers. I rather dreamt of being a prestigious female pilot or a medical doctor on high heeled shoes looking like a model and causing heartbreak to the male doctors like I saw in the moves or being a fashion designer

and wearing very beautiful clothes with my own label.
Vice Chancellor Sir, today I can describe myself as a teacher who does not fly a plane, but pilots young eager minds to the door of infinite discovery in themselves. Instead of clothes, I model my life and experiences for my students to learn from and be better individuals (even though, I design and make some of my own clothes when time permits) and instead of breaking hearts, I break barriers and limitations placed by society and the ignorant on myself and on every femaleneeding someone to believe in them to be the best they could be.

My romance with fungi was an accidental encounter that turned into a permanent marriage. While determining the microbial air quality of a building in a research study, my supervisor, Professor Precious Ede and I found these beautiful growths on the media plates and while I admired the intricate colours of the growth, he encouraged me to not dismiss them as mere contaminants but rather investigate further. This gave birth to all of my work and still growing interest in fungi in general and indoor fungi specifically.

A good percentage of people present here today may have heard of fungi while for some, it would be a first time. Nevertheless, this inaugural lecture affects everyone in every walk of life, therefore, it will not be boring and I hope to make it simple enough for everyone present here today to have something

tangible to take away.

Vice Chancellor Sir, I crave your indulgence to pose a question to the congregation here today. A question I would want everyone to give an answer to themselves at the end of the lecture according to their understanding;

Which of the options listed below, best describes an indoor fungus?

a) **A friend**
b) **A foe**
c) **A friendly foe**
d) **A friend and a foe**

1.0. Introduction

Vice Chancellor Sir, I will begin this lecture by giving us a brief description of what a fungus is.

1.1. Fungi

Fungi are not plants and they are not animals. There are three major kingdoms of multicellular eukaryotes, they are the **kingdom Plantae, kingdom Animalia**, and **kingdom Fungi.** Fungi are therefore defined as eukaryotic (their cells contain membrane-bound organelles and clearly defined nuclei) organismsthat are heterotrophs (they cannot manufacture their own food). They are filamentousmulticellular organisms with hyphae whose cell walls are made up of chitin.

1.2. Origin and History of fungi

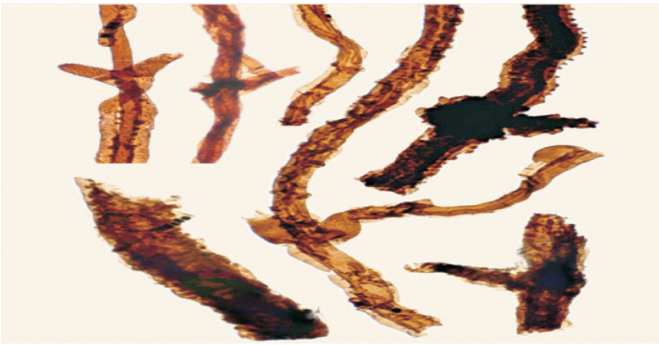


Figure 1: Fossil filaments of *Tortotubus protuberans* showing stages in development of filamentous envelope.(Smith, 2016)

In the absence of abundant fossil record, biochemical characterization has been used to map out the possible evolution

of fungi. Their relatedness has been established using their cell wall composition (presence of chitin, alpha-1,3 and alpha-1,6-glucan), the organization of tryptophan enzymes, and the synthesis of lysine (using the aminoadipic acid pathway).Molecular phylogenetic analyses have also contributed immensely to the identification and understanding of fungal origins and history.

1.3. Characteristics of fungi

Some fungi are multicellular possessing many hyphae which are branching filaments. The hyphae are tubular structures that are split into compartments by walls that are called **septa** witheach cell containing nucleus and other organelles. The network of hyphae is called a **mycelium**.Some fungi are single-celled and are calledyeast while some fungi alternate between single-celled yeast and multicellular forms depending on what stage of the life cycle they are in and are called **dimorphic fungi** (They grow as yeasts at 37°C, but as molds at 25°C).

Fungi cell walls contain **chitin** and they do not contain cellulose. They are heterotrophs which means they cannot produce their own food but must obtain nutrients from organic material using their hyphae which elongates and obtains nutrients from various sources. Some fungi hyphae tether themselves to the substrate they feed on by forming root-like threads called **rhizomorphs**.

Some fungi are called saprobes and are decomposers because

they breakdown and obtain nutrients from dead organic matter while some other fungi parasitize plants and yet some fungi have symbiotic relationships with photosynthetic algae or bacteria, and with plant roots. A symbiotic association of a fungus and an organism that photosynthesizes is called a **lichen**, while a plant root-and-fungus association is called a **mycorrhiza**

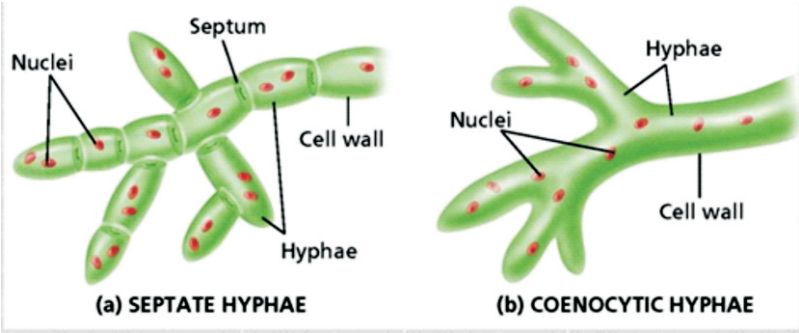


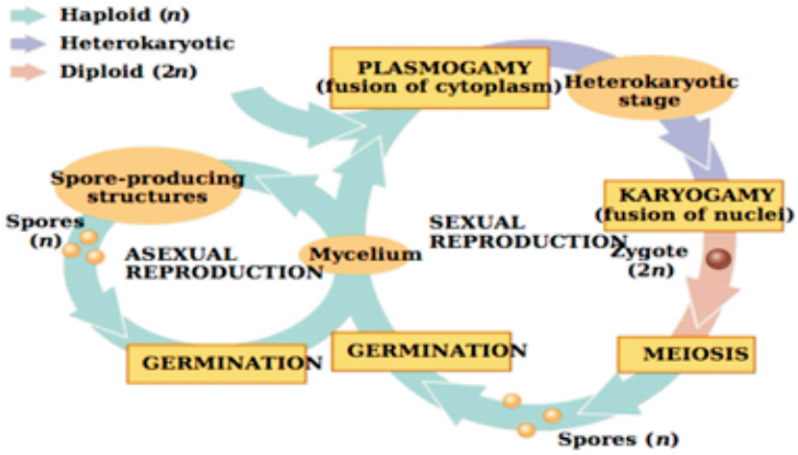
Figure 2: Hyphae structure of fungi (Seth, 2014)

1.4. Reproduction of fungi

Fungi reproduce through both sexual and asexual process. Asexual reproduction occurs either through mycelial fragmentation or through the release of spores. All fungi reproduce using spores which are microscopic cells or group of cells that are dispersed from the parent fungus through water or wind. When the environmental conditions are not favourable for growth, the spores can remain dormant for a very long time until the condition becomes favourable again.

Sexual reproduction in fungi occurs when separate individual

fungus fuse their hyphae together. The three basic stages of sexual reproduction in fungi are the **haploid** stagewhere there is only one set of chromosomes, the **diploid** stage and the **dikaryotic** stage which has two sets of chromosomes that remain separate.



