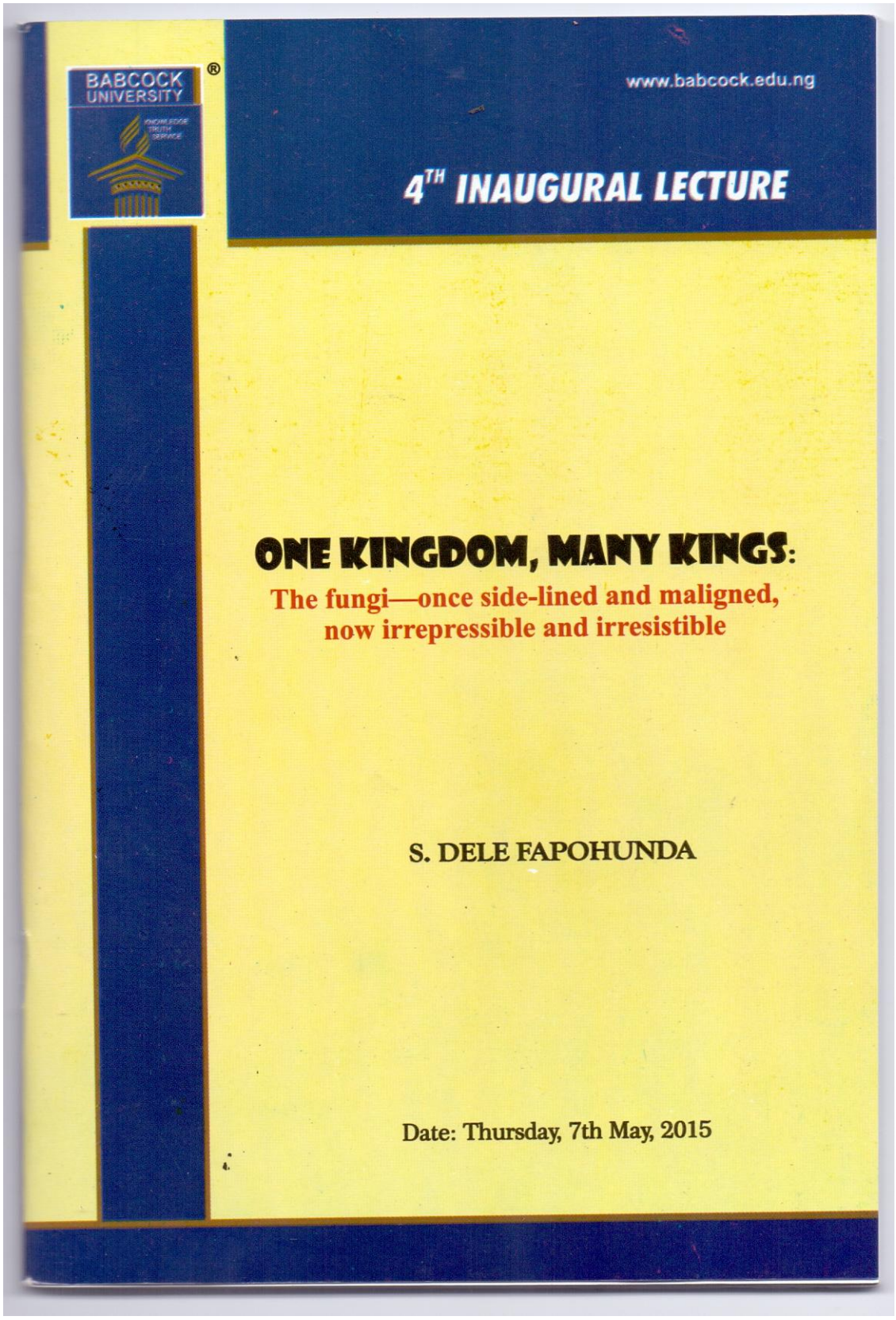
BABCOCK UNIVERSITY
www.babcock.edu.ng
4TH INAUGURAL LECTURE
ONE KINGDOM, MANY KINGS:
The fungi—once side-lined and maligned, now irrepressible and irresistible
S. DELE FAPOHUNDA
Date: Thursday, 7th May, 2015

BABCOCK UNIVERSITY

INAUGURAL LECTURE SERIES

ONE KINGDOM, MANY KINGS:

The fungi—once side-lined and maligned, now irrepressible and irresistible

President/Vice Chancellor

Senior Vice President/Deputy Vice Chancellor

All other Principal Officers and their Associates

Dean, School of Basic and Applied Sciences

Other Deans

Professors and other members of Senate

My Head of Department

Other Heads of Departments

Academic and Non academic staff

My Lords Spiritual and Temporal

Members of my Nuclear and Extended families

Great Students of Babcock University

Gentlemen of the Press

Distinguished Ladies and Gentlemen

Great Babcock University!

'***Creation is a team…'*** Fapohunda, 2015

BABCOCK UNIVERSITY

INAUGURAL LECTURE SERIES

PREAMBLE

I stand here this day in order to acquaint you with my research efforts so far and go ahead to release a bit of my link with the society at large. Inaugural lectures provide appointed Professors the opportunity to inform colleagues, the campus community and the general public of their work to date, including current research and future plans. While deepening and widening academic space it is also designed to enhance the engagement with wider and critical audiences with a view to establishing new career road map for younger ones while establishing new collaborations and protecting existing national and international linkages. It is broadly speaking, a structured and harmonized presentation representing a platform for value addition and original content to academia and humanity in general. An Inaugural lecture is also a way to evaluate the scientific temper of the researcher. This is the only way the word –**inaugural**—defining the process of formally admitting a person to membership or office—can be actualized. Anything short of this may mean doing violence to an age-old vision resulting in a contaminated and endangered academia. I therefore want to appeal that this be upheld and enforced in all Universities in Nigeria as I am happy that the academic culture is well grounded here at Babcock University

INTRODUCTION

Mr Vice Chancellor Sir, I have been actively associated with the microfungi for most of my research life and feel highly honoured to talk on them today. They are silent, gentle, soft, edible, toxic, macroscopic, virulent, attractive, microscopic and destructive. From this expressions, it is clear that we are dealing with an interesting rainbow. Fungi (sing. fungus) are special living forms with structures that resemble threads(hyphae) an interwoven mass of tubular filaments called hyphae which aggregate into a mycelium.They have cell walls strengthened with chitin and unlike higher plants , have no cellulose. Some can only be seen as mere colouration on surfaces while the true structure can be observed through the microscope. They include microorganisms such as yeasts and moulds. Most fungi are inconspicuous because of the small size of their structures, and their cryptic lifestyles in soil and on dead matter.

Mushrooms are aerial expressions of an in-substrate mycelia growth ready for reproduction. For the purpose of this lecture, emphasis on mushrooms will be at a discount.

The fungi, until recently hugely under reported, have been so marginalized and totally ignored in secondary schools to the extent that only plants and animals are being studied leaving a large number of young ones ignorant of members of a whole Kingdom. Sometimes the ignorance becomes alarming when they are considered as some 'kind of bacteria'(Moore *et al*., 2005; Moore *et al*., 2006) . The contempt, and inordinate assault, whether innocent or malicious was so deep that the overall intention was clear—to subsume the Kingdom, and make the members suffer massive devaluation in structure , function and applications. Placing fungi under bacteria or higher plants is an excessively tentative verdict which has now been upturned. As we move along it will be seen that the fungi now occupy a large territory, with unquestionable sovereignty making the initial inability to properly situate them in the organogram of the living qualify as an attempted long-range treason.

Please recall that the early mycologists started as Botanists. However, while most have relocated comfortably in line with contemporary realities, a few still find it difficult to extricate themselves from the web of a dominating discipline. Today, they shall be liberated, today they shall go unchained; today they shall increase and stabilize , in Jesus name. I will take us through the microfungal odyssey while at the same time highlight and elaborate on my involvement in a few of their roles in the earth ecosystem.. Although their internal structures are not seen by many, I feel honoured and humbled to be part of those

the Lord has chosen (mycologists) to show just a little of the secret things. We are told by the Holy Bible that 'the secret things belong to the Lord, our God'(Deut 29:29). Their conduct, their metabolism and genomics can now be seen and each is holding a lot of promise and securing a locus of mammoth significance to humanity.

Their importance can be summarized thus: Mushrooms like *Agaricus spp, Pleurotus ostreatus, Volvariella volvacea, Lentinula edoides* are consumed directly as food by man . *Penicillium chrysogenum*(formerly *P notatum*) is a source of penicillin, an antibiotic. Yeasts like *Saccharomyces,* are used in industrial fermentation in bakery and brewery. They also produce mycotoxins that cause various forms of morbidities in man and animals. The elaboration of some molecular approaches was made possible through *Neurospora crassa*, a pink bread mould. Useful proteins like insulin and some human hormones can be synthesized by members of the ascomycota. Infections like ringworm,athletes foot affect the skin , scalp and other superficial loci. *Candida*, a yeast is known to be implicated in opportunistic infections like candidiasis. Rust and smut are diseases of plants caused by parasitic microfungi *Puccinia spp* and *Ustilago spp*. Some are used as biopesticides in the biological control programmes. Their saprophytic lifestyles is important in recycling and bioremediation. Production of vitamins by the single-cell fungi like yeasts and the multicellular forms like *Nematospora gossypii* as well as the fixing of nitrogen in the roots of plants by *Phoma* are worthy of note .

A possible explanation for fungal success throughout geological time is that they have a tough resolve to survive while other life forms are dying(Visscher *et al.*, 1996). I will confront their analysis with the simplicity and fairness of an impartial party with presentation running through their classification, direct impacts and metabolomics with focus only on few areas over which I enjoy a competitive advantage and guide you in deciding whether they are fair friends or fiery foes.
With humility, therefore,may I appeal that we put our minds into 'NEUTRAL' as a trip into the kingdom is about to begin.

Fungal classification

All fungi have one corporate and global General Overseer called The International *Mycological* Association, which was founded in 1971.The later 1800s saw the application of modern evolutionary theory focusing on descent with modification in the whole scheme of classification.. Organisms were observed to pass on traits to their descendants even though over time, inherited traits may change and so organisms alive today may possess features markedly different from those of their ancestors many generations ago.

As at 2007,the various fungal divisions were- Chytridiomycota which are mainly aquatic, some are parasitic or saprobic; unicellular or filamentous.

Neocallimastigomycota with members found in digestive tracts of herbivores; anaerobic; zoospores with one or more posterior flagella

Blastocladiomycota which are flagellated plant and animal parasites, with some being saprobic. They can be aquatic and terrestrial.

Microsporidia, containing parasites on animals and protists;they are unicellular with highly reduced mitochondria

Glomeromycota, with members that are in obligate, symbiotic relationships in which hyphae penetrate into the cells of roots of plants and trees (arbuscular mycorrhizal associations);

Ascomycota (sac fungi), having some that are parasitic or saprobic on plants and animals.. A few are in symbiotic association with algae to form lichens; while some are unicellular, but most are filamentous.

Basidiomycota which express parasitism or saprobic living on plants or insects; they have septate hyphae, with septa typically inflated (dolipore) and centrally perforated; mycelium of two types: primary consisting of uninucleate cells, succeeded by secondary consisting of dikaryotic cells, \members include the rusts, smuts, jelly fungi, club fungi, coral and shelf fungi, mushrooms, puffballs, stinkhorns, and bird's-nest fungi.

There was the other fungal Kingdom Chromista =Phylum Hyphochytriomycota

Members are that parasitic or saprobic on algae and fungi in fresh water and in soil; they form a small thallus, are often with branched rhizoids; whole of the thallus is eventually converted into a reproductive structure;. Phylum Oomycota They have aquatic tendency. mostly in fresh water, wet soil, and marine habitats, some such as Saprolegnia and Phytophthora are pathogenic(Hibbett *et al*. 2007).

The Botanical Code, which operated until 2011 was renamed in July 2011 as *the International Code of Nomenclature for algae, fungi, and plants,* the lower case for 'algae, fungi and plants' in this Code is to demonstrate their colloquial nature. The International Mycological Congresses are held every 6 years to receive, among other things requests for name modifications. In 2011 at the Melbourne Congress an overwhelming 338 proposals were received to modify the Vienna outing of 2005(Hawksworth 2011). Classification keeps changing as more revelations are made and more fungi are sequenced. Due to the benefits of molecular phylogeny, and with the available ever changing research methods, all fungi are now properly placed. However as at date, , and until 2017, when the next meeting of the Congress shall take place to consider any new development regarding the status of members of the kingdom, the following phyla/divisions shall be in operation in the kingdom Fungi. They are: **Cryptomycota, Chytridiomycota, Microsporidia , Glomeromycota, Neomastigomycota, Ascomycota, Basidiomycota, and Zygomycota**. These are in addition to the fungal-like organisms treated as fungi for nomenclatural purposes: **Myxomycota** and **Oomycota**. This is the current classification to be taught at schools throughout the world

The meeting also confirmed the adoption of '***one fungus, one name'*** principle. This means that the erstwhile easy manouvre from , for example, *Aspergillus* to *Eurotium* is no longer allowed. The step guarantees that the names to use in these cases will be covered through protected lists of names now being developed, but generally the earliest name will be used unless the later one is much better known. Before now, kindly recall , Article 5a of the International Code of Botanical Nomenclature approved one name for an asexual reproductive fungus (anamorph) and another for its sexual phase(teleomorph). With this development ,all names can now compete for relevance and priority irrespective of the stage being referred to(Hawksworth 2015) .

