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## Aflatoxin Contamination in Grains Sold at Selected Markets, Kaduna, Nigeria

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### Abstract

Grains marketed under open and poorly controlled storage conditions are highly susceptible to fungal colonization and subsequent aflatoxin contamination, with significant implications for food safety, public health, and economic valuation. This study quantitatively assessed aflatoxin contamination and associated mycobiota in three staple cereals—maize, millet, and sorghum—sourced from Kawo and Kasuwar Bacci markets in Kaduna between April and July 2025. Representative samples (300 g per grain type) were randomly procured from multiple vendors, aseptically packaged in sterile paper envelopes, and transported for laboratory analysis at the National Agency for Food and Drug Administration and Control (NAFDAC) facility. Quantification of total aflatoxins was conducted using a validated enzyme-linked immunosorbent assay (ELISA) protocol, while fungal isolation and enumeration were performed via standard culture-based techniques following surface sterilization. Microbiological analysis revealed that millet samples from Kawo market exhibited the highest fungal burden ( $3.0 \times 10^5$  cfu/g), followed by sorghum ( $2.0 \times 10^5$  cfu/g) and maize ( $1.2 \times 10^5$  cfu/g). Similarly, at Kasuwar Bacci, millet recorded the highest load ( $1.7 \times 10^5$  cfu/g), with maize ( $1.4 \times 10^5$  cfu/g) and sorghum ( $1.2 \times 10^5$  cfu/g) showing comparatively lower counts. Identified fungal taxa included *Aspergillus flavus*, *Aspergillus niger*, *Penicillium* spp., and *Mucor* spp., all of which are known for their toxigenic potential under favorable conditions. Total aflatoxin concentrations ranged from 2.418 to 2.676  $\mu\text{g}/\text{kg}$ , with the maximum value observed in maize samples from Kasuwar Bacci market. Despite detectable fungal contamination, the relatively low aflatoxin levels indicate compliance with established permissible limits, suggesting that the grains remain within acceptable safety thresholds for human consumption.

### Keywords

Grains,  
Aflatoxins,  
ELISA,  
NAFDAC,  
Markets,  
Kaduna

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## 1.0 INTRODUCTION

Aflatoxin contamination of cereal crops represents a major global food safety concern, contributing to reduced grain quality and adverse health effects (Umereweneza et al., 2018). In Nigeria, staple cereals such as maize, millet, and sorghum form a significant part of daily diets, especially in northern regions where they are processed into foods like tuwo, kunu, and pap (Adebayo et al, 2018). Beyond household consumption, these grains serve as essential raw materials for agro-processing industries (Beukes et al. 2017).

However, these crops are prone to AFs contamination by toxigenic fungi, particularly species of *Aspergillus*, *Fusarium*, and *Penicillium* during cultivation, post-harvest, and storage during pre-harvest, storage, and distribution stages leading to reduction in quality and market value (Ezekiel et al, 2012). It is estimated that approximately 25% of global food crops are affected by mycotoxins, resulting in substantial post-harvest losses ((Anfossi et al., 2016; FAO, 2020).

Aflatoxins, especially AFB<sub>1</sub> and AFB<sub>2</sub>, are highly toxic and classified as Group 1 carcinogens, which causes hepatotoxicity, liver cancer, and oxidative stress (IARC, 2012; Wu, 2014). Furthermore, the occurrence, levels and

pattern of attacks in grains varies across regions due to environmental and storage factors (Pittet 2019). Hence, this study aimed to assess aflatoxin contamination in grains sold at selected markets in Kaduna, Nigeria.

## 2.0 MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out in Kawo and Kasuwar Bacci markets within Kaduna metropolis. Kaduna State lies between latitudes 9°03'N and 11°32'N and longitudes 6°05'E and 8°38'E, with an estimated population of about 8.9 million (NPC,2006). The area experiences a tropical climate characterized by a rainy season (March - October) and a dry season (November-March), with annual rainfall ranging from 1,200 to 1,500 mm and temperatures between 25°C and 35°C. Agriculture and trade dominate economic activities, with cereals widely cultivated and marketed. There is a limited study on aflatoxin contamination in grains sold in Kaduna metropolis, hence the need for this research. Figure 1. Shows Map of study area.