(Source: https://kivtabas.blogspot.com/2021/06/sexual-reproduction-in-fungi.html)

1.5. Classification of fungi

Proper recognition was given to the three major multicellular eukaryotes namely kingdom Plantae, kingdom Animalia, and kingdom Fungi during the middle of the 20th century. The major character difference between the kingdoms is their mode of nutrition. While plants synthesise their food, animals engulf their foods and fungi excrete digestive enzymes on the food and

absorb the digested nutrient.

Initial classification of fungi was based on the morphology of sexual organs, the presence or absence of hyphal cross walls (septa), and by the degree of chromosome repetition (ploidy) in the nuclei of vegetative mycelia. They were classified into four classes: Phycomycetes, Ascomycetes, Basidiomycetes, and Deuteromycetes.

The phylogenetic classification of fungi divides the kingdom into 7 phyla, 10 subphyla, 35 classes, 12 subclasses, and 129 orders (Moore *et al.,* 2020)

1. **Phylum Chytridiomycota** (over 900 species in 105 genera); (Barr, 2011)
    - These are mainly aquatic
    - Some are parasitic or saprotrophic;
    - Unicellular or filamentous;
    - Grow aerobically in water, soil or mud
    - Chitin and glucan cell wall;
    - Reproduce asexually through motile spores (zoospores)
    - Example*Batrachochytriumdendrobatidis*also known as amphibian killing fungusbecauseit causes an infectious disease called chytridiomycosis in amphibians. Shown below is a micrograph of *B. dendrobatidis*

Plate 1: ***Batrachochytriumdendrobatidis*** (source: Alchetron, 2023)

1. **Phylum Blastocladiomycota** (179 species in 14 genera)
    - They are aquatic and terrestrial
    - Parasitic on plants and animals,
    - Flagellated;
    - Alternates between haploid and diploid generations (zygotic meiosis);
    - Example *Allomycesmacrogynus*, *Blastocladiellaemersonii*, (as shown in plate 2) and *Physodermamaydis*

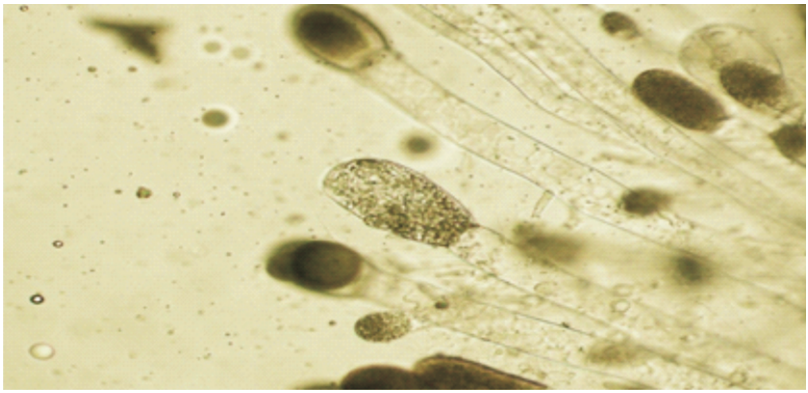


Plate 2: *Blastocladiellaemersonii(Source:* **Xerantheum**, 2010*)*

3. Phylum Neocallimastigomycota (20 species in 6 genera)

- Commonly found in digestive tracts of herbivores;
- They are anaerobic;
- Produce zoospores with one or more posterior flagella;
- lacks mitochondria but contains hydrogenosomes (hydrogen-producing, membrane-bound organelles)
- Examples *Neocallimastix, Oontomyces,* and*Orpinomyces*as shown in plate 3

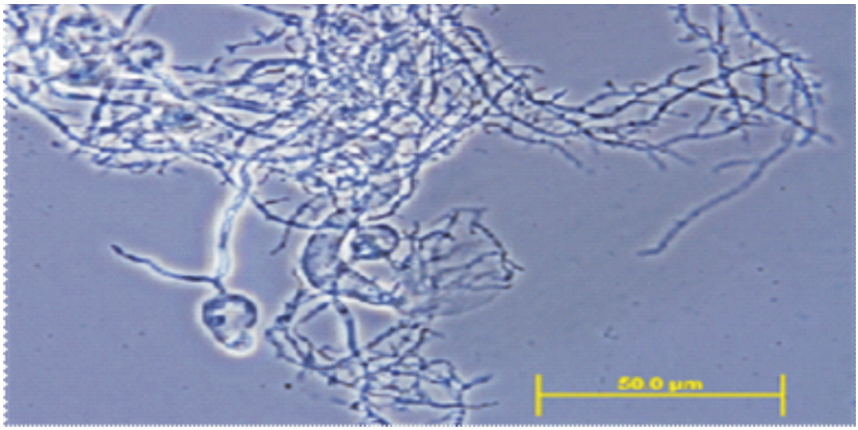


Plate 3: *Orpinomyces* spp. (Source: Youssef, 2013)

4. **Phylum Microsporidia** (1,400+ species in 200 genera);
    - They are unicellular
    - They are parasitic on animals, insects, fish and also on other parasites;
    - Implicated in human infections
    - Reproduction is by either binary fission (merogony or schizogony) or by sporogony
    - *Examples; Fibillanosemacrangonysis, Amblyosporida*spp and *Neopereziida*spp (Tedersoo*et al*, 2018)

5. **Phylum Glomeromycota** (230 species in 12 genera)
    - They are terrestrial soil fungi
    - They are known to form obligate, mutualistic,

symbiotic relationships with roots of plants and trees, thereby forming arbuscular mycorrhizas

- They reproduce asexually (forming spores)
- Their cell walls are composed primarily of chitin
- Example *Rhizopusstolonifera, (shown in Plate 4)*

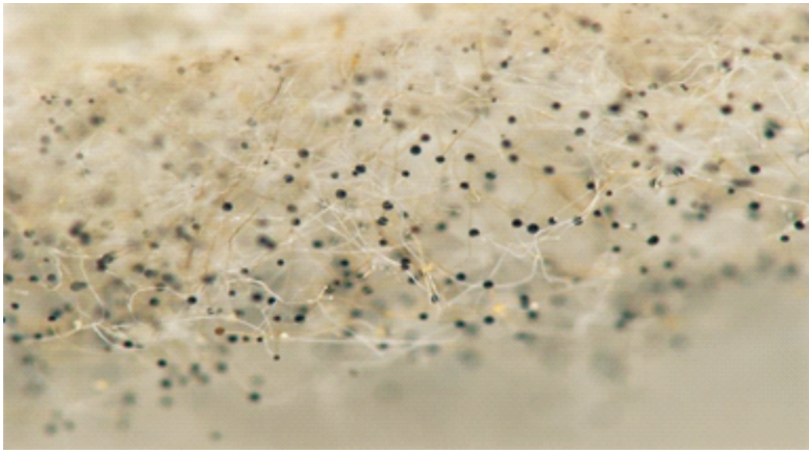


Plate 4: *Rhizopusstolonifera (Black bread mould)*
(Source: Helmenstine, 2019)

6. Phylum Ascomycota (64,163 species in 6355 genera)

- They are commonly called sac fungi and are the largest group of fungi
- They are ubiquitous in the environment as they can be found in marine environment, tree roots, human body etc.
- Some are unicellular, but most of them are

filamentous

- Their cells are either uninucleate or multinucleate
- They are parasitic or saprotrophic on plants, animals, or humans
- Some are symbiotic with algae to form lichens
- They reproduce both sexually and asexually; asexually by budding, fragmentation, fission or by conidia produced on sporiferous hyphae,
- Sexual reproduction is by various means resulting in the production of ascospores
- Examples *Penicillium*spp (shown in plate 5). *Candida* spp. and *Aspergillus* spp.