Another fundamental shift in fungal systematics is that ***Latin*** is no longer an exclusive language for validation. ***English is now added for names published on or after 1 Jan 2013.*** These are all critical decisions of epic proportions. Some of the shifts have nullified rules that were in place for decades. One important question is : will the inclusion of English language be out of sync with or totally frustrate the reason of fixity and centrality earlier associated with latinization of names as enshrined in the codes of nomenclature? I don t think so. Scientists will have to move along with new realities, while being guided by the rule of law in the kingdom

Moulds , medicine and Man

Fungi play a central stage in human diseases. Of immense medical importance are dematophytes like *Epidermophyton flocossum, Microsporum audouinii* and *Trichophyton rubrum* that incite a variety of superficial mycoses in man and animals. Many mycoses (fungal diseases) are age long associates of man(Fapohunda and Fasedemi 1990). These include superficial ones like athletes foot, thrush and many forms of candidiasis. The discomfort in man linked to aspergillosis, can better be imagined.

The discovery of penicillin from *Penicillium chrysogenum.* in 1929, was a boost to the fight against bacterial diseases .From this date on it has been a phenomenal rise in search for other antimicrobials of fungal origin. In organ transplant, there is the possibility of rejection by the body which views the new organ addition as a foreign body deserving destruction only. Cyclosporin A is produced by a fungus *Tolypocladium inflatum.*. This drug inhibits T-cell activation thereby preventing organ rejection. The B vitamins are produced by the single-cell fungi like yeasts and the multicellular forms like *Nematospora gossypii*

Just last year(2014), it became clear that the seemingly intractable problem of antibiotic resistance may soon be a thing of the past as a fungus -derived antibiotic called *viridicatumtoxin B* was developed. (Rice University, 2014). The distinctive molecular structure of this drug was indicative of its ability to help wage the fight against resistant superbugs. We can now see that while some express specificity in their metabolite production, others express novelty in solution provision.They are all KINGs in their separate rights

Setting reliable benchmarks in molecular techniques with many advances in modern genetics were achieved using fungal model. *Neurospora crassa* is handy here. Genes originally discovered in *Saccharomyces cerevisiae* served as the ignition in the search for analogous human genes.

Volatile Organic Compounds (VOCs) of fungal origin regularly contribute to the decline in indoor air quality(Shinoj *et al* 2011) and exposure to them had been linked to symptoms such as headache, nasal irritation, dizziness, fatigue and nausea(Burton *et al*., 2008). *Stachybotrys chartarum* and *Aspergillus* species found air samples were often associated with neuro psychological disorder. Bioaerosols of fungal origin, consisting of spores and hyphal fragments are readily respirable serving as elicitors of bronchial irritation and allergy .Although about 600 species of fungi are in contact with humans, only less than 60 of them are frequently identified .

Emerging and re emerging zygomycoses have now necessitated he shift toward antifungal resistance. Just like antibiotics, some fungi no longer respond to antifungal medications.. The general azole resistance in *Aspergillus* -initiated human diseases and specifically the fluconazole resistance in Candida are subjects of concern. Although some reliable explanations have been given for azole resistance, the mechanism in polyene and echinocandins is not yet conclusive. Unlike in bacteria there is an absence of drug resistant plasmid and transposons in moulds although the prospect of horizontal gene transfer in *Fusarium* species has recently heightened passion for further research in this regard(Chakrabarti , 2011). Of recent, a new strain , *Cryptococcus gatti*, an airborne, extremely rare hypervirulent fungus, earlier noticed in Australia and South America, has just been discovered to cause severe brain and lung infections and has resulted in many deaths in the USA. With the global impact of climate change, its likely spread to Africa is now a source of worry. The conduct of some microfungi could be very strange as to attract inordinate attention and scrutiny. For example the mysterious caterpillar fungus, *Ophiocordyceps sinensis* has the ability to take over and control the host's metabolic activities by arresting its brain. In so doing, it produces bioactive compounds to sustain it function(Lo *et al.,* 2013)

Mould, meals and Man

The general significance of fungi can be shown through cultural food production. Mould associated food items include **flat bread**, which is unleavened and therefore hard and heavy; **gorgonzola** an Italian product that uses *Penicillium roqueforti*; **koji** which is inoculated with *Aspergillus oryzae* and allowed to grow for several days; **leavened bread** made from dough that contains yeast, which results in a light and fluffy bread; **miso**, fermented soybean paste in Japan; **mold-ripened cheese**: requiring the addition of a fungus ***Penicillium camemberti***; **roquefort cheese**; which is made in the town of Roquefort, France, requiring the fungus *Penicillium roqueforti*.; **soy sauce (=shoyu)**, a condiment, requiring the use of

Aspergillus oryzae. ,**tempe**: that uses *Rhizopus oligosporus or R oryzae*; **yeast cake** which is the whole yeast product, which has had its water removed, thereby suspending its metabolism and making it possible to store for a long period of time. This is how yeast is often sold, commercially. Fungi are ready companies of ***kunu*** production(Fapohunda and Adeware 2012) and many other fermented local brews. Studies on their specific mode of action are critical to selection when being considered as starters Therefore the industrially important yeast, *Candida guilliermondii* was investigated for its cultural responses in order to determine its optimum productivity(Fapohunda, 2005). Our teams carried out surveillance studies on millet and sesame in both the Federal Capital Territory(FCT) and Plateau state of Nigeria and we investigated the prevalence of toxigenic *Aspergillus* species and others(Ezekiel *et al.,* 2014). We had earlier isolated Aspergillus flavus and other toxigenic fungi of public health importance in some food and organic matter. The work put in place a mini toxigenic *A. flavus* bank supported by pictorial illustrations, serving as a preliminary project for the establishment of a permanent culture collection centre in Nigeria (Fapohunda *et al*., 2012d)

Enzyme production

The capacity of fungi to secrete enzymes is enormous. This happens whether naturally resident or opportunistic(Fapohunda *et al.,* 2007)The elaboration and activity of such metabolite is accompanied by biodegradation in parasitism , and organic decay. Fungi like *Aspergillus, Fusarium* and *Penicillium* are popular in being able to produce large quantity of industrial enzymes through submerged fermentation (SmF) and solid state fermentation(SSF). *Aspergillus terreus*(Fapohunda, 1992a), *Cladosporium* and *Aspergillus* species(Fapohunda, 1992b;Fapohunda *et al*., 2006) and *Melanocarpus albomyces* had been confirmed as ready tools for the extracellular liberation of lipase and xylanase (Fapohunda, 2004), just as *Trichoderma viride* is at home with cellulase production(Taha *et al.,* 2015). This group of enzymes are significant in the pulp and paper as well as bottling industries. Xylanase, a hemicellulase carries out biobleaching and biopulping making it a good replacement for chemicals. Together with laccase it is also efficient in the clarification of fruit juices (Fapohunda *et al*., 2007b; de Cassia Pereira *et al.,* 2015)

In fermentation and spoilage we have implicated some microfungi on maize(Ogundero and Fapohunda, 1987; Fapohunda 1988, 1989), *Sorghum*(Fapohunda and Ogundero 1990a) and on fast foods in Nigeria(Fapohunda and Ogundero 1990b; Fapohunda *et al* 2014a). The *Alternaria*- mediated degradation

of cereals (Fapohunda and Olajuyigbe, 2006) and a general overview of xylanases were carried out to bring to the fore the peculiar significance of this cocktail of enzymes which I have recognized as 'biocatalyst of constant promise'(Fapohunda *et al.* , 2007b).

Fungal enzymology is a dynamic field and so the distribution and genomic profiling are regularly receiving research attention. The nature of substrate determines the profile of production . For example, the plant pathogenic, endophytic and entomopathogenic fungi produce an array of equipment and arsenal including proteases, chitinases, laccases and cellulases(Esteves *et al* 2014; Sanchez- Prescez *et al* 2014; Correa *et al* 2014). One advantage scored over other enzymes is that most of them are thermostable even when the fungal sources are known mesophiles making them irresistible to molecular biology. The critical niche occupied by fungi is further acknowledged by the fact that virtually all extracellular enzymes concerned with biodegradation or organic residues are linked to them(Hattwenschwiler *et al* 2015).

Environmental harmony is also assured by some members of this Kingdom as many moulds are indicators of soil quality with the capacity to adsorb heavy metals in the ecosystem (Wang and Chen, 2006; Velkova *et al.,* 2012). The use of fungi to reclaim contaminated surfaces further raises their score on the utility ranking. Sludge treatment by lipases is usual .and the recovery of metals from contaminated soils and other sites by *Penicillium chrysogenum* (Illyas *et al* 2013), *Aspergillus niger* (Xu and Ting 2009; Bayat *et al* 2011) and *Humicola grisea*(Chiang,*et al* 2013) are noteworthy.

The role of fungi in productive combination with plant roots(Fapohunda *et al.,* 2011; Fapohunda *et al.,* 2013) have been highlighted. About 90% of higher plants are comfortable having relationships with fungi through their network of mycelium, making it possible to achieve an underground information superhighway among plants. The communication achieved by this subsoil internet allows the sharing of nutrients and necessary information while at the same time, arrest the spread of unwanted neighbours. This confirmed '***wood wide web'*** regularly ensures *cyberbenefit* and *cyberattack,* in the soil mycology.

Recognizing that bacteria and fungi are upstanding components of the microbial community, and not minding the initial cold relationship between bacteria and fungi, we occasionally strayed into the interactions within each of them(Ahmad and Fapohunda, 2010; Fapohunda and Afolayan, 2012; Fapohunda *et al.*, 2012a)

In the feed industry, most national regulatory agencies, where they exist, allow restrictions in the use of enzymes as feed additives. Consequently, the safety of feed enzymes is regularly assessed (Pariza and Cook 2010)

In the food industry, all the products from *Mucor miehei*, *Rhizomucor* spp, *Fusarium oxysporum*, *Aspergillus niger* and *A. oryzae* are generally recognized as safe (GRAS) sometimes serving as pre treatment agents in the formation of sugar from lignocellulose(Deswal *et al*., 2014). Although basic rules of enzymes dictate that each is specific, the mechanism of enzyme promiscuity—ability to catalyse another side reaction in addition the primary reaction-----will continue to be a focus of regular scrutiny . And the increasing passion to tap into the innermost pool of their enzyme rest on one or more of the following----metagenome screening, genome mining and the exploration of the diversity of extremophiles(Adrio and Demain, 2014). In summary, all fungi have a potential larger than known and live like joint KINGS (remember joint heirs?).

MYCOTOXINS

When a food item is mouldy, then it is naturally associated with some fungi. These invading mouls may produce mycotoxins. When Mahatma Gandhi, the world-class statesman of antiquity listed 'commerce without morality' as one of the seven deadly sins, he surely had in mind the conduct of the rich when engaging the weak in a commercial battle. Although Gandhi is gone, his immutable truth shall continue to sustain, particularly when international trade is suspected to be laced with stratagems that regularly leave the economically weak to be on her knees.. Such tactics, though not peculiar to North-South trade relations, are also found among countries in Europe, all leading to disputes and rejects. Although not given to flippancy, Gandhi failed to factor in the role of quality assurance in contemporary health and international trade.

