METHOD TO MITIGATE FUNGAL GROWTH AND MYCOTOXINS CONTAMINATION IN STORED GRAINS AND ANIMAL FEEDS USING "FUNGAL AND MYCOTOXIN SHIELD"

Executive Summary

Our project aims to scale up the development of eco-friendly and low-cost fungistatic nano-hybrid material using Amino Acid-modified Nanoclay (AAMNC), **as fungal and mycotoxins shield (MycoFun-Shield)**. The proposed solution is effective in shielding stored agricultural commodities (grains and animal feeds) against fungal growth and mycotoxin production, using nanotechnology and a green chemistry approach, which combines the antifungal properties of selected amino acid-based surfactants with the adsorption capabilities of nanoclay.

The Objectives of the proposal are:

1. Pre-Scaling Preparation (to finalize product formulation and manufacturing process based on the customer feedback;

2. Regulatory Compliance (to ensure regulatory compliance with relevant regulations and standards;

3. Scalable manufacturing (to develop/partner with feed manufacturers to support the largescale production process; and

4. Monitoring and evaluation (key performance indicators and product feedback.

Problem Statement

Fungal infection and mycotoxin contamination of stored agricultural commodities (grains and feeds) are regional issues in Africa, which lead to their significant rejection in international trade. This causes investors and farmers to incur substantial losses. On the other hand, Nanoclay is increasingly recognized to be effective in the decontamination of mycotoxins because of its large surface area and high adsorption capacity. Consequently, NanoClay could be incorporated into food packaging materials, added into stored grains to prevent contamination, or added into animal feeds to enhance livestock health (Mehdi & Eris, 2018). Therefore, a combination of prevention and decontamination techniques is essential, to ensure safer agricultural products and reducing health risks to its consumers.

Introduction

Mycotoxins are toxic chemical substances produced by various fungi species as secondary metabolites in the field, and during the storage of agricultural products (Pavel et al., 2018; Azeh et al., 2025). These substances are toxic secondary metabolites mainly produced by fungi such as Aspergillus, Penicillium, and Fusarium, which contaminate a range of agricultural commodities, including cereals, nuts, and fruits. These contaminants pose serious threat to food safety, public

health, and economic stability (Milani & Maleki, 2014; Azeh et al., 2025). The economic impact of mycotoxin contamination is significant and complex. Direct losses come from reduced crop yield and quality, resulting in lower market prices and rejection of contaminated produce in international trade. Indirect economic losses are caused by the costs of managing mycotoxins, including monitoring, prevention, and decontamination, as well as healthcare expenses linked to exposure (Wu, 2015). Additionally, mycotoxin contamination can severely impact the livestock industry. Contaminated feed may lead to decreased animal productivity, higher vulnerability to diseases, and even death, further worsening the economic losses. The Food and Agriculture Organization (FAO) estimates that 25% of the world's food crops are affected by mycotoxins each year, creating substantial economic burdens, especially in developing countries where monitoring and control are less rigorous (FAO, 2019). Consequently, there is an urgent need to develop affordable strategies for mycotoxin decontamination of agricultural produce in developing nations such as Nigeria.

About $1.5 billion US dollars of mycotoxin menace are incurred annually in the poultry industry, and 3.5 trillion naira is estimated for post-harvest losses in Nigeria (Imade et al., 2021). Grains and feed contamination lead to poor animal health and productivity, endangering human health (liver and kidney damage, cancer, seizures, depression risks, etc.). Nigeria`s staple foods have a high prevalence of contamination of 90-100% by ochratoxin A, aflatoxins, zearalenone, fumonisins, and deoxynivalenol (Kija, 2025).

Innovativeness and Novelty

Our Product and Design

Our product, AAMNC, branded as "**Fungal and Mycotoxin Shield (MycoFun-shield)**," is made from readily available and affordable materials sourced within Nigeria. These materials are purified and chemically transformed into innovative functional hybrid nanomaterials using safe, eco-friendly chemicals and reagents. This product is specifically designed to protect grains and animal feeds from fungal infection and mycotoxin contamination, ensuring food safety and security, promoting animal health, and supporting a sustainable food value chain that spans from farms to food manufacturing and distribution to retailers.

Commercial Viability (A Letter is required from manufacturers/distributors based on market surveys).

The preliminary findings on our product are:

Unique Features.

I. Findings show that MycoFun-shield offers utmost protection against Aflatoxin Total in stored grains (maize and groundnut) and poultry feeds for 12 months, totally restricting fungal growth.