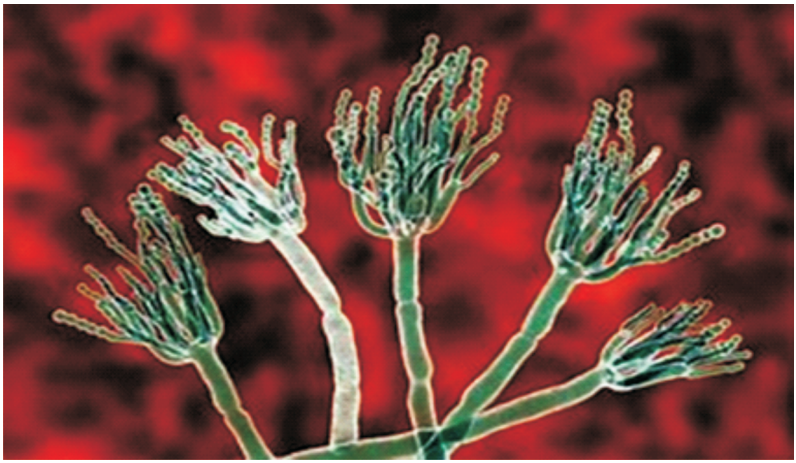


Plate 5: *Penicilliumnotatum*

(Source: iStock Photos, 2023)

7. Phylum Basidiomycota (31,515 species in 1589 genera)

- These are filamentous fungi
- They are parasitic or saprotrophic on plants or insects;
- Undergoes both sexual and asexual reproduction.; asexual reproduction is by fragmentation or conidiawhile sexual reproduction is by club-shaped spore-bearing organ (basidium) that produce four sexual spores (basidiospores).
- They include mushrooms, puffballs, stinkhorns, rusts, and smuts.
- Example *Cryptococcus neoformans (Shown in plate 6)*

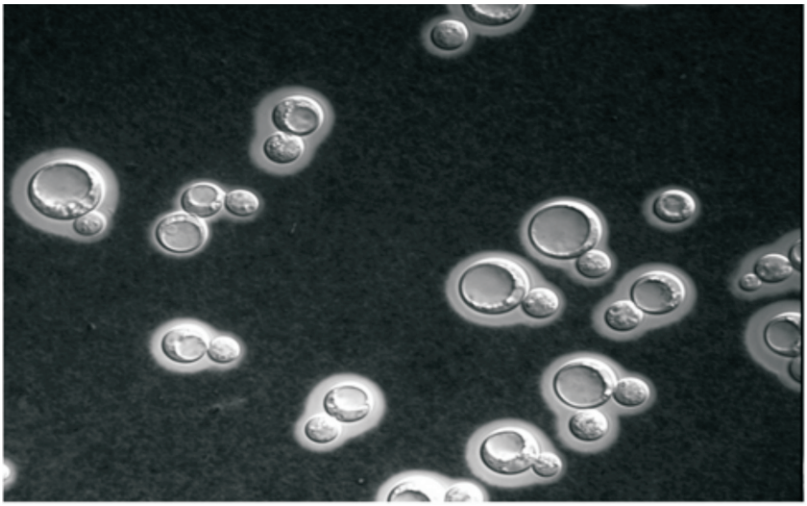


Plate 6: *Cryptococcus neoformans*
(Source: Ivachon, 2020)

2.0. Indoor Fungi

Vice Chancellor Sir, the world of fungi is vast with over one hundred thousand known species and still expanding on a daily basis as new species are discovered, characterised and named. Fungal spores are a normal component of the outdoor environment and there are no special species of fungi that are found either only indoor or outdoor. The Indoor fungi aresimply those that grow and thrive in buildings or any enclosed environment.

Fungi gain access to indoor environment either through the introduction of air from the outdoors to the indoor or through human activities. Fungal spores can be introduced into the indoor through the soil on human feet/shoes, clothing items or any object containing fungal spores.

They are mostly regarded as contaminants especially when they colonise substrates in the buildings such as carpets, wooden floor boards, ceilings, furniture, bathroom fixtures, indoor potted plants, walls and much more.

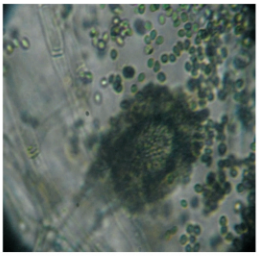
2.1. Common examples of Indoor fungi

Table 1: Examples of fungi species commonly found in indoor environment include;

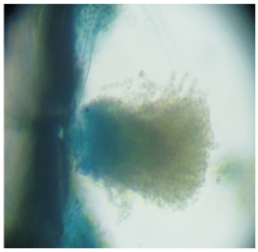
S/n	Fungal Genus	Species
1	*Absidia*	*corymbifera*
2	*Acremonium*	*murorum; strictum*
3	*Alternaria*	*Tenuissiuma*
4	*Aspergillus*	*calidoustus; candidus; clavatus; flavus; fumigatus; niger; penicillioides; restricus; sydowii; terreus; versicolour; westerdijkiae*
5	*Aureobasidium*	*Pullulans*
6	*Botrytis*	*Cinerea*
7	*Candida*	*Peltata*
8	*Chaetomium*	*aureum; globosum*
9	***Chrysonillia***	***Sitophila***
10	*Cladosporium*	*cladosporioides; herbarum; macrocarpum; sphareospermum*
11	*Cryptococcus*	*Laurentii*
12	*Curvularia*	*Lunata*
13	*Emericella*	*Nidulans*
14	*Epicoccum*	*nigrum*
15	*Eurotium*	*amstelodami; chevalieri; herbariorum; rubrum;*
16	*Exophiala*	*Dermatitidis*
17	*Fusarium*	*culmorum; solani; verticillioides*
18	*Geomyces*	*Pannorum*
19	*Geotrichum*	*Candidum*
20	*Microsporum*	*audouinii; ferrugineum*
21	*Mucor*	*circinnolides; plumbeus; racemosus*
22	*Oidiodendron*	*griseum; rhodogenum*
23	*Paecilomyces*	*lilacinus; variotii*
24	*Penicillium*	*brevicompactum; chrysogenum; citreonigrum; citrinum; commune; corylophilum; crustosum; decumbens; expansum; fumiculosum; glabrum; olsonii; palitans; rugulosum; simplicissimum; spinulosum; variable*

25	*Phoma*	*glomerata; macrostoma*
26	*Pyronema*	*Domesticum*
27	*Rhizopus*	*Stolonifera*
28	*Rhodotorula*	*Mucilaginosa*
29	*Schizophyllum*	*Commune*
30	*Scopulariopsis*	*brevicaulis; candida; fusca*
31	*Serpula*	*Lacrymans*
32	*Sistotrema*	*Brinkmannii*
33	*Sporobolomyces*	*Roseus*
34	*Stachybotrys*	*chartarum; echinata*
35	*Syncephalastrum*	*Racemosum*
36	*Trichoderma*	*harzianum; longibrachiatum; viride*
37	*Trichophyton*	*rubrum; mentogrophytes*
38	*Tritirachium*	*Oryzae*
39	*Ulocladium*	*alternariae; atrum; chartarum*
40	*Wallemia*	*Sebi*

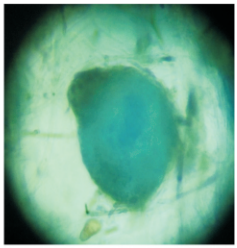
(Adapted from Samson *et al,* 2010; Chuku*et al,* 2010; Chuku *et al,* 2016)



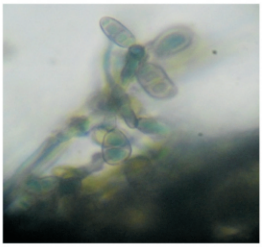
A, clavatus



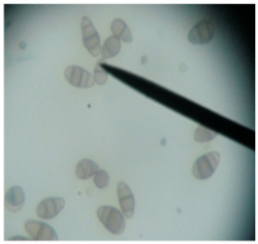
A.restrictus



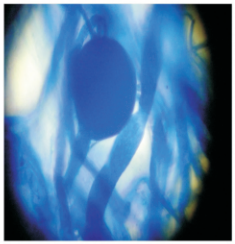
Phoma Sp.