What are Mycotoxins? These are chemicals (secondary metabolites) produced by some moulds that could slip into the food chain to endanger public health *directly* through targets like groundnuts, sauces, maize, wheat and wheat products, beans , cocoa, coffee, oilseeds, nuts, fruits and their juices,

beverages(wine and beer)and *indirectly* through foods obtained from animals given diet already contaminated .These can include milk and its derivatives, as well as fresh and cured pork Mycotoxins are a group of toxins that directly link moulds and meals with man. Those produced by mushrooms are called mushroom toxins. Implicated fungi include *Aspergillus, Penicillium* and *Fusarium* which enjoy growth bloom in temperature and moisture regimes obtainable in Nigeria. Among the several identified toxins are aflatoxins, ochratoxins, fumonisin and zearalenone .Contamination can arise during cultivation in the field, through harvesting, storage and processing. Contamination is aided by insect damage although some fungi like *Fusarium graminearum* and *Aspergillus flavus* can infect maize with no visible wound or any form of physical deformity. Generally ,those from *Fusarium*, which occur on a global basis in cereals and forages are considered important contaminants of poultry feed and regarded as field toxins(Juan *et al* 2013a;Nesic *et al* 2014). The significant and sad reality is that constant consumption of large doses is viewed as an emblem of poverty.

a b c

Fig 1 Three important mycotoxin-producing genera *a.Fusarium* *b.Aspergillus*, c. *Penicillium*

(Source- Fapohunda *et al.,* 2012 archives)

The risks associated with their consumption may include cancer, compromised immune system and reproductive malfunctioning. At the Aspen Cancer Conference in 2001, reports on aflatoxin exposure and incidence of liver cancer in places like China and West African countries were alarming. The Stockholm convention on Persistent Organic chemicals described aflatoxin as the most potent non radiation, carcinogen known to man. Some countries like India and Kenya had experienced deaths arising from chronic intoxication through aflatoxin contaminated meals and in 2006 there were reports of an outbreak of aflatoxicosis that resulted in mortalities in Kenya. On the agricultural plane, the consumption of mould

contaminated grains significantly depressed growth rates and results in harmful metabolic changes that reduce the productivity of broiler and laying chickens, pigs and dairy cattle. They are therefore called 'hidden killers' which regularly attract informed attention from experts , farmers and other stakeholders.

A general overview of the link among man, mycotoxins and meals was carried out in 2007 (Fapohunda, 2007) after an earlier focus on aflatoxin (Fapohunda *et al.,* 2004). And followed up by the health impacts (Negedu *et al*., 2011) We have traced ascribed aflatoxin to the induction of cell and organ abnormalities in both rats and mice(Fapohunda *et al.,* 2007c, 2008). In the experiments , sperm cell abnormalities were observed. This implies that aflatoxin attacks both vegetative and reproductive targets in mammals. Due to their serious health impacts particularly on countries with high poverty rating, the International Congress on "*Mycotoxins and Cancer*" will be held from 2-4 December 2015 in Marrakesh, Morocco**.**

A surveillance study of fungi and mycotoxins on Nigerian crops and even ornaments was reported(Fapohunda *et al*., 2005) . We also reported that zearalenone(ZON),a *Fusarium* toxin erstwhile believed to be peculiar to the temperate regions was indeed present in Nigeria(Ezekiel *et al.,* 2008). The occurrence of ochratoxin A (OTA) in some staples underscores the need to accord all regulated mycotoxins their rightful place in Nigeria(Fapohunda *et al*., 2014b). Mycotoxin profile of street vended snacks(Ezekiel *et al.,* 2012), animal feed(Udom *et al.,* 2012), millet and sesame(Ezekiel *et al* 2014), groundnut and maize based snacks(Kayode *et al.,* 2013), random vended snacks (Rubert *et al* 2013) pepper (Ezekiel *et al.,* 2013), melon seeds and mammalian blood status after dietary toxin contaminant (Fapohunda *et al* 2014c) were all investigated and reported by our team. Morbidities recorded in broiler fed dietary aflatoxin were very alarming(Fapohunda *et al,* 2012b). Aflatoxin- mediated sperm abnormalities in mice were reported earlier (Fapohunda *et al* 2008).In the Federal Capital Territory, a surveillance outing on 5 crops in the 6 area councils(Fig 2) exposed the prevalence of emergent mycotoxins , not hitherto recorded in Nigeria, but whose combination and interaction in consumed *Sorghum,* could engender danger (Anjorin *et al.,* 2015). Some of these emergent toxins were earlier investigated in Italian cereals and cereal products(Juan *et al* 2013b). A possible additive toxigenic impact of their co-occurrence using globally validated technique was released to the public .(Ezekiel *et al.,* 2011). Many determination techniques are constantly being tested, developed and validated(Sulyok *et al* 2006; Vishwanath *et al*., 2009). An example is the liquid chromatography/tandem mass spectrometry which was applied on aflatoxin-contaminated sesame seeds with some success(Fapohunda *et al*., 2012b;2012c). The commendable sensitivity of this multimycotoxin detection method was presented at

the 37th Annual Conference of the Nigeria Institute of Food Science and Technology held at the International Conference Centre, Abuja in 2013(Fapohunda, 2013).

Control and preventive measures include Good Agricultural Practices(GAP) and Good Manufacturing Practices(GMP)and the use of toxin binders which are combined with an array of some physical and chemical steps. The Hazard Analysis Risk-Based Preventive Control (HARPC) an enhanced model of Hazard Analysis and Critical Control Points (HACCP) is also a recent attractive approach. Some chemical methods like the use of clay-based products have proved impractical on poultry diets. Timely harvesting will certainly reduce moisture level not conducive to mould growth. There are however, two hard facts: *One,* mycotoxins may not be totally eradicated even with the best agricultural, storage and processing practices, as expressed generally at learned conferences *Two,* despite low consumer awareness of the problem, health risk related to their ingestion has been quantified as exceeding risks associated from other food-related contaminants such as pesticides, additives, heavy metals and microbial agents. But additives are still being touted as effective even without statistically significant beneficial effect on the target organ. For example, in the case of aflatoxin the target organ is liver; for fumonisin it is the lungs; for zearaleone it is the reproductive organs and for T-2 toxin it's the oral lesion In addition, the anti-mycotoxin additives must show statistically significant benefits on body weight and feed intake. Fapohunda *et al* (2009) demonstrated the potentials of some Nigerian herbs in mitigating aflatoxicosis in albino rats. To reduce risk associated with contamination, regulations and laws are made and enforced by countries and international authorities. Regulatory standards for foods, additives, residues of veterinary drugs and pesticides, naturally occurring toxicants and human –derived contaminants in commodities involved in world trade are set by the *Codex Alimentarius Commission* . This body, currently consisting about 165 member countries , was formed after the World War 2 to safeguard international public health and enhance world trade. The scientific advisory body for Codex is the Joint FAO/WHO Expert Committee on Food Additives—JECFA..By the end of 2003, the number of countries that had set regulatory limits on foods and feeds had reached 100, particularly for total aflatoxins and aflatoxin B1. Regularly, the Western countries meet to set those standards which are maximum permissible, measured in parts per million (milligram per kilogram)or parts per billion (microgram per kilogram) of food. In determining the bases for regulatory limits, factors like toxicity of a given mycotoxin and the need to play a balancing act between strict enforcement of set limits on the one hand and sentencing the population to starvation on the other. Permissible limits are not sacrosanct or

perfect. In fact, sources of error among countries, which may dictate the limits set , can include diverse sampling models for bulk commodities, sample homogenization and measurement uncertainties during analytical procedures. If these are challenges to the advanced countries, surely they are formidable obstacles to the

developing world.. In order to guarantee public health and fair trade, there is the need for harmony in standards, which at present vary from market to market. For example, the US and Australia set 20 *ppb* for total aflatoxin, while the EU countries have a lower limit of 4 *ppb* for same and 2 for aflatoxin B1, for edible groundnuts. This is a form of patriotic protectionism, which is an encouragement for duplication in the West African sub region Infractions from exporters attract due consequences ranging from expensive rejection through downgrading of shipments to trade bans from the importing countries. Most of the time this sad development could be due to variegated infrastructure of monitoring, testing and certification. The solution lies in harmonized criteria regarding major steps in mycotoxin testing like sampling, sample preparation ,detection and interpretation of results so that the same method is used at the exit point of an exporting nation and the entry point of the importer. It is recalled that a capacity building workshop on mycotoxins was hosted by NAFDAC under the able leadership of late Prof Dora Akunyili and, jointly sponsored by the IAEA, in 2005. This regional exercise that drew participants from within and outside the country was a significant and commendable first step in the formation of an antimycotoxin platform in Nigeria.

Handling mycotoxins

Due to their toxicity to skin, safety precautions are always recommended. Therefore, while working in the mycotoxin laboratory, the following are the safety tips Laboratory coats, safety glasses, face mask and disposable gloves must be worn at all times. Hand-washing facilities should be provided at the entrance and distant from activity areas. During sample preparation, opening of samples and transfer of same should be carried out in a fume cupboard to minimize risk of exposure. Spillage of mycotoxins onto the skin should be washed off with copious amounts of water.The laboratory equipment and surfaces can be decontaminated by swabbing with 5% hypochiorite solution using disposable paper towels. The paper towels are then disposed of by incineration. Contaminated glassware should be immersed in a large plastic beaker containing 5% hypochlorite solution and allowed to stand for at least 30 minutes. The pH should then be adjusted to between 7.8 and 8.0 by dropwise addition of 2M hydrochloric acid followed by the addition of acetone until the acetone concentration is 5% by volume. The resulting solution should

be allowed to stand for a further 30 minutes. This procedure is capable of converting the carcinogen to the non-carcinogenic products

The following are general analytical solvents for some mycotoxins

- **Aflatoxins:** Acetonitrile/water, methanol/water
  Type A Trichothecenes: Acetonitrile/water, methanol/water
- **Type B Trichothecenes:** Acetonitrile/water, water/PEG chloroform/methanol
- **Zearalenone:** Ethyl-acetate, methanol, acetonitrile, chloroform and mixtures thereof
- **Moniliformin:** Methanol, acetonitrile/water, water, water/tetra-butyl ammonium hydroxide (TBAH)
- **Beauvericin:** Acetonitrile/water, methanol
- **Ochratoxin A: MTBE,** chloroform, acetonitrile/water, mixtures of toluene/HCl/$MgC1_2$
- **Fumonisins:** Methanol/water(3:1), acetonitrile/water(1:1)
- **Patulin:** Ethyl-acetate, acetone(Kos and Krska(2005)

Table 1

Monetized Health impacts of aflatoxin in Nigeriaa

REGION	MAIZE (consumption in g/day)	GROUNDNUT (consumption in g/day)	POPULATION IN 2010 (in thousands)	HCC CASES (cancers/ year)	DALY	VSL (in millions)
North Central	102	7	25,571	3,698	48,161	$1,513
North East	167	37	21,066	3,075	39,987	$1,258
North West	170	11	39,854	221	2,864	$90
South East	9	7	18,235	258	3,375	$105
South South	1	11	23,352	163	2,115	$67
South West	13	1	30,763	346	4,462	$142
National	84	12	155,842	7,761	100,965	$3,174

Adapted from Meridian/Abt assoc CAR 2013

***KEY*=**

DALY=Disability Adjusted Life Years

HCC-Hepatocellular carcinoma

VSL Value of Statistical Life

Table 1 reveals that the North East and North Central geopolitical zones are flashpoints of aflatoxin contamination and by extension loss (pecuniary terms) in health status among the population . The various forms of morbidities and psychosocial inadequacies as a result of intoxication are expressed as

value of Statistical Life, in millions of dollars. It will be recalled that these northern regions are listed as among those with extreme poverty rate in Nigeria thus reestablishing the link between poverty and aflatoxin consumption

For the first time, the presence of 32 non-regulated fungal metabolites like moniliformin, bikaverin, macrosporin, monocerin, emodin and brevianamid on *Sorghum* seeds in Abuja, Nigeria was reported (Anjorin *et al.*, 2015).These few less studied mycotoxins together with the producing fungi are listed in Table 2

Table 2. Fungal toxins on *Sorghum* grains from six zones of the FCT, Abuja Nigeria.

Metabolite	**Source**
Brevianamide	*Penicillium brevicompactum* *Aspergillus versicolor* *A. fumigatus*
Monili formin	*F.avenaceum* *F.subglutinans* *F.proliferatum* *F.oxysporum* *F. fusariodes*
Emodin	*Penicillium islandicum* *Aspergillus wentii* Wehmer.
Bikaverin	*F. oxysporum* f sp. *vasinfectum; Fusarium verticilliodes*.
Monocerin	*Fusarium spp.* *Exserohilum turcicum* *Dreschslera* spp.
Macrosporin	*Alternaria porri* *A.solani*
Orsenillic acid	*Chaetomium* sp.

(Source:Anjorin *et al*., 2015)

Table 3

Summary of GAPs and GMPs for aflatoxin control (Codex, 2002)

STAGE	COMMODITY	HAZARD	CONTROL MEASURE
Preharvest	Cereal grains, oil seeds, nuts	Mold infestation with subsequent aflatoxin formation	Use resistant crop varieties - Use native beneficials - Insect control - Adequate irrigation - Proper agronomic practices
Harvesting	Cereal grains, oil seeds, nuts	Increase in aflatoxin formation	-Harvest at appropriate time - Rapidly dry to safe moisture level
Postharvest storage	Cereal grains, oil seeds, nuts	Increase and/or occurrence of mycotoxin	-Protect stored product from moisture, insects -Store product on dry, clean surface.
Postharvest, processing and manufacturing	Cereal grains, oil seeds, nuts	Aflatoxin carryover or contamination	-Test all ingredients added -monitor processing/manufacturing -Follow good manufacturing practices
Animal feeding	Dairy, meat and poultry products	Transfer of mycotoxin to livestock products	-Use good quality feed ingredients -Test products for aflatoxin

Source-Ayalew 2013

Key=

GAP=Good Agricultural Practices

GMP=Good Manufacturing Practices

Table 3 shows a cocktail of intervention strategies at all critical hazard points for aflatoxin in the food value chain

BIOLOGICAL CONTROL

Physical sorting, cultural practices and chemical control are limiting in efficiency and environmental quality. The impact of Gamma irradiation on aflatoxin load in sesame seeds was carried out by out team Although an appreciable reduction was recorded, the overall long term advantage of this intervention remains inconclusive(Fapohunda *et al* 2012c,e).