II. Offers protection against a range of mycotoxin-producing fungi, like *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Aspergillus oryzae, Fusarium sp., Mucor sp., Neurospora sp., Penicillium sp., Penicillium notatum, and Rhizopus sp.*

III. MycoFun-shield adsorbs 96-100% mycotoxin (Aflatoxin Total) into the fecal matter of Broiler chickens fed starter poultry feed contaminated with the experimental mycotoxin

IV. Operates in a fungistatic mode, by effectively restricting fungal growth and mycotoxin production in stored grains shielded with the amino acid-modified NanoClay

V. Led to increased poultry weight when fed mycotoxin contaminated feeds shielded with NanoClay, which indicates that it enhances feed efficiency.

VI. It is non-toxic, and preserved the nutritional value of the feed/grains.

Advantages over other mycotoxin inhibitors

i. Unique home-grown hybrid product.

ii. Cost-effective and environment-friendly.

iii. Broad-spectrum activity with a universal efficiency.

iv. Cost-effective production process and environmentally friendly.

v. Scalable and easy to integrate into existing feed production processes.

vi. Prolonged shelf-life of grains treated against microbial contamination, when stored with fungal mycotoxin shield added, thus meeting FDA standards for unprocessed dried foods/grains.

Traction and Milestones Achieved from the preliminary findings are:

i. Field testing under actual conditions recorded 96 to 100% (Aflatoxin Total) elimination in poultry.

ii. When added at three grams (3 g) of Fungal mycotoxin Shield per 1 Kilograms (1 Kg) of stored grains (maize/groundnut) and feeds, recorded 85-95% (Aflatoxin Total) removal. No Aflatoxin Total detected after 12 months of storage under actual storage conditions.

iii. A patent was registered in Nigeria, with the Patent Certificate Number, CRP/ 011273, on Method for Grain Preservation Using Amino Acid-Modified Nanoclay as Fungal and Mycotoxin Shield.

Technology Readiness

Our innovative product was evaluated by testing its viability in protecting grain or feeds under actual conditions against grain storage (Maize/groundnut) and its inclusion in poultry feeds. This

evaluation places our product at the Technology Readiness Level Seven (TRL7). A Patent Certificate Number, CRP/ 011273, was obtained in Nigeria in 2024.

Scalability plans for scaling-up of Amino Acid-modified Nanoclay (AANMNC) Fungal and Mycotoxin Shield

Scheme 1 below outlines a scaling-up plan for the large-scale production of Fungal and Mycotoxins Shield, based on the pilot study for commercializing the product. The scaling-up process is designed to achieve the following six-key framework listed below:

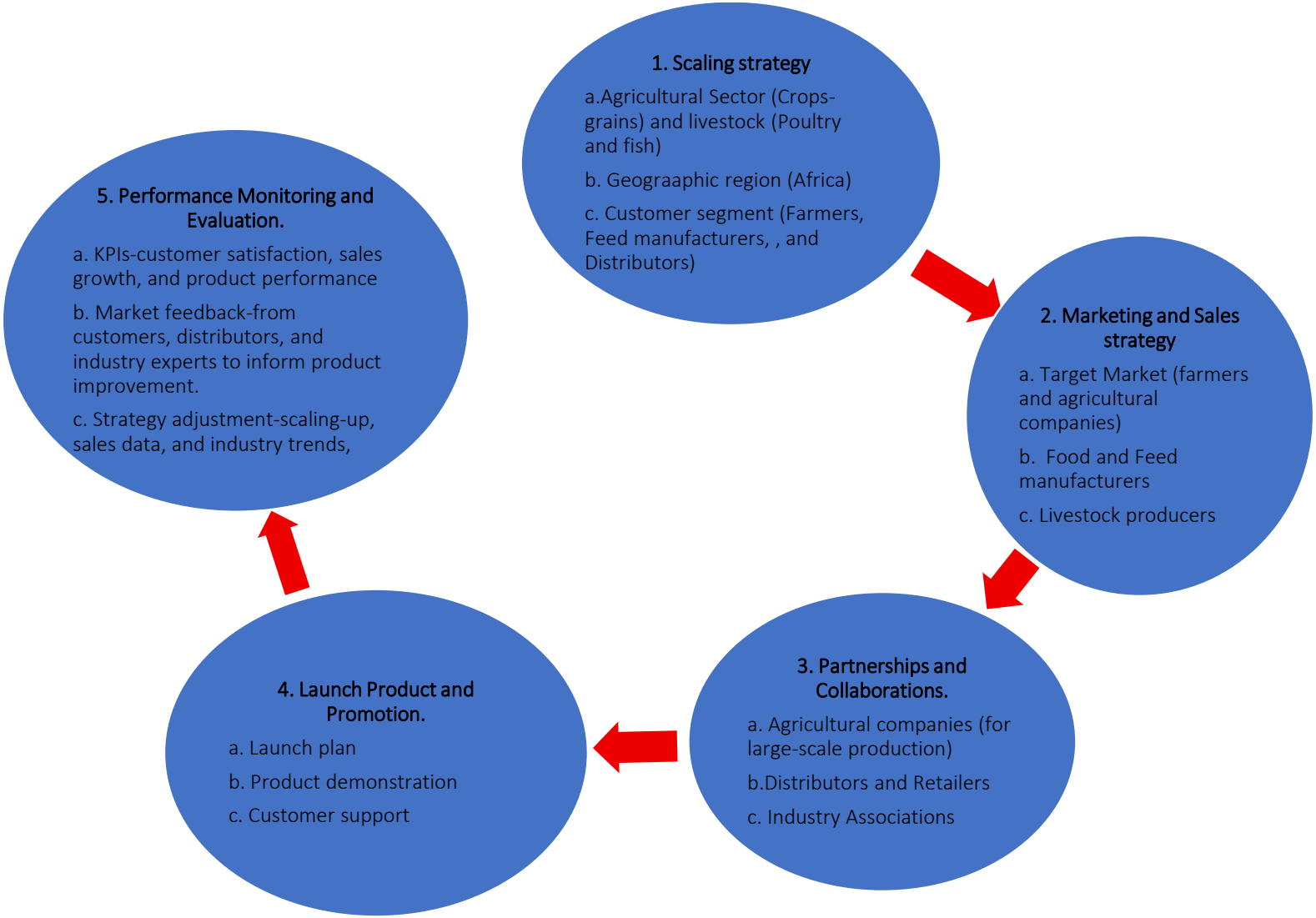
i. Scaling strategy

ii. Operational scaling

iii. Financial planning

iv. Monitoring and evaluation.

v. Expansion and growth.



Scheme 1: Scaling-up strategy for large-scale production and commercialization

References

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PATENT FORM NO. 4

CRP:011273

FEDERAL REPUBLIC OF NIGERIA

Certificate of Registration of Patent

(Patents and Designs Act; CAP 344 Laws of the Federation of Nigeria 1990)

RP: **F/PT/NC/2024/12328**
Date of Patent: **13/05/2024**
Date of Sealing: **17/05/2024**

President of the Federal Republic of Nigeria and Commander-in-chief of the Armed Forces **BOLA AHMED TINUBU, *GCFR.***

Whereas a request for the grant of a patent has been made by: **MOHAMMED ALIYU-PAIKO OF DEPARTMENT OF BIOCHEMISTRY; YAKUBU AZEH OF DEPARTMENT CHEMISTRY; MATHEW T. TSEPAV OF DEPARTMENT PHYSICS all of IBB UNIVERSITY LAPAI, NIGER STATE; SANI S. D. MOHAMMED OF DEPARTMENT BIOTECHNOLOGY, MICROBIOLOGY AND BIOLOGY, NILE UNIVERSITY ABUJA, VINCENT T. BALOGU OF DEPARTMENT MICROBIOLOGY; UTHMAN ABDULJELILI OF DEPARTMENT BIOCHEMISTRY; ALFRED GIMBA OF DEPARTMENT CHEMISTRY all of IBB UNIVERSITY LAPAI, NIGER STATE c/o Uche Obiajunwa of Innov8 Tech Hub, ACO, Airport road, Abuja**

For the sole use and advantage of an invention for: **Method for Grain Preservation Using Amino Acid-Modified Nanoclay as Fungal and Mycotoxin Shield**

AND WHEREAS the Federal Government being willing to encourage all invention which may be for public good, is pleased to accede to the request:

KNOW YE THEREFORE, that I do by this Instrument give and grant unto the person(s) above named and any successor(s), executor(s), administrator(s) and assign(s) (each and any of whom are hereinafter referred to as the patentee) by special licence, full power, sole privilege and authority, that the patentee or any agent or licensee of the patentee may subject to the conditions and provisions prescribed by any statute or order for the time being in force at all times hereafter during the term of years herein mentioned, make, use, exercise and vend the said invention throughout the Federal Republic of Nigeria, and that the patentee shall have and enjoy the whole profit and advantage from time to time accruing by reason of the said invention during the term of twenty years from the date first above written on this Instrument: AND to the end that the patentee may have and enjoy the sole use and exercise of the full benefit of the said invention, I do by this Instrument strictly command all citizens of the Federal Republic of Nigeria that they do not at any time during the continuance of the said term either directly or indirectly make use of or put in practice the said invention, nor in anywise imitate the same, without the written consent, licence or agreement of the patentee, on pain of incurring such penalties as may be justly inflicted on such offenders, and of being answerable to the patentee according to law for damages thereby occasioned:

PROVIDED ALWAYS that this patent shall be revocable on any of the grounds from time to time by law prescribed as grounds for revoking patents granted by me, and the same may be revoked and made void accordingly:

PROVIDED ALSO that nothing herein contained shall prevent the granting of licences in such manner and for such considerations as they may by law be granted

MADE this: **17TH DAY OF MAY 2024**

JANE IGWE
Registrar