

Aflatoxin Contamination of Maize (*Zea mays* L.) and Groundnut (*Arachis hypogaea* L.) and its Consequences for the Nigerian Economy: A Review

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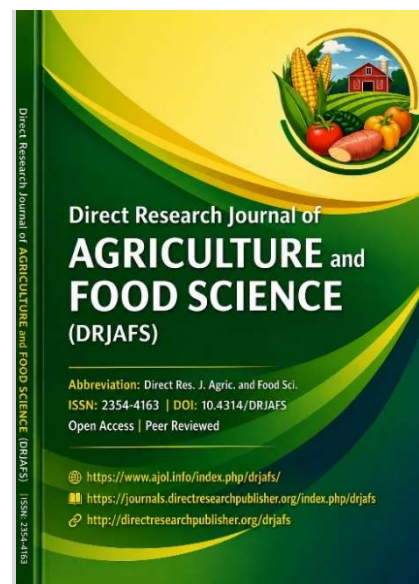
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ABSTRACT: Aflatoxin contamination of maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.) threatens food safety, livelihoods and agricultural trade in Nigeria. This review synthesises evidence on occurrence, contamination drivers, commodity movement, value-chain and health consequences, African comparisons, and prevention and control options. A targeted narrative review was undertaken using the studies and traceable publications identified for this manuscript, with emphasis on Nigerian evidence and African comparative literature published from 2017 to 2026. Evidence was organised thematically against the nine review objectives; prevalence estimates were not pooled because the included studies differed in commodity, sampling frame, analytical method and reporting threshold. Recent Nigerian studies report substantial contamination: a systematic review of 25 studies and 1,627 maize samples found marked seasonal and agroecological variation, while a 2026 survey detected total aflatoxins in 92.2% of 90 composite maize samples (mean 39.58 µg/kg). A 2025 study of maize from north-western Nigeria detected aflatoxins in 80.9% of samples, and recent Nigerian groundnut evidence also indicates substantial exposure concerns. Contamination is associated with crop stress, insect damage, delayed harvesting, inadequate drying, poor storage and weak traceability. Contaminated commodities can move through informal domestic markets and cross-border supply chains, creating costs for farmers, traders, processors and livestock producers, alongside food-security and public-health risks. Evidence from Nigeria and other African countries supports integrated control, including good agricultural practices, rapid drying, improved storage, testing, traceability and locally adapted biological control. The review concludes that coordinated value-chain prevention, affordable testing and market incentives for verified safer produce are important opportunities to reduce exposure and protect trade competitiveness.

Keywords: Aflatoxin; *Aspergillus flavus*; maize; groundnut; Nigeria; food safety; food security; public health; agricultural trade; biological control



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INTRODUCTION

Agriculture remains central to Nigeria's food system and provides income and employment for millions of households. Among the crops that contribute substantially to food and economic activities are maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.). Maize is consumed directly and is also an important raw material for poultry and livestock feed and several food-processing industries. Groundnut is used as food, oilseed, livestock feed and a raw material for numerous small- and medium-scale enterprises. The economic importance of these crops means that anything that reduces their safety, quality or marketability has consequences beyond the farm. Aflatoxins represent one such threat. They are toxic secondary metabolites produced principally by fungi in *Aspergillus* section *Flavi*. Among the major aflatoxins, aflatoxin B1 (AFB1) is of particular concern because of its potent carcinogenicity. *A. flavus* is the principal aflatoxin-producing fungus associated with maize and groundnut, although other members of the section *Flavi* may contribute to contamination, particularly in African agroecosystems (Bandyopadhyay et al., 2019; Akullo et al., 2025). Aflatoxin contamination is capable of occurring at different points in the agricultural value chain. Crop stress, drought, insect injury, high temperature and fungal infection may predispose crops to contamination before harvest, while delayed harvesting, inadequate drying, poor storage and inappropriate transportation may sustain or increase the problem after harvest (Akullo et al., 2025). In practical terms, this means that the presence of aflatoxin in a Nigerian commodity cannot always be traced to the farm alone. Recent Nigerian evidence illustrates the geographical breadth of the problem. A systematic review covering 25 studies and 1,627 maize samples from different Nigerian agroecological zones found aflatoxins among the most prevalent mycotoxins and reported substantial seasonal and geographical variation (Thierry et al., 2025). A more recent study involving samples from farms, stores and markets across Nigerian agroecological zones found total aflatoxins in 92.2% of maize samples, with markets and stores showing greater contamination than farms (Thierry et al., 2026).