*Bipolaris*sp



*Curvularia*sp



*Mucor*sp

Plate 7: Examples of Indoor fungi

My fascination with the indoor fungi stemmed from their ability to grow on, in and around obscure and difficult places within a building, and the fact that they can remain in a building for years without the occupants being visually aware of their presence, considering the reality that humans spend a greater part of their life in an indoor environment; school, office, hospital, worship centres and even some recreational places. Working with indoor fungi is difficult in Nigeria, mainly because you have to literally invade people's privacy especially in living homes, restaurants and offices. My counterparts in order climes find it easier to research indoor fungi,as people willingly volunteer their space for research. I have had to offer "kola nuts" before being allowed to take samples from certain spaces.

My earlier study of indoor fungi assessed their presence in different indoor environment. We looked at the species prevalent in different environment, what combination of criteria encouraged their growth and survival. It was observed that some environments were naturally prone to harbour and encourage the growth of indoor fungi while human activities facilitated their proliferation in other instances.

2.2. Susceptible environment

Although fungi can be found almost everywhere, there are conditions in enclosed environments that make it exceptionally conducive and therefore prone to fungal growth. Top on the list

of these conditions is persistent moisture and humidity above 60% as described by Chuku *et al* (2010) in a study of moulds prevalent in buildings with moisture problem in Port Harcourt and in the assessment of the air quality in flood prone homes in Lafia, Nasarawa State (Chuku *et al,* 2016). Most built environmentsare constructed with organic materials, such as wood used for flooring, roofing and as pillars, cellulose materials used for ceilings and furnishings and fittings made of organic materials which all become susceptible to fungal growth in the presence of constant moisture and the right humidity.

Some specific indoor environment with fungal growth that I have worked on include but not limited to the following;

2.2.1. Hospitals

A hospital whichis an institution that provides medical care and treatment for sick or injured persons, is expected to be a safe zone free from physical harm such as during wars and free from microbial contamination which may adversely affect its patients. This is not always the case as several studies including mine have shown that some microorganisms dominate the hospital environment and can cause infections generally referred to as nosocomial infections. Fungi in particular tend to defy most decontamination protocol and have been isolated from every section of the hospital environment including expected sterile sections of the hospital such as the Intensive Care Unit (ICU) (Belizario *et al,* 2021; Chuku and Chuku, 2018; Ekhaise *et al.* 2010; Samuel *et al,* 2021). Fungi prevalent in

hospital environment are *Aspergillus* spp, *Penicillium* spp, *Fusarium*spp, C*andida* spp, *Curvularia* spp, *Alternaria* spp, *Bipolaris* spp, *Acremonium* spp and *Mucor* spp.

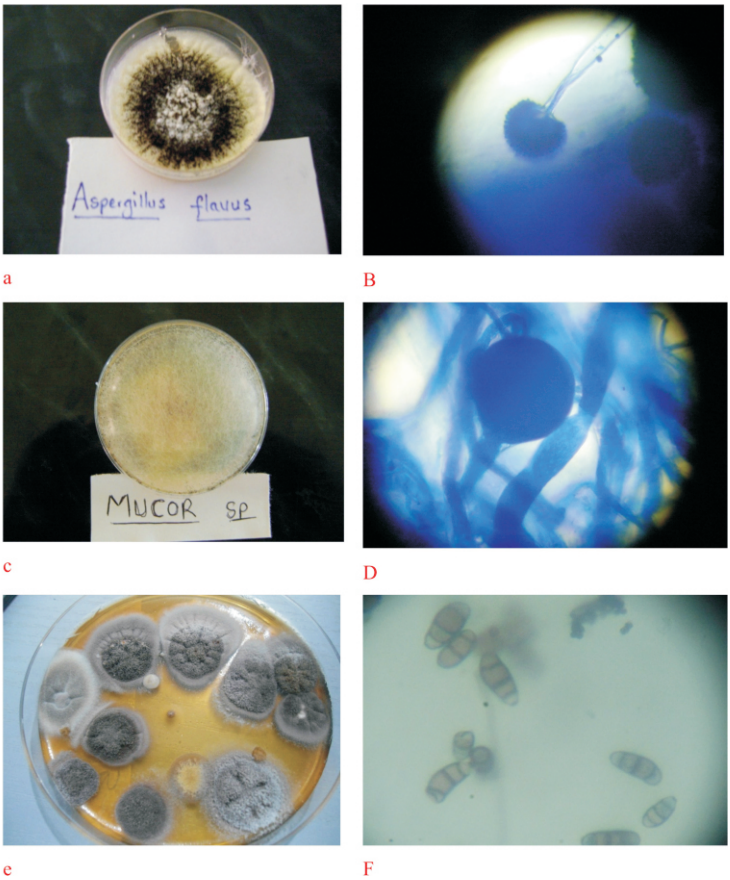


Plate 8: (a: **Colonial Morphology of *Aspergillus flavus* on Sabouraud dextrose agar; b: Microscopic Feature of *Aspergillus flavus* (x40); c: Colonial Morphology of *Mucor*sp on Sabouraud dextrose agar; d: Microscopic Feature of *Mucor*sp (x40); e: Colony morphology of *Curvulariasp; f:* Microscopic Feature of *Curvularia*spp**)

2.2.2. Offices

Basic office space contains and provide substrate for fungal growth such as wooden furniture, air conditioning vents, materials used for office activity, organic waste generated by the occupants and the constant human traffic in and out of public offices all contribute to the occurrence and proliferation of fungi in offices. The average working class populace spends a minimum of six hours per day for five days in a week in the office environment and is exposed to the possibility of dust borne fungi. Fungal species isolated from office environment include *Penicillium* spp*, Rhizopus* spp*, Mucor* spp*, Cladosporum* spp, *Aspergillus* spp, *Alternaria* spp, *Fusarium* spp, *Curvularia* spp,*(*Hassanein, 2022; Wemedo *et al.,*2012). Certain buildings have been associated with fungal infections and allergies due to the presence of indoor fungi and this phenomenon is popularly known as the **sick building syndrome** (WHO, 2002)

2.2.3. Living homes

Living homes come in different architectural design, sizes, material and shape, they contain different furniture and varying number of occupants all of which contribute to the species and number of indoor fungi that can be isolated from them. In my studies of examining living homes and the associated indoor fungi, we observed that well ventilated homes had less occurrence of fungi, homes built with concrete had less

occurrence of fungi, homes with fewer occupants and homes properly sectioned and each section being used appropriately also had less occurrence of fungi. The opposite was the case as poorly aerated homes, homes built with organic materials, overcrowded and multifunctional houses recorded very high occurrence of indoor fungi (Chuku*et al,* 2010; Chuku, 2011; Obi *et al, 2018*). Indoor fungi isolated from living homes include; *Trichophytonrubrum, Mucor* spp, *T.mentagrophytes*, *T. schoenleinii, Penicillum* spp. *Aspergillus flavus. A. fumigatus, A. niger, Bipolaris* spp, *Microsporumaudouinii*, *Rhizopus* spp and *M. ferrugineum*