Biological control is an intervention is most trusted, in reliability, productivity and environmental stability. The exploitation of microbes in deactivation of mycotoxins has been an attractive study particularly with the deactivation of trichothecenes by the bacterial strain, *Eubacterium* BBSH797 and that of ochratoxin A(OTA) and zearalenone by the yeast strain *Trichosporon mycotoxinivorans*. In the case of aflatoxin, up to 70 -90% reduction in contamination rate was recorded in experiments involving non toxigenic strains of *A. flavus* on the toxigenic strain(Dorner 2009). The aim was not to reduce or remove already produced aflatoxin but outcompete/kill/weaken the toxigenic fungus , thereby preventing aflatoxin production

Encouraging advancements in the use of biocontrol strategies have led to the registration of some biopesticides on aflatoxin by appropriate government agencies (Table 4) .

AF-36 based on the nontoxigenic strain *A. flavus* AF36 for control of aflatoxin in cottonseed.

Afla-Guard based on the nontoxigenic strain *A. flavus* NRRL21882 for aflatoxin control on corn (field, sweet, and popcorn) and peanuts (Isakeit, 2012).**Aflasafe TM** based on non toxigenic strain *A flavus* for aflatoxin control on maize.*Bacillus*, *Pseudomonas* and *Bulkholderia* strains completely inhibit *A. flavus* growth. Two years later, faeces –sourced *Stenotrophomonas maltophilia*, and a few other microbes were tested to be effective in reducing aflatoxin B1 reduction (Guan *et al* .,2008).

Let it be known that the principle of aflatoxin accumulation has to be understood in order to appreciate remediation strategies. A multiple genetic mechanisms incite aflatoxin production(Kelly *et al* 2012) which induce metabolic changes including the igniting a defense response as well as structural disruption. This disruption induces transcriptional disequilibrium in the crop (Dolezal *et al* 2014). Crop

specificity is also a significant point in determining candidate biopesticide. For example, there are no known cotton varieties that demonstrate enhanced resistance to *A. flavus* infection and aflatoxin contamination. Therefore, transgenic approaches are being undertaken in cotton that utilize genes encoding antifungal/anti-aflatoxin factors from maize and other sources to counter fungal infection and toxin production(Cary *et al* 2011).

Another critical aspect of biological control is the fear of possible mutation of the hitherto atoxigenic species. Therefore, post-release environmental fate of atoxigenic *A flavus* and other biopesticides is always attracting scrutiny in order that the microbial agent does not go *wild* and virulent or result in any other form of environmental compromise. Many mycotoxicologists have expressed concern on this.

For fumonisin, a mycotoxin almost exclusively found on maize, management has been achieved using a maize seed treatment with *Bacillus amyloliquefaciens* and *Enterobacter hormaechei*.(Pereira *et al* 2010).The use of Bt (*Bacillus thuringiensis*)corn in its control seems to be ignored in policy roundtables, perhaps due to the current heated debate on the overall safety concerns of such Genetically Modified products. Rhizobacteria, particularly those belonging to the *Pseudomonas* and *Bacillus* species resulted in significant reduction in *Fusarium verticilloides* and fumonisin b content(Cavaglieri *et al.*, 2005)while the use of *Bacillus amyloliquefaciens* and *Microbacterium oleovorans* produced a desired reduction in fumonisin in maize (Sartori *et al* 2013).An investigation of the potentials of *Trichoderma harzianum* T16 and T23 on *Fusarium moniliforme* and Fumonisin B1 and B2 and got a satisfactory reduction while Serenade, a biocontrol bacterium ,comprising mainly of *B. subtilis* was used to reduce fumonisin and aflatoxin production by up to 95%(Formenti *et al.*, 2012).

For Ochratoxin, the total removal from foods and feeds is not attainable till date. *Aspergillus. carbonarius* and *A. niger* were earlier successfully biocontrolled by the use of yeast strains(Ponsone *et. al* 2011). The application of experimental *Beauveria. bassiana* ITEM-1559 is now a valid biocontrol strategy to reduce OTA contamination(Cozzi *et al.*, 2013) The biology and non toxic properties of yeast isolates, *Issatchenkia orientalis* , *Metschnikowia pulcherrima* , *Issatchenkia terricola* and *Candida incommunis* were observed to reduce the *A. carbonarius* and *A. niger* colonization on grape berry.(Bleve *et al* 2006).)

Strains of *Aureobasidium pullulans* could reduce drastically the OTA production in wine grapes (de Felice *et al* 2008) just as *Saccharomyces cerevisiae* is effective on *A. ochraceus* and OTA in coffee(Velmourougane *et al* 2011) Shi *et al* 2014 had reported that *B. subtilis* CW 14. inhibited the growth of the OTA-producing species *Aspergillus ochraceus* 3.4412 and *Aspergillus carbonarius*. An interesting dimension was introduced when it was observed that, using high-performance liquid chromatography, the cell-free supernatant degraded 97.6% of OTA after 24 h of incubation at 30 °C, and no degradation products were produced. It could only suggest that Ota was an ingredient of survival and growth for this bacterium . *Streptomyces aureofaciens on OTA producing A niger in grape(*Haggag and Abdall2012*)*. Environmental factors like temperature and humidity can affect the efficacy of biocontrol agents and particularly when the yeast *Metschnikowia pulcherrima* LS16 and two strains of the yeast-like fungus *Aureobasidium pullulans* LS30 and AU34-2- were investigated by De Curtis *et al* (2012)against infection by *A. carbonarius* and *ochratoxin* A (OTA) accumulation in wine grape berries.

The bullet impact of a consortium of yeasts belonging to *D. hansenii*, *D. maramus*, *C. famata*, *C. zeylanoides* and *H. burtonii* species, which were individually screened for antagonistic activity against a toxigenic strain of *P. nordicum* and inhibition of ochratoxin A (OTA) biosynthesis(Virgili *et al* 2012) *C. zeylanoides* and *H. burtonii* were the most effective .

In the case of patulin, the bacterium ,*Rhodosporidium kratochvilovae* LS11 (originally named *Rhodotorula glutinis*) and *Cryptococcus laurentii* LS28 and some low dose fungicides reduced the level of patulin in apples(Lima *et al.,* 2011). Biocontrol yeasts *Rhodosporidium kratochvilovae* strain *LS11(*Castoria *et al* 2011); *Rhodotorula glutinis* are ready candidates of patulin reduction. Ianiri *et al* (2013) while working on *Sporobolomyces sp*. strain IAM 13481,a basidiomycetes yeast, linked genetics with patulin reduction .

Some biocontrol products are already approved and marketed under various trade names as shown in Table 4

Table 4 Biocontrol products for mycotoxins

Product/Trade name	Microbial agent	Food commodity	Manufacturer/distributor
AF36	*Aspergillus flavus* AF36	Corn and cotton	Arizona Cotton Research and protection Council USA
Afla-guard	*A.flavus* strain NRRL21882	Peanuts and corn	Syngenta Crop Protection, USA
AQ-10 biofungicide	*Ampelomyces quisqualts* Cesah ex Schlechtendahl	Apples, grapes, strawberries, tomatoes and cucurbitus	Ecogen. Inc. USA
Aspire	*Candida oleophila* strain 1-182	Apple, pear and citrus	Ecogen. Inc. USA
Biosave 10LP. 110	*Pseudomonas syringae* (strain 10 LP, 110)	Apple, pear, citrus, cherries and potatoes	Eco Science Corporation, USA
Blight Ban A 506	*Pseudomonas fluorescence* A. 506	Apple, pear, strawberries and potatoes	Nu Farm Inc. USA
Contans WG. Intercept WG	*Coniothyrium minitans* Campbell	Onion	Prohyta Biologischer, Germany
Messenger Rhio-plus	*Erwinia amylovora* (Burnll) Winslow *et al* *Bacillus subtilis* FZB 24	Vegetables Potatoes and other vegetables	EDEN Bioscience Corporation, USA KFZB Biotechnick, Germany
Serenade	*B subtilis*	Apple, pear, grapes and vegetables	AGRO Quess Inc. USA
Aflasafe	Mixture of four *Aspergillus flavus* Atoxigenic VCGs La3279, Ka16127, Og0222 and La3304	Maize and groundnut	IITA Business Incubation Platform, Ibadan, Nigeria

Source: (Sharma *et al* 2009; Bandyophadyay 2015)

Although the biocontrol option is regarded as ranking high among other options in acceptability and safety, it is still not a one-bullet remedial solution. Many fears are being expressed on the genetic modification approach to mycotoxin control. It is hoped that the fears may be allayed by the provisions of Section 33, Fourth schedule of the National Biosafety Law just signed in April 2015.

This calls for a model as proposed in 2010 (Fig 2)which invites a cocktail of solutions(Fapohunda, 2010)

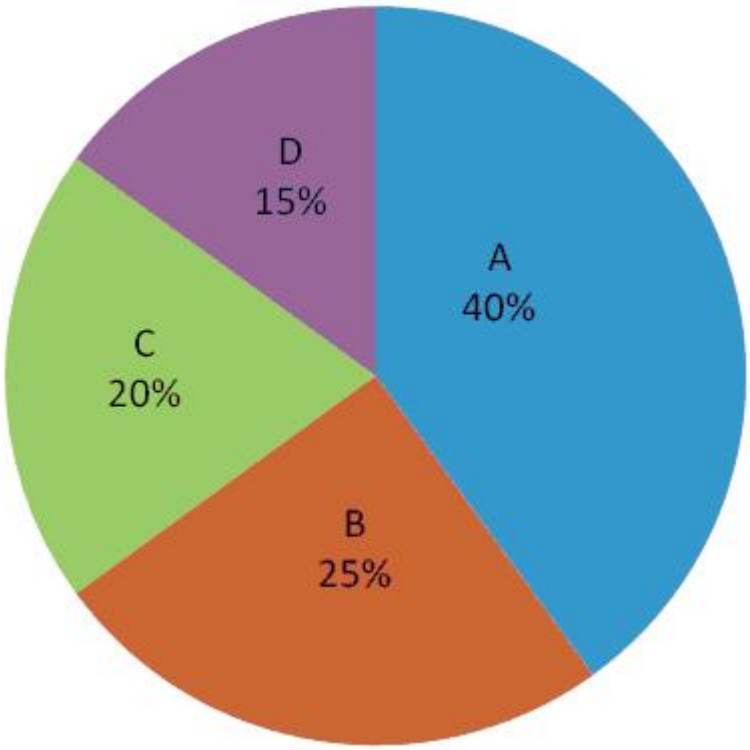

Fig 2 Proposed model for mycotoxin management in sub Saharan Africa

(Source: Fapohunda 2010 www.mycotoxins.com. http://services.leatherheadfood.com/eman/FactSheet.aspx?ID=71)

Key:

A=Enlightenment/Awareness Campaign (in local languages through jingles, posters, handbills, regular meetings with farmer and commodity traders. **Government** and **food and feed -safety activists** e.g. MSN. will facilitate this.

B=Regulations and standards, including monitoring compliance (assistance /extension service to farmers and exporters;).
The arrest of lax regulations will be facilitated by **government.**

C=Capacity building. (Involving globally validated procedures for detection/analysis, user-friendly management techniques) This is to be facilitated by **Government; international bodies e.g. Universities, Research Institutes, EU, FDA; food and feed safety activists**.

D=Good Practices. (Involving Agricultural , Manufacturing, Cultural like winnowing, and physical sorting).Farmers and the manufacturing industry will facilitate this in conjunction with **government** and **food and feed safety activists**.

All these are essentially interrelated and call for a synergy in the effort of national governments, relevant mycotoxin non governmental bodies and international agencies. The option of prevention is recommended in a way that end users will always express conscious willingness to execute.

The world is now fully on the alert particularly when Europe hitherto not considered a serious candidate, now has , through climate change, the possibility of native aflatoxin cases in the near future. The International Society of Mycotoxicology was launched in 2005 with a promise to get involved in the solution for the enhancement of health and trade. The Mycotoxicology Society of Nigeria was formed in 2006 with members who were bound by profession, passion and mission. One of the aims is to use its efforts and expertise to cut mycotoxin intake in half within the next decade .