These findings are important economically because agricultural commodities do not remain where they are produced. Maize and groundnut move from farms to village markets, aggregation centres, warehouses, processing facilities and urban markets. They may then cross state boundaries, national borders and, ultimately, continents through international trade. Thus, contamination originating in one location can become a problem elsewhere. The economic significance of aflatoxin contamination is therefore best understood through the entire value chain. The farmer may receive a lower price; the trader may lose a consignment; the processor may incur additional testing and sorting costs; the livestock producer may experience reduced productivity; the

consumer may face health risks; and the exporter may lose access to an international market. Aflatoxin consequently creates a chain of biological, social and economic losses.

Statement of the Problem

Nigeria has the capacity to produce substantial quantities of maize and groundnut, yet the economic benefits derived from these commodities can be reduced by aflatoxin contamination. The problem is especially concerning because contamination may occur without obvious visual signs. A grain may appear acceptable to the consumer or trader while still containing aflatoxin concentrations that exceed regulatory limits. The problem begins at the production level but can become more complex after harvest. Poor drying, inadequate storage, insect infestation and prolonged storage may provide favourable conditions for fungal growth and toxin production. Contaminated produce can then be mixed with other commodities during aggregation and transported to markets in different regions. Recent Nigerian research supports this concern. Thierry et al. (2026) reported higher mycotoxin contamination in maize from stores and markets than from farms, suggesting that post-harvest stages can become important points of contamination and exposure. The problem also has an international dimension. Agricultural commodities that fail aflatoxin standards may be rejected by importing countries. Such rejection represents more than the loss of a particular consignment. It may involve transportation costs, testing expenses, storage charges, loss of contracts and damage to the reputation of Nigerian agricultural products. Aflatoxin contamination therefore creates a paradox. Nigeria may produce a valuable agricultural commodity, but contamination can prevent part of that production from achieving its full economic value.

Justification of the Review

Aflatoxin research in Nigeria has often focused on occurrence, fungal identification, analytical detection and health effects. These areas remain important, but there is an equally important economic question: What does aflatoxin contamination cost Nigeria? The answer extends beyond the monetary value of contaminated grain. Economic losses can occur at every stage of the value chain, including production, storage, transportation, processing, livestock production, household consumption and export. Aflatoxin also connects agriculture with public health. When exposure contributes to liver cancer and other adverse outcomes, families and the wider economy bear costs through healthcare expenditure, loss of labour and premature mortality. Wenndt et al. (2023) demonstrated the public-health significance of aflatoxin exposure in Nigerian staple foods through a quantitative assessment based on 41 studies. The review is therefore

justified because Nigeria needs an integrated understanding of aflatoxin as a food-safety, agricultural, health and economic-development problem. Nigeria could also develop aflatoxin-safe commodity certification schemes. Such schemes could create an economic distinction between ordinary produce and verified low-aflatoxin produce. This would transform aflatoxin management from a regulatory burden into a potential market opportunity.

Aim of the review

The aim of this review is to examine aflatoxin contamination of maize (*Zea mays* L.) and groundnut (*Arachis hypogaea* L.) in Nigeria and assess its implications for the Nigerian economy, food security, public health and agricultural trade, including domestic and international markets.

Objectives of the review

The objectives of this review are to:

1. Examine the occurrence of aflatoxin contamination in maize and groundnut in Nigeria;
2. Identify the major factors responsible for contamination;
3. Describe the movement of contaminated commodities within Nigeria and across international borders;
4. Assess the consequences of aflatoxin contamination for farmers, traders, processors and livestock producers;
5. Examine its implications for food security and public health;
6. Assess the consequences for domestic and international agricultural trade;
7. Compare the Nigerian situation with selected African countries;
8. Review current prevention and control strategies; and
9. Identify opportunities for reducing the economic burden of aflatoxin contamination in Nigeria.