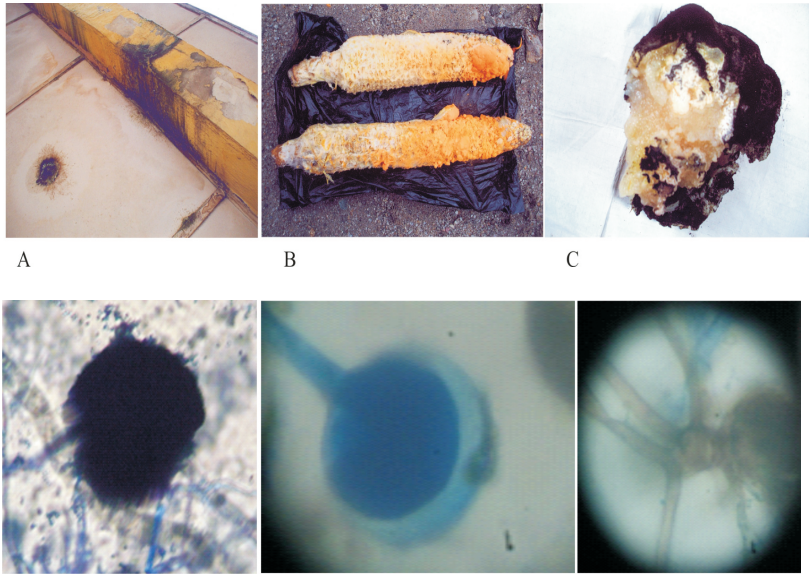


Plate 9: a –*A. niger* growth on wall and ceiling (micrograph below); b –*Microsporumcanis* on corn cob (micrograph below); c – *Rhizopus*sp on cassava meal (micrograph below)

2.2.4. Lecture halls

Standard lecture halls in Nigeria are architecturally well ventilated halls consisting of wood with plastic or metal seats, ceiling fans and white board. Exceptions come with an airconditioned unit and upholster seats. Most of the lecture theatres are subjected to carrying above their designed capacity when in use and are in constant use. With the constant traffic of persons into the lecture halls, it was not a surprise to isolate an array of fungi species in studies carried out. Other researchers who have also investigated the microbiome of lecture halls have isolated the same fungi genera that occurred every time and everywhere. They are; *Aspergillus* spp*, Alternaria* spp, *Cladosporium* spp and *Penicillium* spp (Sheik *et al,* 2015; Ejdys, 2013; Wemedo, *et al* 2012; Buppan *et al,* 2019).

Assessment of other indoors such as restaurants, student hostels, hotels and grocery stores yielded the same set of fungi thereby supporting our earlier assertion that these fungal spores gain entrance into buildings through human traffic and activities.

Key factors to the proliferation of indoor fungi are the presence of constant moisture, availability of substrate and relative humidity above 60%.

3.0. Indoor Fungi: Friends?

A friend is someone you have developed a certain level of mutual trust and understanding with and every friendship has some level and form of benefit for the individuals involved, else it wouldn't be a friendship.

Generally,fungi and its metabolites have been used for and incorporated into the everyday life of man and society in a beneficial manner, thereby fulfilling the unspoken rule of friendship. Some of the ways in which fungi are positively used include;

3.1. Medicine

Some fungi and their metabolites have been used to produce drugs. The most popular is the **Penicillin**drug which is produced by the fungi *Penicilliumnotatum, and P. Chrysogenum* **Cephalosporin** is from *Acremonium* spp, **Citricacid** and some steroids are produced from *Aspergillusniger*, **Cyclosporine** which is an immunosuppressant is from *Tolypocladiuminflatum.* Other drugs produced from fungi are griseofulvin and streptomycin ***(Bills and Goler, 2016).***

3.2. Food

Some members of the phylum Basidiomycota, known as the mushrooms and truffles are edible and are used as sources of protein and minerals. Some are processed into capsules and powdered form for ease of ingesting. Examples include

Pleurotusostreatus (oyster mushroom), *Morchellaesculenta* (morel mushroom), *Agaricusbisporus* (white button mushroom), *Flammulinafiliformis* (enoki mushroom), H*ericiumerinaceus* (lion mane mushroom).

Figure 4: a) Powdered and b) Capsule forms of H*ericiumerinaceus* (Axe, 2021)

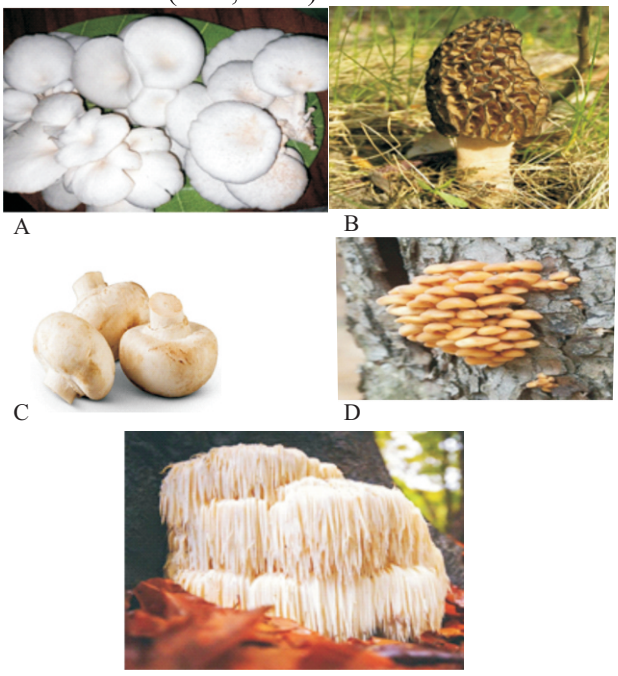


Plate 10: Edible mushrooms. a-*Pleurotusostreatus* (oyster mushroom). b- *Morchellaesculenta* (morel mushroom), c- *Agaricusbisporus* (white button mushroom), d- *Flammulinafiliformis* (enoki mushroom), e- *Hericiumerinaceus* (lion mane mushroom) (Source: Axe, 2021; Private farm).

3.3. Industries

An enzyme called zymase which is present in fungi is responsible for its fermentation ability. They are able to ferment sugars and have been used in production of wine, alcoholic beverages, baking (bread, cakes, etc). Examples of fungi used in the food industry include *Saccharomyces cerevisiae, Aspergillus flavus, Candida utilis, P. camemberta* and *Aspergillus spp* which is used in the fermentation of soybeans and wheat, while *Penicillium roqueforti and P. camemberta* are used for ripening of cheese.

Aspergillus niger and Aspergillus oryzae produce the enzyme amylase while *Saccharomyces cerevisiae* produce invertase which uses the process of hydrolysis to convert sucrose into fructose and glucose. *A. niger* is used for the production of oxalic acid. Organic acids generated in commercial scale using fungi is far less expensive compared to acids generated using citrus fruits. A group study in Jos, Plateau State used the fermentation ability of *A. niger* to convert corn cob to a feed component for animals (Lohlum et al., 2014)

3.4. Agriculture

The presence of fungi in the soil is very important and beneficial to agriculture. Fungi are decomposers and have the ability to decompose organic matter (dead plants, animals, insects) in the soil, thereby increasing soil fertility and the nutritional quality of

the soil. Fungi form symbiotic relationships with plants which is called mycorrhizae. This relationship enables the plants obtain phosphorus and other minerals. Fungi aid in decreasing the amount of nitrogen in the soil by converting it to protein for the plant use. Fungi that are involved in agriculture include, *Fusarium* spp, *Chaetomium* spp, *Penicillium* spp, *Aspergillus* spp and *Chytridium* spp.