In Nigeria the alarming low level of awareness on mycotoxins by local commodity traders and farmers is a source for worry, in that even when grains are glaringly damaged and mouldy, the reality of cheapness over undamaged ones translates to an automatic high exposure rate of the toxins to the low income sector of the population and the attendant lethal repercussion. When a situation of ignorance is combined with poverty and food challenge, where government regulations are not enforced or non existent, the result is an endemic continental scandal that ought to attract the immediate attention of the United Nations

The prevalence of fungi having the potentials for toxigenicity (Ezekiel and Fapohunda 2012; Fapohunda *et al* 2012d) heightens the resolve to come up with a mycotoxin policy in Nigeria. When the European Union(EU) continuously reject some Nigerian agricultural commodities like melon, peanuts and *ogbono* then it became clear that the country has been getting a few things wrong.. The gravity and persistence of this problem underscored the invitation by the European Mycotoxin Awareness Network (EMAN) to present a commissioned paper on aflatoxin in Sub Saharan Africa (Fapohunda 2010). Right now, Nigeria has adopted the EU standards regarding total aflatoxins and aflatoxin B1.

Mycology and the future

Mycological research, like any others in bioscience is not to be regarded as an emblem of organized confusion, rather a symbol of boisterous and sustained research activity

In mycology, there s now a fast and sustained trip from biochemistry to genomics moreso when mycotoxin production can be linked with some other critical metabolites like amino acids(Yu *et al.*, 1998;Xu *et al*., 2014) thereby giving fillip to the development and upgrading of new software tools (Zhang *et al.,* 2011). Many investigations into the mode of trafficking and export of mycotoxins in the cells are being reported (Kisler and Broz 2015). Indeed the future belongs to molecular strategies because there lies the principles behind and the mechanisms of action in fungal metabolomics(van Dijk *et al*., 2014). The focus now on genome mining which represents a limitless shift in myco-mining,is designed to activate genes that are sometimes silent. Through this procedure, all the innate and hidden potentials of fungi can be laid bare and exploited more in drug production and agriculture. Accurate predictions of secondary metabolite profile can be made using the gene cluster(Andersen *et al*., 2012) The procedure carried out on *Aspergillus nidulans* in order to identify biosynthetic super clusters scattered across different chromosomes(Sanchez *et al*., 2011), is also applicable to other microfungi(Andersen *et al*., 2012, Inglis *et al.,* 2013). Investigations into the genomic analyses on some fungi are on going(Cacho *et al.,* 2015) and the report on *Fusarium* and *Cladosporium* species has just been concluded. A sampling of contaminated foodstuffs throughout southwest Nigeria yielded three fungal isolates belonging to the genus *Fusarium* and two isolates belonging to the genus *Cladosporium*. Through molecular investigations we were able to confirm our morphological species identifications with BLAST queries for sequences from three genomic regions (beta-tubulin, calmodulin and ITS). BLAST results uncovered a species identification inconsistency for one *Fusarium* isolate, SRRC1606, based on its ITS sequence, and for both

Cladosporium isolates based on their beta-tubulin sequences, compared to the other loci. Using additional species sequences obtained from GenBank, we explored phylogenetic associations for each genomic region and found evidence of recombination in all three loci for the *Fusarium* species examined, but only in the beta-tubulin locus for our *Cladosporium* population.. Understanding these population dynamics, with relation to fungi that are ready food contaminants, may serve to help us better protect consumers against dietary mycotoxins(Moore and Fapohunda, 2015)..

Emergent and masked mycotoxins, are now being treated with all attention they deserve. Since many co-occur on same substrate, the overall effect of their synergism is not yet concluded. Examples of such are beauvericin and enniatins(Juan *et al.,* 2013b). This group and the masked mycotoxins may hold promise for future beneficial application. A recent mass interest in mycotoxin research in Nigeria and Africa is a direct reflection of a relentless uptrend in mycoawareness. It is clear that fungi are ***indomitable*** and ***irresistible***

Myco prospecting can be enhanced and made reliable only if proper identification is attained. In order for this to be actualized, a few things need be put in place.

1 The setting up of a mycological culture collection centre in Nigeria. Proper identification confers credibility on mycological research. At present, mycological specimens are reliably identified from outside Nigeria .

2 A Mycotoxin policy. The policy is expected to encompass standard mycotoxin research laboratory(ies) with validated equipment and personnel, regular capacity building, intensive extension and consumer awareness services. In 2014, the Kenyan government opened a new, modern laboratory facility which will enable researchers to accelerate cutting-edge solutions to aflatoxin contamination. The policy will also take care of tight biosecurity controls.

Countries in Africa are now facing stark reality of the situation at hand. Interestingly both Kenya and Nigeria took a giant stride in January 2015. In its first cabinet meeting of the year,2015 the government of Kenya has allocated 1.5 billion Kenyan Shillings to fight the aflatoxin problem in the country. Also in January this same year the Federal government inaugurated 2 committees----the Inter Ministerial Committee on Food Safety and the National Food Safety management committee. Food is a very important candidate in human needs. Happily both the 10-point Millenium Development Goals (MDGs)

which wind down this year 2015 and the proposed replacement-a 17-point Sustainable Development Goals (SDGs) recognize wholesome consumption as a way out of poverty. More of this commendable step are welcome.

The importance of fungi contrasts to the limited capacity to study them in Nigeria nay Africa. Mycology can be divided into medical mycology, food mycology, industrial mycology, aspects of plant pathology, symbioses, ecology, biodiversity, and systematics, with numerous overlaps between fields and expertise. The renaissance being enjoyed now, needs sustenance. For each group, there are specific needs, background and isolation procedure. For example the obligate parasites like the downy mildews, powdery mildews, and rusts are difficult to isolate for obvious reasons. Although there may be close to a million species only less than 80,000 have been identified and enjoy some classification. This has also made opportunities so wide as it may take many more years before certainty is attained in fungal classification. There will always be continuous need for a reconstruction of the group through application of new methods. Recently we used polyphasic methodology to identify some of the fungal isolates collected from North central geopolitical zone of Nigeria(Okeke *et al*., 2014).

The yearning of the fungus for a living territory and exclusive identity is now actualized after long suffering patience and adamantine resolve. However, such attainment can only be meaningful if traction is lent to the tempo of mycological research. With the growing emerging fungal threats alarmingly with anthropogenic sources, a groundswell of research in mycotoxin and enzyme studies and the need to organize into national, regional and international bodies in mycology and related areas, it is an auspice that the gravitas so far scored will result in boundless benefits for humanity.

Services to University and humanity

I have been Chairman and member of many University Committees and panels at various times .. These include= Chairman, Senate Committee on Standing Rules. This is the only Committee till date that recommended the membership and conduct on the floor of the University Senate; Chairman Instructional Materials Committee; Sponsor Final year (Diamond Class 2007)students that among others constructed the Students Support Centre(then called Counseling Centre). I am also the only Senate member on record to be invited by a sitting Chairman of Senate to take over proceedings. It is historic and

unprecedented here at BU. My tenure as editor in Chief of Acta Satech, an official journal of the then Faculty of Science and Technology witnessed more significant visibility for the University. I was a Head of Department of Basic and Applied Sciences that then comprised Microbiology and Biochemistry. Other

responsibilities include -External assessor to state, Federal and Private Universities with respect to Bachelor's, Masters doctoral and Professorial assessments,supervision of many students at the undergraduate and postgraduate levels, consultant to Bill and Melinda Gates- sponsored Country assessment on aflatoxin in Nigeria ; participant/invited guest at the of the formation of African Mycotoxin Network in Cape Town South Africa, invited guest and member Platform Committee of the PACA, in Dar Es Salaam, Tanzania..

The setting up of the Mycotoxicology Society of Nigeria(MSN) was an idea to which I contributed . I, with colleagues- Mrs F Oluwabamiwo, Mrs T Imafidon both of NAFDAC; Mrs Margaret Eshiett of SON and Prof. Olusegun Atanda of McPherson University saw to founding of this active national body on Mycotoxins in Africa. It is gratifying to note that a similar body in Morocco is also on board. All the 5 of us constitute the board of Trustees of this body and I was the founding President (2006-2010). Younger ones like the current national Secretary of the body were impressed by our pioneering effort and quickly keyed in into the vision. Right now, he is on loan from BU (Nigeria) to the Africa Union in Adis Ababa as the Senior Technical manager on aflatoxins. I am sure you will praise God for this .Just as you have done in your various fields, I have contributed in my little way to making Babcock University visible. At our stakeholders' meeting in Cape Town , South Africa in 2010, it was clear that MSN was a catalyst to the formation of the African Mycotoxin Network. At this point, I have to appreciate Prof. A.A. Alalade , the pioneer Vice Chancellor of BU who gave the full support at the founding of MSN here at Babcock in 2006. I feel humbled that the project we jointly planted 9 years ago is now a reference Society throughout the world. Indeed, a life with no impact is one with no value. Abraham Lincoln said 'whatever you are, be a good one'. Embracing this, and the fact a man who only lives for himself is a failure. , a new NGO which enunciates food and feed safety activism, has just been put in place as another of my contribution to humanity. Truly, we need to be the change we wish to see in the world(Mahatma Gandhi1869-1948).You are all invited as members

I have attended and presented papers, and chaired sessions, at many conferences, seminars and workshops both within and outside Nigeria. In furtherance of my belief in the gown-town principle , I have personally contributed through self sponsored interactions, workshops; press releases and

interviews. All these are to make sure that ***mycotoxicovigilance*** , a fight against mycotoxin-induced malnutrition, is a sought- after emerging revolution that will last the distance. The revolutionary and conscious domestication and exploitation of the fungi makes them ***irresistible*** in scientific scrutiny and mining with the hope that they will fill the gaps in our quest for high quality of life.. Also recognizing the need to make an industry of my history, measured and informed opinions, mostly solicited, are contributed on many national and international contemporary issues in the media, some in my field , others not.

Mr. Vice Chancellor Sir, I hope I have attempted to allow members of this kingdom to face justice and particularly to restore and preserve the dignity of the fungal *persona*, in this presentation. Having taken a brief trip through this kingdom and now back, we are confronted with 2 questions—Are they **fiery foes** or **fair friends**? May I once again request that you please move our minds to 'FORWARD' as I know you will agree with my exit report which is clear=they are fair friends doing best what they know how to do. Remember, creation is a TEAM,(SDAH 359) each occupying a niche capable of expressing in full and not mere tokenism. In spite of its earlier travails , Mycology is now proud of its history just as it enthusiastically faces the future. As a team member, humanity may not be able to do without this field. The members are irresistible. They and humanity are to manage each other well in order to enjoy the fruit of nature.

Academics is about the TRUTH and the church is also about the TRUTH, Babcock University(like other faith based Universities) is expected at all times to have a double dose of the TRUTH. Since Professorship is a call to greater leadership espousing guided responsibility and authority, I feel honoured to partake in this exclusive form of leadership. As I admire this , I strongly advise that both the clergy and academia should be separately preserved in all faith based institutions in Nigeria. The rot in the political terrain should not be allowed to contaminate religion. I promise to discuss this leadership issue in detail at another platform very soon.

Mr Vice Chancellor sir, I want to thank the pioneer Vice chancellor of this great University, Prof A A Alalade, for recognizing me, for giving me the opportunity to serve in many capacities. He ran an all-inclusive open administration in order to get things done. Perhaps he realized that life was too short for one to think small. God will continue to shower him with His grace.

I also thank the present Vice Chancellor Prof JAK Makinde, who has continued to make my stay here very rich, eventful and interesting. God almighty will reward you accordingly in Jesus name.

LESSONS ABOUT LIFE

Learn to give something, however little, to someone today

There s no future in the past. So be forward looking

You (only you) determine to be happy

Everybody counts but not much. Its only GOD Almighty who is the repository of total power that counts MUCH

'Doveryai, no Proveryai 'an old Russian proverb meaning 'Trust, but verify…' I have learnt that in my journey through this earth even your own shadow leaves you when you are in darkness.

Religion is not a sedative, so as you listen to sermons activate your senses. Remember your religious teacher is not Deputy God. His ***sin- bag***, which he carries about regularly, may be heavier than yours. Remember also ,you are directly responsible to God your Creator

A random, impromptu pick on me shows I am a sinner (John7:53—8:11); therefore I am expected to continuously remove the log of wood from my eyes(Matt 7: 4-5)The implication of these 2 Bible verses taken together is =***I should spend much time improving myself that I have no time left to criticize others***. I am sure you will assist me to achieve this. So help me God.

Mr Vice Chancellor Sir, this is the route I have taken so far. I have landed, having the belief that today's outing will add to the ingredients of success already credited to research

APPRECIATION

Mr Vice Chancellor sir, I have crossed many dangerous hurdles and defeated many unseen foes in life that I sometimes look back and ask HOW did I survive? Since I cannot answer that question, my reaction is to always express my appreciation and gratitude to my Creator, the creator of Heaven and earth, the repository of WISDOM and KNOWLEDGE, the one who did not manouvre into power through blackmail, intrigues, the one who is not swayed by the lure of lucre, the Creator unto only whom you can sin(Psalm 51.4) and only who can grant mercy(Ps. 41.4). the One who will judge with all fairness. Unto Him, DIRECTLY, I commit my life at all times. I am grateful to Him at all times.He has acknowledged me; He has recognized me; He has appreciated me. He is my Song(SDAH 22) and my Help(SDAH 50).