REVIEW METHODOLOGY

Review design and scope: This paper is a narrative evidence review, not a primary laboratory or field study and not a fully reproducible systematic review. It synthesises published evidence relevant to the nine stated objectives, prioritising Nigeria-specific studies on maize and groundnut and using selected African country literature for comparison.

Evidence identification and eligibility: The evidence base reported in this revision includes the traceable

studies cited in the manuscript and targeted searches of scholarly publisher and journal pages for relevant publications available through October 2026. Search concepts included aflatoxin/aflatoxins, maize/corn, groundnut/peanut, Nigeria, prevalence/occurrence, storage, market, trade, health risk, economic impact, biological control and Aflasafe. Studies were retained when they reported Nigerian or relevant African evidence on occurrence, determinants, exposure, control, regulation or trade. Reviews were used to contextualise primary studies; publication year alone was not treated as evidence of study quality.

Data extraction and synthesis: For each relevant source, the review considered country, commodity, sampling context, reported occurrence or concentration, analytical approach where available, control strategy and implications for health or trade. Findings were grouped thematically under the review objectives. Prevalence values from different studies are reported as study-specific estimates and are not directly pooled because sampling frames, locations, commodities, assays and regulatory thresholds differ.

Quality appraisal and limitations: This is a targeted narrative review and does not claim exhaustive database coverage, duplicate independent screening, protocol registration or formal risk-of-bias scoring. The manuscript's economic discussion is therefore a qualitative synthesis of documented pathways and reported trade-rejection counts, not a national cost-of-illness or cost-benefit calculation. The evidence base is stronger for maize occurrence and biological control than for nationally representative groundnut prevalence, internal commodity-flow tracing and monetised losses. These limitations are considered when interpreting the conclusions.

Aflatoxins and Aflatoxin-producing Fungi

Aflatoxins are secondary metabolites produced mainly by fungi in *Aspergillus* section *Flavi*. The principal aflatoxins of food-safety concern are AFB1, AFB2, AFG1 and AFG2. AFB1 is the most important toxicologically because of its carcinogenicity and its association with hepatocellular carcinoma. *A. flavus* is a major causal organism in maize and groundnut. However, not all strains of *A. flavus* produce aflatoxins. Some naturally occurring strains are atoxigenic, and this biological characteristic forms the basis of biological-control approaches such as Aflasafe (Bandyopadhyay et al., 2019). In West Africa, additional members of *Aspergillus* section *Flavi* may contribute to contamination. Consequently, accurate identification of local fungal populations is important when designing biological-control products. This is one reason why biological-control products are developed using locally

adapted atoxigenic strains rather than simply transferring a product developed for another ecological region.

Aflatoxin Contamination of Maize and Groundnut in Nigeria

Maize and groundnut are particularly vulnerable to aflatoxin contamination because they are widely cultivated and consumed and are frequently produced and stored under conditions that may favour fungal growth.

The recent systematic review by Thierry et al. (2025) provides important evidence of the geographical breadth of mycotoxin contamination in Nigerian maize. The review analysed 25 studies comprising 1,627 samples and reported marked variation among agroecological zones and seasons. Aflatoxin concentrations were particularly elevated during the rainy season. A 2026 study further reinforces the concern. Across seven Nigerian agroecological zones, 92.2% of 90 composite maize samples were contaminated with total aflatoxins, with a mean concentration of 39.58 µg/kg. Importantly, samples from markets and stores were more contaminated than those collected from farms (Thierry et al., 2026). A north-western Nigerian market survey detected total aflatoxins in 80.9% of 21 maize samples, with 42.8% above the Nigerian limit applied by that study; the small sample means it is a regional signal rather than a national prevalence estimate (Bashir et al., 2025). A 2025 assessment of stored maize and groundnut in Katsina reported high AFB1 exposure concerns in the sampled commodities, although its local sampling frame should not be generalised to all Nigeria (Abubakar et al., 2025). These studies reinforce the need for more representative, repeated surveillance that reports sample size, assay performance, concentration distributions and the exact regulatory benchmark used. Groundnut is similarly vulnerable. A 2025 African review reported high occurrence of aflatoxins in Nigerian groundnut, including raw and processed products, demonstrating that contamination can persist into food products derived from the crop (Akullo et al., 2025). These findings indicate that aflatoxin contamination in Nigeria is not an isolated event. It is a recurring food-chain problem affecting production areas, markets and consumers.