3.5. Cosmetics

Mushrooms as members of the phylum Basidiomycotahave been in use for centuries as cosmetics products by the Asian world. Presently, mushrooms and their extracts are incorporated into skin and hair care products. They possess moisturizing effect (Liu and He, 2012), skin whitening effect through the inhibition of tyrosinase activity (Nagasaka*et al,* 2015). They contain kojic acid which is added to creams, lotions and serums which inhibit melanin production on the surface of treated skin. They express antioxidant effect (Maity *et al,* 2011), anti-wrinkle effect by inhibiting the activity of elastase (Kim*et al,* 2014) and for hair health, nails and teeth when applied in shampoos (Meehan, 2015). Some of the popularcosmetic products with mushroom extracts are provided in Table 2 (Wu *et al,* 2016). Shiitake (*Lentinula edodes*) and reishi mushrooms (*Ganodermalucidum*) are two of the most popular mushrooms used in skin care products. Other mushrooms found in skin care preparations include chaga (*Inonotus obliquus*), maitake

(*Grifolafrondosa*), antrodia (*Antrodiacinnamomea*), and Cordyceps (*Cordycepssinensis*). They are a cheap and effective source of vitamin D, iron, copper and selenium used to prevent hair breakage, dandruff and promote general healthy hair.

Table 2: Some cosmetic products containing mushroom extracts.

Product Name	Mushroom/Extract Included	Function
Aveeno Positively Ageless Daily Exfoliating Cleanser, U.S.	*Lentinula edodes*	Lift away dirt, oil and makeup and fight signs of aging
One Love Organics Vitamin D Moisture Mist, U.K.	*Lentinula edodes*	Part lightweight moisturizer and part toner
Osmia Organics Luz Facial Brightening Serum, U.S.	*Lentinula edodes* extract	Skin looking bright and luminous
CV Skinlabs Body Repair Lotion, U.S.	*Ganoderma lucidum*	Wound-healing and anti-inflammatory
Dr. Andrew Weil for Origins Mega-Mushroom Skin Relief Face Mask, U.S.	*Ganoderma lucidum*	Anti-inflammatory properties
Four Sigma Foods Instant Reishi Herbal Mushroom Tea, U.K.	*Ganoderma lucidum*	Immunity boost
Kat Burki Form Control Marine Collagen Gel, U.K.	*Ganoderma lucidum*	Boost collagen, improve elasticity and provide hydration
Menard Embellir Refresh Massage, France	*Ganoderma lucidum*	Skin anti-aging
Moon Juice Spirit Dust, U.S.	*Ganoderma lucidum*	Immune system
Tela Beauty Organics Encore Styling Cream, U.K.	*Ganoderma lucidum*	Provide hair with sun protection and prevent color fading
Yves Saint Laurent Temps Majeur Elixir De Nuit, France	*Ganoderma lucidum*	Anti-aging
Vitamega Facial Moisturizing Mask, Brazil	*Agaricus subrufescens* (also known as *A. brasiliensis*)	Renew and revitalize skin
Kose Sekkisei Cream, Japan	*Cordyceps sinensis*	Moisturizer and suppress melanin production
Root Science RS Reborn Organic Face Mask, U.S.	*Inonotus obliquus*	Anti-inflammatory to help soothe irritated skin
Alqvimia Eternal Youth Cream Facial Máxima Regeneración, Spain	*Schizophyllum commune*	Anti-aging and lifting
Sulwhasoo Hydroaid, Korea	*Schizophyllum commune* extract	Hydrating cream promoting clear, radiant skin
La Prairie Advanced Marine Biology Night Solution, Switzerland	*Tremella fuciformis*	Moisturizer which nourishes, revitalizes and hydrates skin
BeautyDiy Aqua Circulation Hydrating Gel, Taiwan	*Tremella* polysaccharide	Moisturizing gel
Surkran Grape Seed Lift Eye Mask, U.S.	*Tremella* polysaccharide	Improve skin around eyes
Hankook Sansim Firming Cream (Tan Ryuk SANG), Korea	*Ganoderma lucidum* and *Pleurotus ostreatus*	Make skin tight and vitalized
La Bella Figura Gentle Enzyme Cleanser, Italia	*Ganoderma lucidum* and *Lentinula edodes* extracts	Antioxidants and vitamin D
Pureology NanoWorks Shineluxe, France	*Ganoderma lucidum*, *Lentinula edodes*, and *Mucor miehei*	Anti-age and anti-fade
Snowberry Bright Defense Day Cream No. 1, New Zealand	Mushroom extract	Hydrate and illuminate dull skin, along with anti-bacterial properties to help prevent acne
Murad Invisiblur Perfecting Shield, U.S.	Mushroom peptides	Diminish fine lines and wrinkles by aiding regulation of collagen and elastin

(Mushroom Cosmetics: The Present and Future - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Cosmetic-products-containing-mushrooms-and-their ingredients_tbl2_305078746 [accessed 17 Mar, 2023])

Truffle face cream/ Age Delay Radiance (**White Truffle Extract**, also called "White Diamond).This contains *superoxide dismutase which prevents fine lines and age spots.* It is used for deep skin hydration, brightening, and cellular regeneration.

Lentinula edodes (shitika) It contains a polysaccharide called lentinan. It is used for brightening the skin and making it feel silkier.

It is used for skin hydration. The components of ganodemainclude, jojoba, hemp, hyaluronic oil

Figure 5: Cosmetics produced from mushroom (Beauty Hood, 2021)

The examples of fungi mentioned as “Friend” can be found indoors, but recollect that the fungus is first processed to extract what is beneficial to human and the environment. The question therefore remains; **“is the fungus found growing indoors beneficial to man or the environment at the time, place and form in which it grows?”**

4.0. Indoor Fungi: Foes?

A foe is an enemy. A foe is one who plans and intends to harmanother, he/she/it is hostile, an adversary and always in opposition. Indoor fungi and their metabolism have been associated with numerous negative reports which also include the health issues of man, animals, plants and spoilage of foods. A brief look at some areas of concern are

4.1. Toxins

Some genera of indoor fungi produce a secondary metabolite known as mycotoxin and these group of fungi are referred to as toxigenic. There are three major genera that produce mycotoxins and they are *Aspergillus, Penicillium* and *Fusarium*. They are harmful to both humans and animals when they are consumed and have the ability to produce neurotoxic and carcinogenic effects (FeijóCorrêa *et al*., 2018). Some of the mycotoxins include Ochratoxins, Aflatoxins, Trichothecenes, Fumonisins, Zearalenone and Deoxynivalenol

4.2. Food spoilage

Indoor fungi are saprophytic, thrive in both normal room temperature(22-24^{0}C) and lower (<22^{0}C)and spoil food items by producing enzymes that break down the food and cause spoilage or produce mycotoxins which could be fatal if ingested. They grow in food items such as bread, meat, dairy products, grains, fruits and vegetablesas well as raw or cooked food items. Food

spoilage by fungi result in loss of flavour, discoloration and rotting. Examples of indoor fungi most associated with food spoilage include *Aspergillus* spp, *Penicillium* spp, *Rhizopus* spp, *Fusarium* spp, *Eurotium* spp, *Mucor* spp, and *Yeast*.