Please permit me to access a few faiths in order to underscore the need for appreciation by any man irrespective of belief . Islam reminds us that ***True worship means sincere thankfulness to God: Allah explained in the Quran that the only people who truly worship Him are those who give gratitude to Him, so those who are not among the people of gratitude are not among the people of Ibadah (worship and obedience). "… and be grateful to Allah, if is Him you worship" (Al-Baqarah 2:172).*** -Gratitude for the abundance that you have received is the best assurance that the abundance will continue =Prophet Muhammad(570-632)Founder of Islam

Three ways to express thankfulness to God: The classical Muslim scholars have indicated that Shukr can be shown in three ways: Shukr of the heart (Qalb), Shukr of the tongue (Lisan),and Shukr of the limbs (Jawarih), Every time Allah gives us a blessing, we must use it in a way that benefits humanity and that pleases Allah.(Taya Ghayyur)

Gratitude is a vaccine, an antitoxin and an antiseptic –John Henry Jowett(1864-1923) Presbyterian Preacher

You have no cause for anything but gratitude and joy---Gaitama Buddha(563-483BC) Founder of Buddhism

And whatever you do in word or deed, do all in the name of the Lord Jesus, giving thanks to God ….Colossians 3:17

O give thanks to the LORD, for he is good: for his mercy endures for ever. Psalms 107:1

In every thing give thanks: for this is the will of God in Christ Jesus concerning you. 1 Thessalonians 5:18

I am grateful to God for making me a benefit to humanity and I will continue to please HIM through the application of the knowledge HE has given me. The administration of Babcock University, has expressed an uncompromising embrace of scholarship, by committing enormous resources for today s event. That is a clear message to other Universities and it deserves commendation and appreciation.The present defining turn in fungal studies is a toast to the feisty resolve of the grandmasters in this discipline. I thank Professor DL Hawksworth and Dr Ranajit Bandyophadyay for invaluable information made available to me on current systematics and aflasafe respectively. Eminent and respected mycologists from whom I have benefitted are Professors R A Alabi, B A Oso and J I Pitt. Professors C O Akueshi; and V W Ogundero. have been my mentors at both the undergraduate and postgraduate days in the University with

whom I am in touch till date.. They are indeed a standard example of mentor-mentee relationship in academics. I also recognize my colleagues like Professors L. Adebajo, Olusegun Atanda and those at NAFDAC, SON , FIIRO and IITA. All the collaborations/ assistance and fellowship given by CABI, UK, USDA, DSE (Germany) and TWAS are duly appreciated. I also thank all the staff and faculty of the School of Basic and Applied Sciences who have contributed immensely to the success of today. The extra effort the current School s secretary Ms Bernice Obanigba demonstrates in making this day a worthy outing is acknowledged. Special appreciation goes to the members of Inaugural Planning Committee, who are men and women of intellectual integrity and humility: Emeritus Prof. Michael Omolewa, Profs A.A Akinsoyinu, F D Onajobi, G O Alegbeleye, ; D O Adeboye, G O Tayo and Dr Kola Ayodele for making constructive suggestions on the lecture . I equally express gratitude to colleague Deans, Heads of Departments and Units as well as my students for giving invaluable support so far. The Nigerian Press has also been commendable in their support of my activities.

Colleagues from outside Nigeria who made my research easier and irresistible include Dr Geromy Moore(USA), Prof Nelson Lima(Portugal) and Dr Michael Sulyok(Austria). They have all made salutary contributions to the advancement of this attractive discipline

All the members of my family-immediate and extended- are appreciated. Its indeed a privilege to belong to the *Tomori* Fapohunda lineage…a family of outstanding academics, seasoned professionals and disciplined business men and women. I want to single out my mother for gratitude. She demonstrated a strong resolve to get me educated particularly at the secondary school , when all hope seemed bleak and aborted. It is my prayer that she will live long enough to witness happier days in Jesus name .There are two senior brothers who always stand by me and my immediate family. Elder Ayo Fapohunda and Captain Solomon Aluko take it as a self imposed duty to regularly pray for me . They are always there as reliable support. I must also note Chief Ebenezer Babatope, a bundle of courage and energy, who at one time, recognised some potentials in me and decided to guide me through a brief national assignment. God will bless all of you abundantly.

In fungal science, we see God s touch, wisdom, wonders and grace. Mycologist are men in constant productive motion. I am making a case for a global intensive study of mycology in all secondary schools. A secret of our living may be there.

Now that fungi are relishing in a deserving face lift in their kingdom, I want to remind us here that we need a ***faith-lift*** in life and it is achieved not by having a deaf loyalty to any man. In achieving that, we hold on to only one ultimate KING, the King of kings with one everlasting kingdom**.** No one person can exclusively lay claim to HIM **.** Linking up with him **directly** is the password to earthly success and salvation. And in Jesus name, I am sure we shall be satisfied with being ***joint heirs*** and not many kings in HIS kingdom .

Mr Vice Chancellor Sir, distinguished guests, the fact that you are here today has further edified mycology. Therefore, I thank you all for your presence and attention. Our Creator will grant you journey mercies back home

God bless you all .

REFERENCES

Adrio J L and Arnold L. Demain 2014, Microbial Enzymes: Tools for Biotechnological Processes Biomolecules 4, 117-139; doi:10.3390/biom4010117

Ahmad, S. and **Fapohunda, S. O**. (2010) Production of microbial polyesters by Pseudomonas alcaligenes Acta Satech 3(2) 113-114

Akar T, Tunali S. 2006. Biosorption characteristics of Aspergillus flavus biomass for removal Pb (II) and Cu (II) ions from aqueous solutions. Bioresour. Technol., 97(15): 1780-1787

Andersen,M R , Jakob B. Nielsen, Andreas Klitgaard, Lene M. Petersen, Mia Zachariasen, Tilde J. Hansen, Lene H. Blicher, Charlotte H. Gotfredsen, Thomas O. Larsen, Kristian F. Nielsen, and Uffe H. Mortensen 2012.Accurate prediction of secondary metabolite gene clusters in filamentous fungi. Proceedings of the National Academy of Sciences of the United States of America Current Issue 110 (1) E99–E107, doi: 10.1073/pnas.1205532110

Anjorin, S.T., **S.O. Fapohunda** M. Sulyok, A. Negedu, I.M. Ogara and R, Krska 2015. Mycotoxin profile on guinea corn (Sorghum bicolor L. Moench) seeds in the Federal Capital Territory (FCT), Abuja, Nigeria(submitted for publication)

Bandyophadyay R.2015, Personal communication

Bayat, O · Volkan Arslan · Belgin Bayat 2011. Use of Aspergillus niger in the bioleaching of colemanite for the production of boric acid

Electronic J. Biotechnol. 14 (3), Issue of May 15, 2011

Bhatnagar D; Cleveland T E and Kingston D G 1991. Enzymological evidence of separate pathways for aflatoxin B1 and B2 biosynthesis. Biochemistry 30: 4343-4350

Bleve, G., F. Grieco, G. Cozzi, A. Logrieco, and A. Visconti. 2006. Isolation of epiphytic yeasts with potential for biocontrol of Aspergillus carbonarius and A. niger on grape. Int J. Fd Microbiol. 108:204-209

Brown GD, Denning DW, Levitz SM. 2012. Tackling human fungal infections: Science. 336(6082):647

Brown Univ. Health Education.Yeast Infection.

Availablebhttp://brown.edu/Student_Services/Health_Services/Health_Education/womens_health/yeast_infections.php Accessed. 7/3/2015.

Brakhage, A A , and Volker Schroeckh 2011.Fungal secondary metabolites – Strategies to activate silent gene clusters Fungal Gen and Biol. 48, (1) 15–22

Brakhage, A A 2013.Regulation of fungal secondary metabolism. Nature Rev. Microbiol. 11, 21-32 doi:10.1038/nrmicro2916

Burton N.C., Adhikari A., Iossifova Y., Grinshpun S.A., Reponen T. 2008 Effect of gaseous chlorine dioxide on indoor microbial contaminants. J. Air Waste Man Asso.. 58:647–656.

Cary, J W; Kanniah Rajasekaran, Robert L. Brown, Meng Luo, Zhi-Yuan Chen, and Deepak Bhatnagar 2011. Developing Resistance to Aflatoxin in Maize and CottonseedToxins (Basel). 3(6): 678–696

Chooi, Y. H., Fang, J., Liu, H., Filler, S. G., Wang, P., and Tang, Y. (2013). Genome mining of a prenylated and immunosuppressive polyketide from pathogenic fungi. Org. Lett. 15, 780–783. doi: 10.1021/ol303435y

Chooi, Y.-H., and Solomon, P. S. (2014). A chemical ecogenomics approach to understand the roles of secondary metabolites in fungal cereal pathogens. Front. Microbiol. 5:640. doi: 10.3389/fmicb.2014.00640

CAC - Codex Alimentarius Commission . Discussion paper on mycotoxins in Sorghum. Joint FAO/WHO Food Standards Programme CODEX Committee on contaminants in foods' 5th Session held in The Hague, The Netherlands on 21-25 March 2011.

Cacho R A , Yi Tang and Yit-Heng Chooi 2015 Next-generation sequencing approach for connecting secondary metabolites to biosynthetic gene clusters in fungi. Front. Microbiol., 14 January 2015 | doi: 10.3389/fmicb.2014.00774

Castoria, R., Mannina, L., Duran-Patron, R., Maffei, F., Sobolev, A.P., de Felice, D.V., Pinedo-Rivilla, C., Ritieni, A., Ferracane, R., Wright, S.A.I., 2011 Conversion of the mycotoxin patulin to the less toxic desoxypatulinic acid by the biocontrol yeast Rhodosporidium kratochvilovae Strain LS11. J. Agric. Food Chem., 59: 11571-11578.

Cavaglieri, L., Orlando, J., Rodriguez, M.I., Chulze, S. & Etcheverry, M. 2005. Biocontrol of Bacillus subtilis against Fusarium verticillioides in vitro and the maize root level. Res. Microbiol. **156**: 748-754

Chakrabarti A 2011. Drug resistance in fungi. Reg. Health For. 15(1)97-103

Chiang, Y.W., Santos, R.M., Monballiu, A., Ghyselbrecht, K., Martens, J.A., Mattos, M.L.T., Van Gerven, T., Meesschaert, B. (2013). Effects of bioleaching on the chemical, mineralogical and morphological properties of natural and waste-derived alkaline materials. Minerals Eng, DOI: 10.1016/j.mineng.2012.09.004

Chulze, S.N 2010.. Strategies to reduce mycotoxin levels in maize during storage: a review. Fd. Addit. Contam 27(5): 651–657

Corrêa RC, Rhoden SA, Mota TR, Azevedo JL, Pamphile JA, de Souza CG, Polizeli Mde L, Bracht A, Peralta RM. 2014 Endophytic fungi: expanding the arsenal of industrial enzyme producers. J Ind Microbiol Biotechnol. Oct;41(10):1467-78. doi: 10.1007/s10295-014-1496-2.

Cozzi,G; Stefania Somma, Miriam Haidukowski, and Antonio F. Logrieco 2013 Ochratoxin A Management in Vineyards by Lobesia botrana . Biocont.Toxins (Basel). 5(1): 49–59

de Cassia Pereira J, Paganini Marques N, Rodrigues A, Brito de Oliveira T, Boscolo M, da Silva R, Gomes E, Bocchini Martins DA. 2015 Thermophilic fungi as new sources for production of cellulases and xylanases with potential use in sugarcane bagasse saccharification. J Appl Microbiol. Jan 21. doi: 10.1111/jam.12757.

De Curtis,F; D.V. de Felice, G. Ianiri, V. De Cicco, R. Castoria 2012.Environmental factors affect the activity of biocontrol agents against ochratoxigenic Aspergillus carbonarius on wine grape. Int.J .Fd. Microbiol. 159 : 17–24

Deswal D, Gupta R, Nandal P, Kuhad RC. 2014. Fungal pretreatment improves amenability of lignocellulosic material for its saccharification to sugars. Carbohydr Polym. Jan;99:264-9. doi: 10.1016/j.carbpol.2013.08.045.

Dolezal, A L Xiaomei Shu, Gregory R. OBrian, Dahlia M. Nielsen, Charles P. Woloshuk, Rebecca S. Boston, and Gary A. Payne. 2014. Aspergillus flavus infection induces transcriptional and physical changes in developing maize kernels Front Microbiol.; 5: 384.