Factors Responsible for Aflatoxin Contamination

Aflatoxin contamination results from the interaction of fungal, environmental and human factors.

Pre-harvest factors

Drought stress, high temperature, insect damage, poor crop nutrition and other forms of plant stress can predispose maize and groundnut to infection by

aflatoxigenic fungi. Climate variability may further alter the distribution and intensity of contamination.

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Harvest-related factors

Delayed harvesting, mechanical injury and harvesting under unsuitable moisture conditions may facilitate fungal colonisation. Damaged kernels are particularly vulnerable because physical injury provides opportunities for fungal invasion.

Drying

Effective drying is one of the most important post-harvest interventions. Grain that remains wet for too long provides favourable conditions for fungal development.

Storage

Poor ventilation, high humidity, high temperature, insect infestation and prolonged storage can increase the likelihood of aflatoxin contamination. Evidence from Giwa, Kaduna State, demonstrates the relevance of storage conditions to the Nigerian situation. Abdurrazaq et al. (2025) investigated maize and groundnut during storage and highlighted aflatoxin contamination as a concern for both food safety and crop market value.

Handling and marketing

Mixing contaminated produce with apparently good-quality produce during aggregation may distribute contamination through larger consignments. Poor traceability then makes it difficult to identify the original source.

Geographical Dissemination of Aflatoxin Contamination within Nigeria

Aflatoxin does not spread from person to person like an infectious disease. What moves geographically is principally the contaminated agricultural commodity, while fungal spores and propagules may also be dispersed through agricultural environments and materials.

The Nigerian pathway can be conceptualised as:

Farm → harvesting → drying → storage → local market → aggregation → transportation → wholesale market → processing/feed industry → consumer or exporter.

This distinction is important. A farmer may produce contaminated maize in one state, but the economic and public-health consequences may appear much farther away. Maize and groundnut are transported from producing communities to larger markets and processing centres. During this movement, commodities may be mixed with produce from several farms. Consequently, a

consignment reaching a major urban market may no longer have an easily identifiable production history.

Recent evidence that Nigerian market and storage samples may have greater contamination than farm samples further emphasises the importance of monitoring post-farm stages (Thierry et al., 2026). The movement of contaminated commodities is therefore an important but often overlooked component of aflatoxin management in Nigeria.

Cross-Border and Intercontinental Dissemination

The movement of commodities does not stop at Nigerian state boundaries. Maize, groundnut and their products may enter regional African trade and, where quality requirements are satisfied, international markets. Within Africa, aflatoxin contamination has already affected cross-border trade. Kenya, for example, has experienced serious aflatoxin problems involving maize and has implemented regulatory and surveillance responses to protect consumers and agricultural markets (Omara et al., 2021). At the international level, contaminated commodities can be transported by road to ports and subsequently shipped to foreign markets. If testing at the destination reveals aflatoxin concentrations above the importing country's regulatory limits, the consignment may be rejected. This is economically important for Nigeria because rejection occurs after resources have already been invested in production, transportation, aggregation, storage and export preparation.

Economic Importance of Maize and Groundnut to Nigeria

The economic importance of maize and groundnut extends across multiple sectors. Maize provides food for households and raw material for livestock-feed and food-processing industries. Groundnut contributes to household nutrition, oil production, snacks, and livestock feed and agro-processing. The value of these crops is therefore not limited to their farm-gate price. Each tonne of maize or groundnut can support several economic activities before reaching the consumer.

When contamination occurs, the loss can consequently be multiplied across the value chain.

Direct Economic Consequences of Aflatoxin Contamination

The most immediate economic effect of aflatoxin contamination is loss of commodity value. A farmer may harvest a good quantity of maize but receive a poor price because the grain fails a buyer's quality requirements. A trader may discover that a consignment cannot be sold to a processor. A processor may incur additional costs for testing and sorting. An exporter may lose an entire

shipment. These losses are particularly serious because the cost is often incurred after money has already been
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spent on production and transportation. Aflatoxin contamination therefore changes the economics of a commodity from a potentially profitable product into a liability.