4.3. Health

Every fungus that has the ability to cause disease in humans and other organisms is referred to as pathogenic and there are over three hundred known pathogenic fungi that cause diseases in humans. It is very difficult to estimate the exact burden of infections caused by fungi because despite the daily growing threat to human health, fungal infections receive little or no attention even in hospitals and hardly receives any resources globally. This also translates to lack of data of fungal infection, policies or scheduled programmes concerning fungi. The World Health Organization (WHO), for the first time released a list of fungal priority pathogens to guide research, development and public health action (WHO, 2022). Topping that list are four species labelled as **critical group**; *Cryptococcus neoformans, Candida auris, Aspergillus fumigates* and *Candida albicans* (Table 3). My work in indoor fungi over the years has shown that *Aspergillus fumigatus and Candida albicans* are among the mostisolated from homes with moisture problems (Chuku *et al,* 2010; Chuku *et al,* 2016; Chuku *et al.,* 2019), from infections associated with occupation (Makinde *et al,* 2010), among school children (Chuku *et al,* 2011), and between gender (Chuku *et al,* 2012)

Table 3. WHO fungal priority pathogens list

Cryptococcus neoformans	*Nakaseomycesglabrata (Candida glabrata)*	*Scedosporium*spp
Candida auris,	*Histoplasma*spp	*Lomentosporaprolificans*
Aspergillus fumigatus	*Eumycetoma causative* agents	*Coccidioides*spp
Candida albicans	*Mucorales*	*Pichia kudriavzeveii (Candida krusei)*
	*Fusarium*spp	*Cryptococcus gattii*
	Candida tropicalis	*Talaromycesmarneffei*
	Candida parapsilosis	*Pneumocystis jirovecii*
		*Paracoccidioides*spp

4.4. Sick building syndrome

The sick building syndrome, commonly referred to as SBS is the condition that describes the health conditions of individuals that is directly linked to the time of stay of such individual in a specific building. The term has been associated with **chemical pollution** inside a building which produces volatile organic compounds (VOC) from pesticides, carpeting, manufactured wood product and cleaning agent. Other chemical contamination come from combustion by-product from cooking stove, use of firewood inside (fire place), and heaters; **inadequate ventilation of a building** as a result of poor building design; **electromagnetic radiation** such as from microwave, computer and television; **psychological factors** which include dissatisfaction of work, excessive work stress and poor inter personal relationship, and **biological contaminants** (bacteria, fungi, viruses) from insect and bird dropping, pollens

and spores introduced from the outdoor, air conditioning systems, constantly wet carpets, upholstery, ceiling tiles and stagnant water in drain pipes (Chuku, 2011; EPA, 1991).

Common physical symptoms associated with sick building syndrome include asthma-like symptoms such as chest tightness and wheezing (Aleruchi *et al.,* 2021), neurotoxic effect which include fever, muscle aches, headaches, cough and chills, mucous membrane irritation and upper respiratory congestion(irritation of the nose, eye and throat) anddryness of the skin (Ahlroth, 2017).

4.5. House hold items

Most household items are destroyed by indoor fungi. Leather is destroyed by *Mucor*sp, *Aspergillus* sp, *Penicillium* sp; shoes and clothes by*A. niger, A. flavus, Alternariasolani;* food items even stored in refrigerators are destroyed by *Cladosporium cladosporioides, Penicilliumitalicum;* grains are destroyed by *Aspergillus* sp, *Penicillium* sp; paper is destroyed by *Chaetomium* sp, *Penicillium* sp, *Stachybotrys* sp; walls and ceilings are invaded by *Aspergillus* sp, *Fusarium*sp, *Ulocladium* sp; and wood is destroyed by *Mucor*sp, *Rhizopus* sp, *Alternaria* sp, *Fusarium* sp, *Penicillium*sp, *Trichoderma* sp, *Talaromyces* sp.

5.0. Way Forward

Indoor fungi cannot be completely eliminated from buildings because they have the ability to grow anywhere and on anything as long as there is moisture, but their concentration and subsequent effect on humans can be minimized.

5.1. First of all, their presence must be identified and recognized, and this is best done by physical inspection of items such as ceiling, walls, pipes, clothing, refrigerators, freezers, air-conditioners, specific spaces like bathroom, laundry and kitchen contained in an indoor environment.

5.2. The presence of fungi must be eliminated when identified. The steps include;

a). Identifying the source of moisture and eliminating it

b). Throwing out items that have been contaminated with fungi where possible, instead of cleaning

c). If cleaning a small area of contamination, the use of disposable gloves, respiratory protection (e.g., N-95 disposable respirator) and eye protection is advised.

d). Dampen the area with detergent solution to prevent spread of spores and then clean using a damp cloth with baking soda.

e). If the contaminated area is large or the fungi reappears after initial cleaning, then consider the services of a professional.

5.3. The best approach to indoor fungi contamination is prevention. To prevent is to remove sources of excess moisture, keep a relative humidity of between 30% and 50%, control humidity with the use of air conditioners, clean up floods and spills as soon as they occur, remove food spots and stains from carpets and floors, do not lay carpets directly on concrete that may be prone to leakage or in areas that may come in contact with water and for restaurants, the use of exhaust fan will control moisture.

My present and future research focus is first dealing with the metabolites of indoor fungi which are toxins that are detrimental to both animal and human health using natural resources and secondly the cultivation of fungi (mushrooms) and extraction of active components beneficial to the health of both animals and humans.

6.0. Conclusion and Recommendation

There are over 300 species of fungi that are harmful to humans if they are ingested or exposed leading to either mild irritation such as ENT cases, skin rashes or complicated conditions like organ failure or death. A smaller number of fungi also affect animals and plants causing diseases, death and loss of economic revenue. In clear contrast are the fungi that are beneficial to man and the environment such as enhancing the flavour of food, essential ingredient in baking, brewing and wine making, alternative to

meat (Tempeh), food source, medicine, cosmetics, supplements and remediation. This makes fungi both friend and foe

However, Indoor fungi has no benefit to humans as it only results in loss of property, resources, defacing of structure, compromise of the integrity of structure and either mild or fatal health conditions to occupants of the indoor environment.

The major reasons why fungi grow indoors (homes, offices, classrooms, restaurants etc.) are due to the presence or occurrence of flooding, leaks in the building which can be from poor plumbing work, leaky roof,excessive humidity from cooking facilities, bathrooms, sinks and other activities that increase the concentration of humidity.

In my few years of research into indoor fungi, I have established the prevalent indoor fungi especially in homes with moisture problems to be *Mucor*sp, *Aspergillus* sp, *Trichophyton* sp, *Micosporuim* sp, *Stachybotrys* sp (black mould), *Penicillium* sp, *Fusarium* sp, *Trichoderma* sp, *Cladosporum* sp and *Alternaria* sp. The medical conditions associated with occupants of buildings with moisture problem having indoor fungi have been ascertained and include tinea infections (Tinea corporis, T, capitis, T. pedis, T. cruris, T. unguium and T. barbae), respiratory infections such as wheezing, headaches and weakness, and allergies which result in cough and sneezing.

Solutions have also been proffered for the elimination of indoor fungi and identified remedy against fungal infection of indoor fungi using plant extracts such as ***Zingiberofficinale*** **Roscoe (Ginger)**, which can be effectively used against *Penicillium* sp*, Fusarium* sp***, Curvulariasp and*** *Aspergillus* sp***; Eucalyptus camaldulensis***, which is highly effective against *Penicillium and Candida* species and *Borassusaethiopium* (murichi) which can be used against Dermatophytes have also been a part of my research.