Dorner J. W. (2009). Biological control of aflatoxin contamination in corn using a nontoxigenic strain of Aspergillus flavus. J. Food Prot. 72 801–804 [PubMed

Dworecka-Kaszak B 2014 Cordyceps fungi as natural killers, new hopes for medicine and biological control factor. Ann Parasitol. 60(3):151-8

Esteves AC, Saraiva M, Correia A, Alves A. 2014.Botryosphaeriales fungi produce extracellular enzymes with biotechnological potential. Can J Microbiol. 60(5):332-42. doi: 10.1139/cjm-2014-0134

Ezekiel C N', A. C. Odebode and **S. O. Fapohunda** (2008) Zearalenone production by naturally-occurring Fusarium species on maize,wheat and soybeans from Nigeria J. Biol Env. Sci. 2 (5) 77-82

Ezekiel C.N., A.C. Odebode, **S.O. Fapohunda**, G.O. Tayo, O.J. Olawuyi, O.B. Olaoye, A.O. Olarinmoye and O.O. Adeyemi (2011)Toxigenic potential of co-occurring aflatoxin and ochratoxin a detected in poultry feed on Clarias gariepinus larvae .Nature and Science 9(5):186-192

Ezekiel C.N and **Fapohunda S.O**. (2012)Mycological and Nutrient Profile of Soymilk. Glo. Adv. Res. J. Food. Sci. Technol.1(2): 025-030

Ezekiel, C N, Funmi O. Kayode, **Stephen O. Fapohunda**, Momodu F. Olorunfemi and Barinaada T. Kponi (2012) Aflatoxigenic moulds and aflatoxins in street-vended snacks in Lagos, Nigeria Int J. Fd. Safety.14:.83-88

Ezekiel C N, I.E. Udom, J.C. Frisvad, M.C. Adetunji, J. Houbraken, **S.O. Fapohunda**,R.A. Samson, O.O. Atanda, M.C. Agi-Otto & O.A. Onashile 2014Assessment of aflatoxigenic Aspergillus and other fungi in millet and sesame from Plateau State, Nigeria Mycology: An Int J. Fungal Biol, 5:1, 16-22, DOI 10.1080/21501203.2014.88976

Ezekiel C N ;Olorunfemi M; **Fapohunda S O** and Kayode F 2013 Mycobiota and aflatoxin B1 contamination of Piper nigrum L(Ashanti pepper), P.guineense (black papper) and Monodora myristica (calabash nutmeg) from Lagos , Nigeria. Int. Fd. Res. J.. 20(1) 1881-6

Fapohunda, S.O. 1988. Amino acid composition and mycology of sekete, a fermented product from Zea mays Die Nahrung-Food 32:571-575

Fapohunda, S.O. 1989 Fungal flora of malting grains of Zea mays Linn Die Nahrung-Food 33:3-7.

Fapohunda, S.O. and Ogundero, V. W. 1990 Physiology of fungi associated with fast foods in Nigeria. International Biodeter J. 26:23-32

Fapohunda, S.O. and Fasedemi B. T. 1990 Mycotic infections of domestic animals and man. J of Teacher Edu 5:77-90 .

Fapohunda, S.O. and Ogundero V.W. 1990, Malted Sorghum bicolor grains and physiology of associated microfungi, Die Nahrung-Food 34(3):241-246. doi: 10.1002/food.19900340308

Fapohunda, S.O. 1992a studies on Aspergillus and Cladosporium species infecting stored cereals, Pak. J. Sci. Ind. Res.. 35:335-337

Fapohunda, S.O. 1992b Physiology of Aspergillus terreus, a deteriogen of cereals in Nigeria. Acta Bot Indica 20 (1): 120-125.

Fapohunda S.O. (2004): Studies on Melanocarpus albomyces, a thermophilic compost fungus Sci. Africana 3: 60-64

Fapohunda S.O.; Olajuyigbe, O.O and Omenka, R.O. (2004): Aflatoxins in foods and feeds – Acta Satech 1: 91-104

Fapohunda,S O (2005) Cultural responses of Candida guilliermondii,a grain saprophyte Sci. Africana 4;19-23

Fapohunda S O; Esan E B , Ogunwenmo K O and Adedayo O (2005) A report of Fusarium oxysporum on Codiaeum variegatum cultivars in Nigeria Acta satech 2 (1) 40-41

Fapohunda S O (2006) Production of lipase and toxic metabolites from Cladosporium cladosporioides under varied conditions Mycol. Balcan. 3 :89-93

Fapohunda, S.O and Olajuyigbe, O.O (2006): Studies on stored cereal degradation by Alternaria tenuissima . Acta Bot Mex 77 ;31-40

Fapohunda S O 2007 Moulds,meals,man and mycotoxins Ipan News 8 : 6-9

Fapohunda S O , Idowu,O and Ezekiel C 2007 Opportunistic Aspergillus flavus from tuberculosis patients Sci. Africana 6(1): 94-99

Fapohunda S O , Olajuyigbe O O and Esiaba I 2007 Fungal xylanases. Biol Environ.Sci.Tropics J. 4(2): 206-211

Fapohunda S O; Awoyinka O. A; Olajuyigbe,O O , Ezekiel C and Esiaba I (2007) Enzyme-related aflatoxin production in vital organs of rats fed with Aspergillus species- inoculated rat chow J. Biol. Environ. Sci 1:1-4

Fapohunda S O, C.N. Ezekiel, O.A. Alabi, A.Omole &S.O. Chioma (2008)Aflatoxin-mediated sperm and blood cell abnormalities in mice fed with contaminated corn Mycobiology 36(4) 255-259

Fapohunda S O ;Akintewe, T; Olarinmoye, O A and Ezekiel, C N (2009) Anti aflatoxigenic potentials of two Nigerian herbs on albino rats. J. Biol. Environ. Sci. 3(9) 81-90

Fapohunda,S O (2010):Impact of mycotoxins on sub-saharan Africa : Nigeria as a case study http://www.mycotoxins.org/factsheet accessed 20 Feb 2015

Fapohunda, S.O , O. J. Olawuyi and C. P. Okei (2011) Antimicrobial and phytochemical potentials of arbuscular mycorrhizal fungi in Nigeria. The S. Pacific J.Natural Appl. Sci., 29 :21–25

Fapohunda S O and Afolayan A (2012) Fermentation of Cocoa Beans and Antimicrobial Potentials of the pod Husk Phytochemicals J. Phys. Pharm. Adv., 2012, 2(3):158-164

Fapohunda SO, Adeware A (2012) Microbial Load and Keeping Quality of Kunu under Various Preservative Regimes. J Nutr Food Sci 2:141. doi:10.4172/2155-9600.1000141

Fapohunda,S O ; Mmom, J U and Fakeye, F. (2012a)Proximate analyses, phytochemical screening and antibacterial potentials of bitter cola, cinnamon, ginger and banana peel. Academ Arena 2012;4(8):8-15

Fapohunda, S O. Ogunbode, S M. Wahab, M K A.; Salau, A K. Oladejo, R K and . Akintola, G B. (2012b) Enzyme profile and haematology as indices of morbidity in broilers fed dietary aflatoxin. Academ Arena 4(8):21-25

Fapohunda S. O., Anjorin S. T. and Adesanmi C. A.(2012c) Nutritional Profile of Gamma-Irradiated and Non-Irradiated *Sesamum indicum* Seeds From Abuja Market. J. Animal Prod. Adv. 2 (3) : 161-165

Fapohunda , s o , G.G. Moore O.T. Ganiyu and S.B. Beltz (2012d)Toxigenic Aspergillus flavus and other fungi of public health concern in food and organic matter in southwest Nigeria. Mycology: An Int. J Fungal Biol. 3, (3), 210 – 219

Fapohunda SO, Anjorin, ST, Akueche EC and B. Harcourt (2012e) Multi mycotoxin profile of gamma-radiated sesame seeds from Abuja markets, Nigeria using LC-MS/MS. Nature and Science 10(10):127-134

Fapohunda S.O.;Olawuyi O.J.,Bello O.B.and Lawal T.2013 Comparative Shoot Responses of two Nigerian Crops to Glomus clarum and other Fertilizers Greener J. Agric.Sci. 3(4) 280-85

Fapohunda, S.O. 2013 An Overview of the occurrence and the impact of aflatoxins on public health and trade. A paper presented at the 37th Annual Conference of Nigerian Institute of Food Science and Technology. (ABUJA, 2013), At International Conference Centre Central Area, Abuja, FCT on the 22 -26th October, 2013.

Fapohunda SO, Esan A, Alabi OA, Adebote O, Kolawole O, Olayinka O, Atehnkeng J. and Kuhlmann 2014 Treated Melon Seeds and Aflatoxin Profile in Relation to Blood Parameters in Exposed Mice J. Microbiol. Res. Rev. 2(5): 40-47

Fapohunda, S O;A.A. Akeredolu;F.A. Alatise;F.C. Onyenweaku 2014Microbial Profile inFillings of Meat Pie inTwo Remo LocalGovernment Areas of Ogun State, Nigeria Greener J. Microbiol Antimicrob . 2 (3), 049-058,

Fapohunda,S O; Negedu, A, Okeke, O.F.I, Fapohunda, T, Wahab and Okeke, F 2014 Ochratoxins - A review J.Agric. Sci. and Rev. 3(11) 105-115

Formenti, S , Naresh Magan, Amedeo Pietri and Paola Battilani 2012. In vitro impact on growth, fumonisins and aflatoxins production by Fusarium verticillioides and Aspergillus flavus using anti-fungal compounds and a biological control agent Phytopathol. Mediter. (2012) 51, (1) 247−256

Gajecki M (2002) Zearalenone--undesirable substances in feed. Pol J Vet Sci 5: 117–122

Gouramo h and Bullerman L B 1995. Aspergillus flavus and Aspergillus parasiticus: afl;atoxigenic fungi of concern in foods and feeds: A Review J Food Protection 58: 1395-1404

Guan S, Ji C, Zhou T, Li J, Ma Q, Niu T. 2008. Aflatoxin B(1) degradation by Stenotrophomonas maltophilia and other microbes selected using coumarin medium. Int J Mol Sci. 9(8):1489–1503

Haggag W M and Abdall A. M. 2012 Evaluation of Streptomyces Aureofaciens and Rhodotorulaglutinis Against Ochratoxin A Producing Aspergillus niger in Grapevines. J. Microbiol. Res. 2(6): 170-175

Hawksworth D L 2011 A new dawn for the naming of fungi: impacts of decisions made in Melbourne in July 2011 on the future publication and regulation of fungal names. IMA Fungus 2(2) 155-162

Hawksworth D L 2015 Personal Communication

Hibbett, D.S., Bindera, M., Bischoff, J.F., Blackwell, M., Cannon, P.F., Eriksson, O.E., Huhndorf, S., James, T., Kirk, P.M., Lücking, R., Thorsten Lumbsch, H., Lutzonig, F., Matheny, P.B., McLaughlin, D.J., Powell, M.J. Redhead, S., Schoch, C.L. Spatafora, J.W., Stalpers, J.L., Vilgalys, R., Aime, M.C., Aptroot, A., Bauer, R., Begerow, D., Benny, G.L., Castlebury, L.A., Crous, P.W., Dai, Y-C., Gams, W., Geiser, D.M., Griffith, G.W., Gueidan, C., Hawksworth, D.L., Hestmark, G., Hosaka, K., Humber, R.A., Hyde, K.D., Ironside, J.E., Kõljalg, U., Kurtzman, C.P., Larsson, K.-H., Lichtwardt, R., Longcore, J., Miądlikowska, J., Miller, A., Moncalvo, J.-M., Mozley-Standridge, S., Oberwinkler, F., Parmasto, E., Reeb, V., Rogers, J.D., Roux, C., Ryvarden, L., Sampaio, J.P., Schüssler, A., Sugiyama, J., Thorn, R.G., Tibell, L., Untereiner, W.A., Walker, C., Wang, Z., Weir, A., Weiss, M., White, M.M., Winka, K.,

Yao, Y.-J. & Zhang, N. (2007). A higher-level phylogenetic classification of the Fungi. Mycol. Res., 111: 509-547. DOI:http://dx.doi.org/10.1016/j.mycres.2007.03.004.

Hou Y-J, Zhao Y-Y, Xiong B, Cui X-S, Kim N-H, Y X Xu , and S-C Sun (2013) Mycotoxin-Containing Diet Causes Oxidative Stress in the Mouse. PLoS ONE 8(3): e60374. doi:10.1371/journal.pone.0060374

Hsu JL, Ruoss SJ, Bower ND, Lin M, Holodniy M, Stevens DA. 2011. Diagnosing invasive fungal disease in critically ill patients. Crit. Rev. Microbiol. 37(4):277-312

Hueza IM, Raspantini PC, Raspantini LE, Latorre AO, Górniak SL. 2014. Zearalenone, an estrogenic mycotoxin, is an immunotoxic compound. Toxins (Basel).;6(3):1080-95. doi: 10.3390/toxins6031080.