Effects on Farmer Income and Rural Livelihoods

Smallholder farmers are particularly vulnerable because they may have limited access to drying equipment, improved storage, testing facilities and effective control technologies. A reduction in the market value of contaminated maize or groundnut directly affects household income. This may reduce the ability of farmers to purchase improved seeds, fertilizer and other inputs for subsequent production cycles. There is also an important behavioural dimension. If farmers do not receive better prices for safer produce, they may have little economic incentive to invest in aflatoxin-control technologies. Evidence from northern Nigeria suggests that farmers can be willing to pay for biological-control technologies when they understand their benefits and when market incentives exist. Ayedun et al. (2017), studying 492 maize and groundnut farmers in Kano and Kaduna states, found that experience with Aflasafe, access to extension services and access to credit influenced willingness to pay. This finding is important because it suggests that aflatoxin control should be linked to market rewards, not only to regulation.

Effects on Food Processing Industries

Aflatoxin contamination creates additional costs for food processors. Processors may need to test raw materials before purchase or processing. Where contaminated grain is detected, additional sorting, cleaning or rejection may be necessary. The economic loss becomes even greater when contamination is discovered after processing has begun. At that point, the producer has already invested in transportation, labour, electricity, packaging and other processing activities. A strong food-safety system should therefore identify contamination as early as possible, preferably before value is added to the commodity.

Effects on Livestock and Poultry Production

The economic consequences of aflatoxin contamination extend to animal agriculture because maize and groundnut products are important feed ingredients. Animals consuming contaminated feed may experience reduced growth, poor feed utilisation, impaired immunity, disease susceptibility and, at high exposure levels, mortality. These outcomes increase production costs and reduce the profitability of livestock enterprises. The problem can subsequently move back into the human food chain

through reduced availability and higher prices of animal products. Thus, aflatoxin control in maize and groundnut is

also indirectly an investment in Nigeria's poultry, livestock and feed industries.

Public-Health Consequences and Economic Costs

The health consequences of aflatoxin exposure provide another major pathway to economic loss. Aflatoxin B1 is a potent carcinogen and chronic exposure is associated particularly with hepatocellular carcinoma. Aflatoxin exposure can also contribute to impaired growth and other adverse health outcomes. Wenndt et al. (2023) reviewed 41 Nigerian studies and estimated that aflatoxin exposure through maize was associated with approximately 1.77 hepatocellular carcinoma cases per 100,000 people per year, while exposure through groundnut was associated with approximately 0.44 cases per 100,000 people per year. These estimates should not be interpreted as a complete estimate of Nigeria's total aflatoxin disease burden. Nevertheless, they demonstrate that the health consequences are large enough to warrant economic attention. The economic burden of disease includes healthcare expenditure, loss of productive working time, caregiving costs and premature mortality. For agricultural households, illness may also reduce the availability of labour during critical periods of the farming season. Consequently, preventing aflatoxin exposure can produce economic benefits even when those benefits are not immediately visible in agricultural statistics.

Aflatoxin and Food Security

Food security is not simply a question of how much food is produced. Food must also be safe. Aflatoxin contamination can make an otherwise available commodity unsuitable for human or animal consumption. This creates a qualitative form of food insecurity: the food exists, but it may not be safe enough to consume. For households with limited resources, the problem is particularly difficult. Families may face a choice between discarding contaminated food and consuming it because safer alternatives are more expensive or unavailable. A national food-security strategy must therefore include food-safety measures, particularly for widely consumed staples such as maize and groundnut.

Impact on Domestic Trade

Nigeria has an extensive network of informal and formal food markets. These markets connect rural production areas with urban consumers. Traditional markets are particularly important because many households depend on them for food. However, these markets may have limited access to laboratory testing and traceability systems. Wenndt et al. (2023) emphasised the importance of traditional food markets in the Nigerian food system and

identified production, storage and transportation as important points for aflatoxin management. Strengthening
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surveillance at these points would therefore provide an important opportunity to prevent contaminated commodities from circulating widely.

Impact on International Trade

International trade is one of the clearest economic pathways through which aflatoxin affects national development. Export markets increasingly demand compliance with food-safety standards. A commodity that fails an aflatoxin limit may be rejected even when it is otherwise of good physical quality. Evidence reviewed by Chilaka et al. (2022) indicates that between 2005 and 2020, 579 consignments of African agricultural products were rejected by the European Union because of mycotoxin contamination. Nigeria accounted for 67 of those rejected consignments. Groundnut and groundnut products constituted the largest share of the affected products. Such rejections have direct financial consequences and can also undermine confidence in the exporting country's commodities. For Nigeria, improved aflatoxin control could therefore contribute to agricultural export diversification and reduce dependence on crude-oil earnings.