Recommendation

1. Everyone should develop a healthy respect for fungi, especially the ones that reside within our indoor environment. A single breath taken in for life in a heavily contaminated environment could be a breath that could lead to death.

2. Deliberate effort should be made to prevent high humidity (>60%) in homes and offices. This would be achieved if construction of buildings takes into consideration the need for proper ventilation, as most times this is not the case right here in Lafia.

3. Quality building materials, appropriate site for construction and professionals should be made a priority when building any structure for human habitation

4. Individuals and government should be deliberate in addressing leaking/flooding incidences and eliminating excess moisture in buildings through immediate clean up and elimination of the source of the flooding or leakage

5. For the growth of medical mycology, to collate data, enhance research and improve health of the populace, routine mycological diagnosis and autopsies should be introduced in Nigeria.

6. The benefit of the edible fungi, should be harnessed to its fullest by the University management. A mushroom farm could be set up, to provide revenue for the University while providing a source of healthy protein for the staff, and as raw material for research into the various potential of mushroom potency against infections .

Mr. Vice Chancellor Sir, today I have made known to everyone here my research and interest on the pathogenic fungi found within the indoor environment that may cause diseases in humans, their effect on different categories of people, age, gender, occupation and health status, and my effort in the control and elimination of the source of infection and remedy to infections from indoor fungi using natural resources.

My name is Aleruchi Chuku, a Professor of Medical Mycology.

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Finally, I must pay tribute to two people who have made tremendous impact and input to my life and who would have been here today but have been called home by their creator, Mr Nnamdi Justice Chuku who passed on two years ago and Miss Nkechiyere Iwedi who will be buried two weeks from now. May they continue to find rest in the Lord.

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CITATION OF PROFESSOR ALERUCHI CHUKU

Aleruchi Chuku was born as the first child and daughter out of five children to Engr. Deacon Gabriel Chuku and Deaconess Augusta Gabriel Chukuin Rumuche, Emohua Local Government area of Rivers State on the 14th of March, 1973. She had her basic primary and secondary education at the Army Children Nursery and Primary School, GRA and Government Girls Secondary School, Harbour road, all in Port Harcourt, Rivers State. She attended the University of Port Harcourt, where she obtained B.Sc. Microbiology in 1998. She obtained her postgraduate degrees from **the** Rivers State University of Science and Technology where she obtained an M.Phil. and PhD. in 2005 and 2009 respectively.

Before taking up appointment as a Senior Lecturer with Federal University of Lafia in December, 2012, she had worked as a Laboratory Scientist with a private hospital in Osun State during her Youth Service from 1999 to 2000, taught Biology at Faith Baptist College, Port Harcourt while consulting for Transparent Earth Nigeria as a HSE Manager. In 2008, she moved to the National Veterinary Research Institute, Vom in Plateau State as a Research Scientist with the Dermatophylosis Unit of the Bacteriology Department while doubling as an adjunct lecturer with the Federal College of Veterinary and Medical Laboratory Technology, Vom which lasted to 2012. These positions built her skills in scientific research and productivity.

She assumed duty at Federal University Lafia as a Senior Lecturer in 2012, where she demonstrated competency in research, teaching and administration. In 2017 she was promoted to the position of a Reader and in 2020 she became a Professor. In between at her promotions from Senior Lecturer to a Professor, she held positions such as the Examination Officer for the Department from 2013 to 2014, and became Acting Head of Department from 2014 to 2016. While heading the Department of Microbiology, she was appointed the Pioneer Coordinator of the Student Industrial Work Experience Scheme (SIWES), from 2014 to 2017. She nurtured the Unit until it was transformed into a Directorate and she was appointed the pioneer Acting Director where she served from 2017 to 2021. She became the Postgraduate Coordinator for the Department of Microbiology from 2017 to 2018. She was again appointed the Head of Microbiology Department in 2019. While in this position she was appointed as the Head of Curriculum Development Unit of the Directorate of Academic Planning for the University from 2021-2022. In November 1, 2022 she was appointed the Director, Academic Planning and on the 7th of June 2023, she became the Deputy Vice Chancellor, Academic Affairs of the University.

Professor Aleruchi Chuku is an astute administrator as she has chaired and participated in numerous University Committees at Departmental, Faculty and University levels, the committees

include but not limited to; Member of the **University** Examination Malpractice and Misconduct Committee, Faculty Research Grant Committee , Member of Editorial Board of FULafia Journal of Science and Technology, Member of Faculty of Science Publication/Seminar/Training Committee, Member of Faculty of Science Ethics and Disciplinary Committee, Member of Senate Business Committee, Member, Committee on Review of Appointment & Promotion guidelines, Chairman, Faculty of Science Curriculum Committee, Chairman, University Accreditation Committee, Chairman, Faculty of Science ICT Committee, Chairman, Senate Committee on 30% CCMAS, Member of University Governing Council Committee on Budget Monitoring from 2016 till date just to mention a few.

In spite of Professor Chukus' several engagements as an administrator and member of several University committees, she has handled her primary responsibilities of teaching and research judiciously. She has taught and still teaches both undergraduate and postgraduate courses. She has similarly demonstrated capacity in the conduct of research. She has carried out research in areas of moulds in living homes, effects of moulds on people living in homes with moisture problems, bacteria associated with fungi in skin infections, Dermatophytes and their effects on humans and long lasting methods of fungal preservation. The output of the several researches conducted has led to the authoring of over sixty (60) journal articles in

renowned peer reviewed national and international journals and several book chapters. She has over thirty (30) conference and workshop papers to her credit and has attended over thirty conferences and workshops both in Nigeria and abroad.

Professor Aleruchi Chuku is a member of several professional bodies. She is an Associate Member, Institute of Medical Laboratory Science Council of Nigeria. (AMLSCN), Member of the International Society for Human and Animal Mycology (ISHAM), Member of the Mycological Society of Nigeria (MYCOSON), Member of the Nigerian Society for Microbiology (NSM), and member of the American Society for Microbiology (ASM), just to mention a few.

In her pursuit of excellence, she won three TETFund Institutional Based Research grants worth N2million naira each and the researches have all been successfully conducted. She is currently working in the following research areas; Long- Term preservation and genetic morphology of preserved fungi isolates, Nanotechnology and Fungi, and Public health effect of indoor moulds contracted through environmental conditions and necessary contact, effect of flooding and fungal infections in residents of flood prone areas, the efficacy of mushroom extracts to health and mycotoxins and human health.

She has successfully mentored, supervised and graduated over fifteen M.Sc. students, two Ph.D. students and currently has nine Ph.D. and six M.Sc. Students under her supervision.

Professor Chuku is a woman of firsts,

i. First substantive Head of Department in Microbiology
ii. First Female Head of Department in Microbiology
iii. First Female Head of Department in the Faculty of Science
iv. First female Professor produced in the Department of Microbiology
v. First female Professor produced in the Faculty of Science
vi. First Professor to successfully graduate the First Ph.D students in Federal University of Lafia.
vii. First Female Director of Academic Planning of the University
viii. First Female Deputy Vice Chancellor at the Federal University of Lafia.

In providing community service, Professor Aleruchi Chuku is a member of the Red Cross Society of Nigeria, a Special Marshal of the Federal Road Service Corps, Chairman Board of Trustees of GraceCity Empowerment Foundation and an advocate of the Girl Child education. She is a devout Christian, with a calling in music, she is a seasoned and eloquent public speaker with great

presentation skills, an astute organizer who loves and enjoys working with teenagers, a dynamic scholar, hard-working and brilliant academic.

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