Ianiri G., Idnurm A., Wright S. A. I., Durán-Patrón R., Mannina L., Ferracane R., Ritieni A. and Castoria R. "Searching for genes responsible for patulin degradation in a biocontrol yeast provides insight into the basis for resistance to this mycotoxin" Appl. Env. Microbiol. 79 (9), 3101-3115, 2013

Inglis,D O; Jonathan Binkley, Marek S Skrzypek, Martha B Arnaud, Gustavo C Cerqueira, Prachi Shah, Farrell Wymore, Jennifer R Wortman and Gavin Sherlock 2013. Comprehensive annotation of secondary metabolite biosynthetic genes and gene clusters of Aspergillus nidulans, A. fumigatus, A. niger and A. oryzae BMC Microbiology, 13:91 doi:10.1186/1471-2180-13-91

Isakeit, T. Prevention of aflatoxin contamination of corn using af-36 or afla-guard®. Available in: <http://amarillo.tamu.edu/files/2010/11/09_FS_FC004_Atoxigenic.pdf> Accessed on 15 April 2015

Juan C; Manes, J Raiola AS and Ritieni A 2013 Evaluation of beauvericin and enniantins in Italian cereal products and multicereal food by liquid chromatography coupled to triple quadrupole mass spectrometry.Fd. Chem. 140 (4) 755-762

Juan C, Ritieni A, Mañes J. 2013 .Occurrence of Fusarium mycotoxins in Italian cereal and cereal products from organic farming. Food Chem. 2013 Dec 1;141(3):1747-55. doi: 10.1016/j.foodchem.2013.04.061. Epub 2013 May 8.

Khan A.A.H., Karuppayil S.M., Chary M., Kunwar I.K., Waghray S. 2009 Isolation, identification and testing of allergenicity of fungi from air-conditioned indoor environments. Aerobiologia.;25:119–123.

Kayode O F, M. Sulyok, **S.O. Fapohunda**, C.N. Ezekiel, R. Krska & C.R.B. Oguntona 2013 Mycotoxins and fungal metabolites in groundnut- and maize-based snacks from Nigeria Fd. Addit.Contam. Part B 11/2013; 6(4):294-300

Keller, N P; Dischingere, C J; Bhatnagar, D; Cleveland T E and ullah a H 1993 Purification of a 40kilodalton methl transferase active in the aflatoxin biosynthesis pathway. Appl Env Microbiol 59:479-484

Kelley R. Y., Williams W. P., Mylroie J. E., Boykin D. L., Harper J. W., Windham G. L., Ankala, A., Shan, X. 2012. (2012). Identification of maize genes associated with host plant resistance or susceptibility to Aspergillus flavus infection and aflatoxin accumulation. PLoS ONE 7:e36892 10.1371/journal.pone.0036892

Kistler, HC and Broz K. 2015. Cellular compartmentalization of secondary metabolism. Front Microbiol. 2015 Feb 9;6:68. doi: 10.3389/fmicb.2015.00068. eCollection 2015.

Kos, G and R Krska 2005 Factsheets on analytical methods EMAN www.mycotoxin.org Accessed 3 March 2015

Lima, G∗ , Raffaello Castoria, Filippo De Curtis,Assunta Raiola, Alberto Ritieni, Vincenzo De Cicco 2011. Integrated control of blue mould using new fungicides and biocontrol yeasts lowers levels of fungicide residues and patulin contamination in apples Postharv Biol. Technol. 60 (2011) 164–172

Lo HC, Hsieh C, Lin FY, Hsu TH 2013 A Systematic Review of the Mysterious Caterpillar Fungus Ophiocordyceps sinensis in Dong-ChongXiaCao (Dōng Chóng Xià Cǎo) and Related Bioactive IngredientsJ Tradit Complement Med. 2013 Jan;3(1):16-32. doi: 10.4103/2225-4110.106538.

Matumba, L., Monjerezi, M., Khonga, E. B., Lakudzala, D.D.. Aflatoxins in Sorghum, Sorghum malt and traditional opaque beer in southern Malawi. Fd. Control 2011, 22, 266-268.

Moore, G G and **S. O. Fapohunda** 2015. Molecular investigations of food-borne Cladosporium and Fusarium species from Nigeria. SpringerPlus(under review)

Moore D., Fryer K., Quinn C., Roberts S., Townley R. (2005) How much are your children taught about fungi in school? Mycologist 19: 152 - 158.

Moore, D., Pöder, R., Molitoris, H-P., Money, N.P., Figlas, D. & Lebel, T. (2006). Crisis in teaching future generations about fungi. Mycol. Res. 110: 626-627. DOI: http://dx.doi.org/10.1016/j.mycres.2006.05.005.

Negedu, A., Atawodi, S.E. Ameh, J.B., Umoh, V.J., and Tanko, H.Y.2011.. Economic and health perspectives of mycotoxins: a review. Cont. J. Biomed. Sci. 5 (1): 5-26.

Nesic K; Ivanovi S and Nesic V 2014 Fusarial Toxins: Secondary metabolites of Fusarium fungi. Rev Environ. Contam Toxicol 228: 101-20

Ogundero V. W. and **Fapohunda, S. O**. 1987. The mycoflora of fermenting maize (Zea mays Linn) grains during sekete production, Nig J. Sci., 21:65-68

Okeke, O.F.I, **Fapohunda, S. O,** Soares, C, Lima, N and Ayanbimpe, G. M 2015 Identification of Mycotoxigenic Fungi from Grains in a Nigerian Region Using the Modern Polyphasic Methodology (accepted for presentation at ISHAM conference 2015 Melbourne, Australia).

Pariza, M.W.; Cook, M. 2010,. Determining the safety of enzymes used in animal feed. Regul. Toxicol. Pharmcol. 56, 332–342.

Pe Kardos, N., and Demain, A. L. (2011). Penicillin: the medicine with the greatest impact on therapeutic outcomes. Appl. Microbiol. Biotechnol. 92, 677–687. doi: 10.1007/s00253-011-3587-6

Pereira, P., Nesci, A., Castillo, C. & Etcheverry, M. 2010. Impact of bacterial biocontrol agents on fumonisin B1 content and Fusarium verticillioides infection on field-grown maize. Biol. Control 53: 258-266.

Ponsone ML, Chiotta ML, Combina M,Dalcero A, Chulze S. Biocontrol as a strategy to reduce the impact of ochratoxin A and Aspergillus section Nigri in grapes. Int J Food Microbiol.2011;151:70-77.

Rubert J; **S O Fapohunda**; Soler, C; Ezekiel, C; Manes, J and Kayode F 2013 A survey of mycotoxins in random street-vended snacks from Lagos, Nigeria using QuEChERS-HPLC-MS/MS. Food Control 32 673-677

Sanchez, J F; Ruth Entwistle, Jui-Hsiang Hung, Junko Yaegashi, Sofina Jain, Yi-Ming Chiang, Clay C. C. Wang, and Berl R. Oakley 2011 Genome-Based Deletion Analysis Reveals the Prenyl Xanthone Biosynthesis Pathway in Aspergillus nidulansJ Am Chem Soc. 133(11): 4010–4017.

Sánchez-Pérez L.C ; Juan Esteban Barranco-Florido,Silvia Rodríguez-Navarro, José Francisco Cervantes-Mayagoitia, and Miguel Ángel Ramos-López. 2014 Enzymes of Entomopathogenic Fungi, Advances and Insights. Advances in Enzyme Research, , 2, 65-76

Sartori M, ,1 Andrea Nesci,1 Carlos Castillo2 and Miriam Etcheverry 2013
Biological control of fumonisins production in maize at field level. International Journal of Agricultural Policy and Research 1 (7), pp. 188-196

Schatzmayr G, Zehner F, Täubel M, Schatzmayr D, Klimitsch A, Loibner AP, Binder EM.2006 Microbiologicals for deactivating mycotoxins. Mol Nutr Food Res. 50(6):543-51

Semeiks, J., Borek, D., Otwinowski, Z., and Grishin, N. V. (2014). Comparative genome sequencing reveals chemotype-specific gene clusters in the toxigenic black mold Stachybotrys. BMC Genomics 15:590. doi: 10.1186/1471-2164-15-590

Sharma, R.R.; Singh, D.; Singh, R. 2009.Biological control of postharvest diseases of fruits and vegetables by microbial antagonists: A review. Biological Control, Orlando, 50, (3), 205-221.

Sharma R P and Kim Y W 1991.trichothecenes in Mycotoxins and Ohytoalexins eds. R P Sharma and D K Schlenke boca Raton FL CRC Press pp 339-59

Shi L, Liang Z, Li J, Hao J, Xu Y, Huang K, Tian J, He X, Xu W.2014 Ochratoxin A biocontrol and biodegradation by Bacillus subtilis CW 14. J Sci Food Agric. 94(9):1879-85.

Shinoj S., Visvanathan R., Panigrahi S., Kochubabu M. 2011 Oil palm fiber (OPF) and its composites: a review. Ind. Crops Prod..;33(1):7–22.

Sulyok, M.; Berthiller, F.; Krska, R.; Schumacher, R. Development and validation of a liquid chromatography/tandem mass spectrometric method for the determination of 39 mycotoxins in wheat and maize. Rapid Commun. Mass Spectrom., 2006, 20, 2649–2659.

Taha,A S J; Alaa Jabbar Taha, Zeena G. Faisal 2015.Purification and Kinetic Study on Cellulase Produced by Local Trichoderma viride Nature and Science;13(1)87-90

Tsekova K, Christova D, Ianis M. 2006. Heavy metal biosorption sites in Penicillium cyclopium. J. Appl. Sci. Environ. Mgt., 10(3): 117-121

Udom I. E., Ezekiel C. N., **Fapohunda S. O**., Okoye Z. S. C. and Kalu C. A. (2012) Incidence of Aspergillus Section Flavi and Concentration of Aflatoxin in Feed Concentrates for Cattle in Jos, Nigeria J Vet Adv 2(1): 39-46

van Dijk, E. L., Auger, H., Jaszczyszyn, Y., and Thermes, C. (2014). Ten years of next-generation sequencing technology. Trends Genet. 30, 418–426. doi: 10.1016/j.tig.2014.07.001

Velkova Z ; Margarita Stoytcheva and Velizar Gochev 2012.Biosorption of Cu (II) onto chemically modified waste mycelium of Aspergillus awamori: Equilibrium, kinetics and modeling studies J. BioSci. Biotech., 1(2): 163-169.

Velmourougane K, Bhat R, Gopinandhan TN, Panneerselvam P.2011. Management of Aspergillus ochraceus and ochratoxin-A contamination in coffee during on-farm processing through commercial yeast inoculation. Biol Control. 57:215–221.

Virgili R, Simoncini N, Toscani T, Camardo Leggieri M, Formenti S, Battilani P2012. Biocontrol of Penicillium nordicum growth and ochratoxin A production by native yeasts of dry cured hamToxins (Basel).4(2):68-82. doi: 10.3390/toxins4020068. Epub 2012

Vishwanath, V.; Sulyok, M.; Labuda, R.; Bicker, W.; Krska, R. Simultaneous determination of 186 fungal and bacterial metabolites in indoor matrices by liquid chromatography/tandem mass spectrometry. Anal. Bioanal. Chem. 2009, 395, 1355–1372.

Visscher, H., Brinkuis, H., Dilcher, D.L., Elsik, W.C., Eshet, Y., Looy, C.V., Rampino, M.R. & Traverse, A. (1996). The terminal Paleozoic fungal event: evidence of terrestrial

ecosystem destabilization and collapse. Proceedings of the National Academy of Sciences of the United States of America, 93: 2155-2158. Stable URL: http://www.jstor.org/stable/38482

Wang J, Chen C. 2006. Biosorption of heavy metals by Saccharomyces cerevisiae: A review. Biotechnol. Adv., 24(5): 427-451.

Xu T J and Ting Y P 2009 Fungal bioleaching of incineration fly ash: Metal extraction and modeling growth kinetics . Enzyme Microb Technol. 44(5):323-328.

Xu, W., Gavia, D. J., and Tang, Y. (2014). Biosynthesis of fungal indole alkaloids. Nat. Prod. Rep. 31, 1474–1487. doi: 10.1039/c4np00073k\

Yu J; Chang PK; Ehrlich PC Gary JW Montabano B dyer J M; Bhatnagar d and Cleveland T E 1998. Characterization of critical amino acids of an Aspergillus parasiticus cytochrome p-450 mono oxygenase ebcoded by ard Ainvolved in the biosynthesis of aflatoxin B1, G1 and B2 and B2. Appl Env Microbial. 64:4834-4841

Zhang, W., Chen, J., Yang, Y., Tang, Y., Shang, J., and Shen, B. (2011). A practical comparison of de novo genome assembly software tools for next-generation sequencing technologies. PLoS ONE 6:e17915. doi: 10.1371/journal.pone.0017915