Aflatoxin Contamination in Some African Countries

Aflatoxin contamination is a continental problem, although its intensity varies among countries and ecological zones. Kenya provides one of the clearest examples of the consequences of aflatoxin contamination. Omara et al. (2021) documented widespread contamination of maize, groundnut and other food and feed commodities and reviewed major aflatoxicosis episodes. Their review also highlighted poor grain handling, inadequate storage, transportation practices, limited awareness and weak regulatory implementation as important contributors. The Kenyan experience demonstrates that aflatoxin can become both a public-health emergency and a trade problem. Uganda has also documented widespread aflatoxin contamination in maize, groundnut and other agricultural commodities. Omara et al. (2020) identified poor pre-, peri- and post-harvest practices, inadequate awareness and regulatory limitations as important contributors. The Ugandan experience reinforces the importance of addressing contamination throughout the value chain. Senegal and The Gambia demonstrate the potential of regional biological control. Senghor et al. (2021) reported the approval of Aflasafe SN01 as a biocontrol product for aflatoxin mitigation in both countries. The product uses native atoxigenic *A. flavus* strains to competitively reduce contamination. Recent evidence from Burkina Faso, Mali, Niger and Togo is particularly encouraging. Bonkougou et al. (2024) reported significantly lower aflatoxin levels in treated crops than in

untreated crops across the four countries, with most treated crops meeting the 4 ppb total-aflatoxin threshold

used in their study. The authors concluded that regional biological control could generate important health and economic benefits. Broader African syntheses similarly identify aflatoxin contamination as a persistent food- and feed-safety challenge and emphasise uneven surveillance and regulatory capacity (Imade et al., 2021; Meijer et al., 2021). These experiences provide useful lessons for Nigeria: the scale of the problem may be large, but practical and economically relevant interventions are possible.

International Perspective

Aflatoxin contamination is a global food-safety issue because maize, groundnut and their products are traded internationally. Countries with strict food-safety regulations may reject commodities that exceed their aflatoxin limits. Although such standards protect consumers, they can create economic challenges for exporting countries that lack adequate testing, storage and contamination-control systems. Akullo et al. (2025) showed that regulatory limits vary among countries and that these differences have implications for both domestic and international trade. For Nigeria, compliance with international standards should therefore be regarded not merely as a regulatory requirement but as a pathway to improving the competitiveness and reputation of Nigerian agricultural products.

Biological Control and Aflasafe in Nigeria

Biological control using atoxigenic *A. flavus* strains is among the most promising approaches to aflatoxin management in Nigeria. The principle is relatively straightforward: naturally occurring atoxigenic strains are introduced into the crop environment where they compete with aflatoxin-producing strains. Because the beneficial strains occupy the ecological niche that would otherwise be available to toxigenic strains, aflatoxin production can be substantially reduced. Nigeria has unusually strong evidence supporting this approach. Bandyopadhyay et al. (2019) reported results from a large-scale, multi-year evaluation of Aflasafe. More than 213,000 tonnes of maize harvested from treated fields were assessed; more than 95% contained less than 20 ppb total aflatoxin and more than 90% contained less than 4 ppb. Treated grain generally had more than 80% less aflatoxin than grain from untreated fields. The significance of this finding extends beyond microbiology. Safer maize can access markets that demand aflatoxin compliance. Therefore, biological control can potentially convert a food-safety intervention into an income-generating intervention.

Economic Acceptability of Aflatoxin Control

The success of any control programme depends partly on whether farmers can and will adopt it. Ayedun et al. (2017) *Direct Res. J. Agric. Food Sci.* 89

demonstrated that many maize and groundnut farmers in Kano and Kaduna were willing to pay for Aflasafe, particularly those who had previously experienced the technology. Extension contacts and access to credit were important determinants of willingness to pay. This finding has an important policy implication. Farmers should not simply be told to control aflatoxin. They should be shown how controlling it can improve the value and marketability of their produce. A premium market for certified aflatoxin-safe maize and groundnut could therefore provide a practical economic incentive for adoption.

Current Control Strategies

Effective aflatoxin management requires several interventions operating together.

These include:

- good agricultural practices;
- use of adapted and improved crop varieties;
- reduction of drought and insect stress;
- timely harvesting;
- rapid and effective drying;
- improved storage facilities;
- insect control;
- sorting of damaged grains;
- regular aflatoxin testing;
- biological control;
- improved market surveillance;
- food-safety regulation;
- farmer education;
- traceability; and
- strengthened laboratory capacity.

The key principle is that control should begin before contamination becomes established and continue through the entire value chain.

Challenges to Aflatoxin Management in Nigeria

Several factors continue to limit effective control. First, many farmers and traders have limited awareness of the economic consequences of aflatoxin. Secondly, laboratory testing is not readily accessible in many rural areas. Thirdly, inadequate drying and storage infrastructure can undermine good agricultural practices. Another difficulty is the informal nature of much agricultural trade. Produce may change hands several times without adequate documentation. This makes traceability difficult and can allow contaminated commodities to move long distances before detection. Weak enforcement and differences between domestic and export-oriented standards can also create inconsistencies in food-safety management. Finally,

farmers may be reluctant to invest in control technologies unless they can see a financial return.

Recommendations

Strengthen farm-level prevention

Farmers should receive practical training in timely harvesting, drying, sorting, storage and pest management.

Expand biological control

Aflasafe and other locally adapted biological-control products should be expanded in major maize- and groundnut-producing regions.

Establish testing points along the value chain

Affordable rapid-testing facilities should be made available at major aggregation centres, warehouses, processing facilities and markets.

Improve storage infrastructure

Investment in appropriate drying facilities, improved warehouses and hermetic storage should be prioritised.

Develop traceability

Nigeria should strengthen systems that enable contaminated commodities to be traced back to their production and storage points.

Introduce market incentives

Farmers who produce aflatoxin-safe commodities should receive price premiums where possible.

Strengthen export certification

Export commodities should be tested and certified before shipment to reduce border rejection and protect Nigeria's agricultural reputation.

Improve public awareness

Aflatoxin education should target farmers, traders, processors, livestock producers, consumers and policymakers.

Strengthen regional collaboration

Nigeria should work with other African countries on harmonised standards, surveillance, research and biological-control technologies.

Integrate agriculture and health policies

Aflatoxin management should be incorporated into national programmes addressing food security, cancer prevention, agricultural development and public health.

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Synthesis of Evidence against the Review Objectives

Occurrence in Nigeria (Objectives 1 and 5): Evidence consistently identifies maize and groundnut as important exposure vehicles, but prevalence estimates vary by geography, season, sample type and assay. The 2025 systematic review of Nigerian maize and the 2025–2026 regional studies should be read as complementary, not interchangeable, evidence.

Drivers and commodity movement (Objectives 2 and 3): Pre-harvest drought and heat stress, insect damage, delayed harvest, slow drying, humid storage, insects and mixing of lots can contribute to contamination or make it harder to identify affected sources. Commodity transport does not itself create aflatoxin; it can distribute contaminated lots and obscure traceability. Direct Nigerian tracing studies are limited in the sources reviewed.

Stakeholder, food-security and health consequences (Objectives 4 and 5): The likely burden is distributed across reduced farm-gate value, rejected lots, testing and sorting costs, feed-related productivity losses and exposure-related disease. Wenndt et al. (2023) provide a modelled health-risk estimate, not a count of observed cases attributable to a specific shipment or a complete national burden estimate.

Domestic and international trade (Objective 6): Domestic markets are important routes of exposure where testing and traceability are limited. The cited EU rejection analysis reports 67 Nigerian consignments among 579 African consignments rejected for mycotoxin contamination over 2005–2020; these are historical rejection counts, not a current annual rejection rate or a direct estimate of financial loss.

African comparison and control (Objectives 7 and 8): Kenya and Uganda illustrate persistent contamination and surveillance challenges; Senegal and The Gambia, and studies in Burkina Faso, Mali, Niger and Togo, provide examples of locally adapted biological control. Differences in crops, climate, regulations and programme scale mean that intervention outcomes should not be transferred to Nigeria without local evaluation.

Economic opportunities and unresolved gap (Objective 9): The clearest opportunities are preventing contamination before harvest, drying and storing safely, testing at aggregation and processing points, using locally adapted biocontrol, tracing lots and rewarding verified safer produce. A major unresolved evidence gap is a

transparent Nigerian cost estimate covering farmer losses, market rejection, health costs, animal productivity and control expenditure.

Table 1: Comparison of selected Nigerian and African evidence published in 2024–2026. Figures are study-specific and should not be interpreted as directly comparable pooled estimates.

Study / setting	Commodity and sample context	Reported result	What it adds to this review	Caution in comparison
Thierry et al. (2025), Nigeria	Systematic review; 25 studies, 1,627 maize samples	Aflatoxins among prevalent mycotoxins; strong seasonal and agroecological variation; rainy-season contamination higher.	National breadth and seasonal pattern.	Secondary synthesis; individual studies use differing assays and sample frames.
Thierry et al. (2026), Nigeria	90 composite maize samples across farms, stores and markets	Total aflatoxins detected in 92.2%; mean 39.58 µg/kg; market/store samples more contaminated than farm samples.	Highlights post-harvest monitoring and exposure risk.	Composite sample design; not equivalent to a nationally representative household or market survey.
Bashir et al. (2025), north-west Nigeria	21 market maize samples from seven states	Aflatoxins detected in 80.9%; 42.8% exceeded the Nigerian limit used by the authors.	Regional evidence on market maize and toxigenic fungi.	Small sample size; not a national prevalence estimate.
Abubakar et al. (2025), Katsina, Nigeria	Stored maize and groundnut samples across three senatorial zones	The authors reported high AFB1 contamination/exposure concerns in sampled commodities.	Adds recent local evidence covering both focal commodities.	Local storage samples; threshold statements should be checked against current official standards.
Akullo et al. (2025), Africa review	Review of maize and groundnut products in multiple African countries	Reports high occurrence in Nigerian groundnut products and compares regulatory limits.	Supports the groundnut and regulatory/trade strands.	Secondary review; estimates vary across source studies.
Bonkougou et al. (2024), Burkina Faso, Mali, Niger and Togo	Field evaluation of commercial biocontrol on maize, groundnut and sorghum	Treated crops had lower aflatoxin levels; many treated crops met the study's 4 ppb benchmark.	Comparative evidence for biological control in African farming systems.	Do not assume identical efficacy or economics in all Nigerian agroecological zones.

CONCLUSION

Aflatoxin contamination of maize and groundnut is more than a microbiological or food-safety problem. In Nigeria, it is a value-chain problem with agricultural, economic, health and trade dimensions. The evidence shows that contamination can occur before harvest and continue through drying, storage, transportation, processing and marketing. The contaminated commodity may move from one Nigerian region to another and may eventually cross international borders. In this sense, aflatoxin contamination can travel with agricultural trade, while its economic consequences can spread across the entire value chain. Recent Nigerian evidence demonstrates that the problem remains substantial. Studies across different agroecological zones have documented significant contamination, while recent market and storage findings suggest that post-harvest stages deserve much greater attention (Thierry et al., 2025, 2026). The consequences are equally broad. Farmers can lose income; traders and

processors can lose market value; livestock producers can experience reduced productivity; households can face health costs; and exporters can lose access to

international markets. Yet the situation is not without solutions. Nigeria has strong evidence that biological control can substantially reduce aflatoxin contamination. The large-scale Aflasafe experience demonstrates that safer maize and groundnut can be produced under real farming conditions and that aflatoxin compliance can create access to better markets (Bandyopadhyay et al., 2019). The economic case for control is therefore compelling. Nigeria should not regard aflatoxin management merely as another cost imposed on farmers and food businesses. Rather, it should be regarded as an investment in protecting agricultural value, improving farmer income, reducing avoidable health expenditure, strengthening livestock production, protecting food security and expanding Nigeria's agricultural export

potential. Ultimately, the goal should be to develop a Nigerian maize and groundnut value chain in which safe food commands value, quality is rewarded, contamination is detected early, and agricultural products can move confidently from Nigerian farms to Nigerian households and international markets.

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