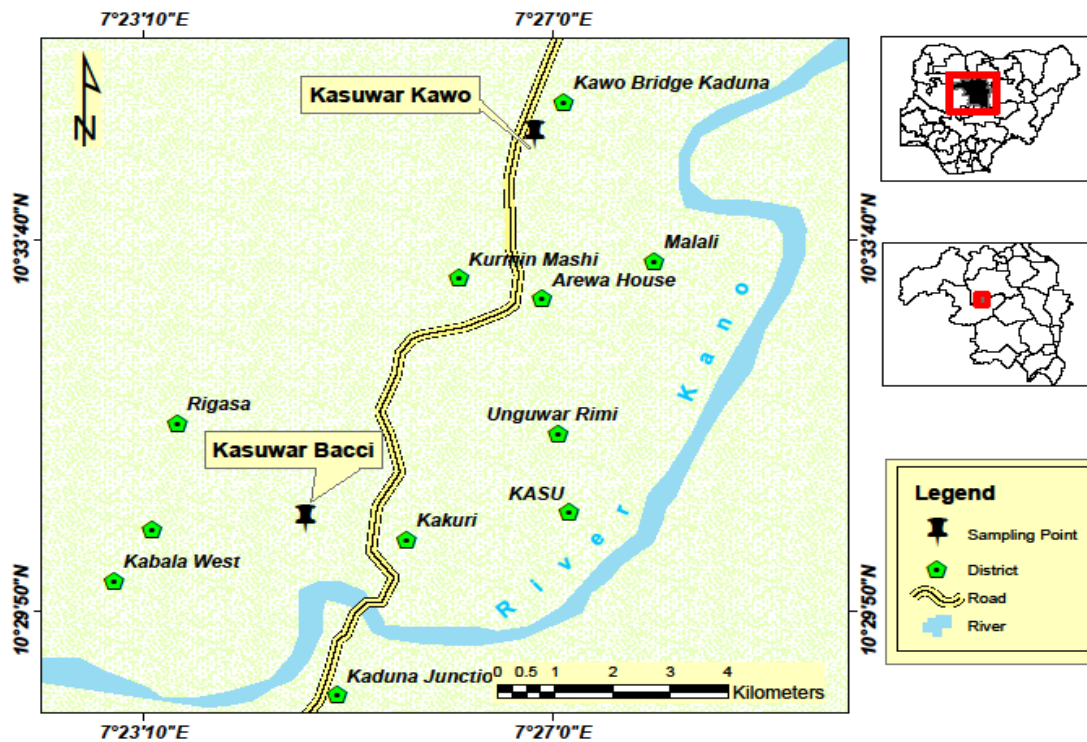


Figure 1. Map of the study area.

## 2.2 Sample Collection and Preparation

Maize, millet, and sorghum samples were randomly collected from vendors at each market. The samples were brought to NAFDAC laboratory in separate labeled paper envelopes for analysis. 200 g of each sample was cleaned, ground into powder with laboratory blender, and stored in sterile, labeled airtight Ziploc bags at room temperature until analysis.

## 2.3 Determination of Aflatoxin Levels

Aflatoxin analysis was performed using ELISA following standard protocols (Maggira et al., 2022). 2 g of each sample was extracted with 70% methanol, agitated using an orbital shaker at 120rpm for 10minutes, and filtered. 100ul of the sample was diluted into 600ul of

distilled water, and 50ul of the standard along with conjugate and antibody was added to each wells and swirled gently using aflatoxin kits. The sample was incubated at 28°C for 30 minutes and the liquid portion was decanted from the wells by taping the micro wells holder upside down three times. All the wells were filled with 250ul wash buffer, and decanted three times. 100ul of substrate was added to each well and mixed gently, then incubated for a period of 15minutes at 28°C. After incubation, washing, and substrate reaction, absorbance was measured using an ELISA reader (FAO/WHO, 2020).

### 3. DATA ANALYSIS

Data were analyzed using descriptive statistics and one-way ANOVA in MS Excel (version 23.0). Chi-square ( $\chi^2$ ) test was applied to determine the relationship between aflatoxin levels and sampling locations at a 0.05 significance level.

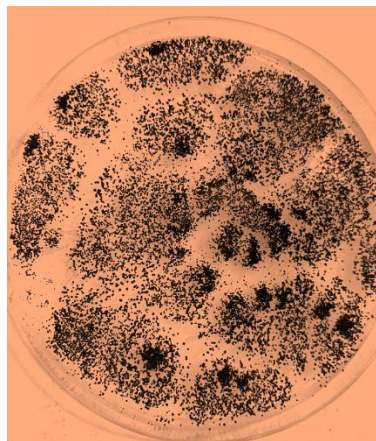
### 4.0 RESULTS

Table 1 shows the fungal species isolated from the sampled grains and their corresponding loads analysis. The results indicate millet sold at Kawo market has the highest fungal loads

( $3.0 \times 10^5$  cfu/g), followed by sorghum ( $2.0 \times 10^5$  cfu/g), and while maize had low fungal loads ( $1.2 \times 10^5$  cfu/g). At Kasuwar Bacci, the fungal loads were higher in Millet ( $1.7 \times 10^5$  cfu/g) followed by maize ( $1.4 \times 10^5$  cfu/g), with sorghum having the lowest ( $1.2 \times 10^5$  cfu/g). There was a positive correlation ( $r= 0.67$ ,  $p < 0.05$ ) between fungal load and aflatoxine concentration. Representatives of microscopic identification of fungi associated with grains sold at Kawo and Kasuwar Bacci are shown in plates I-III.

**Table 1: Fungal Species in Grains Sold at Kawo and Kasuwan Bacci (April-July, 2025)**

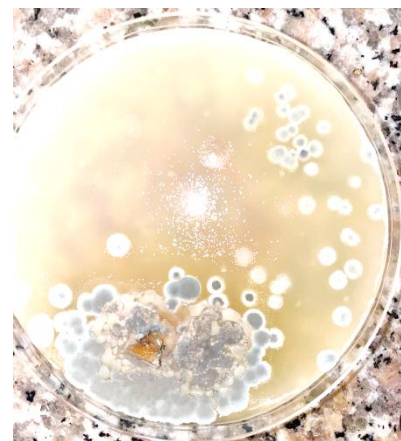
Market	Grain	Fungal species	Fungal load (cfu/g)
Kawo	Maize	<i>Aspergillus niger</i> , <i>A. flavus</i>	$1.2 \times 10^5$
	Millet	<i>Mucor sp</i>	$3.0 \times 10^5$
	Sorghum	<i>Penicillium sp</i> , <i>A. niger sp</i> <i>A. niger</i> , <i>Mucor sp.</i>	$2.0 \times 10^5$
Kasuwar Bacci	Maize	<i>Mucor</i> , <i>Penicillium sp</i>	$1.4 \times 10^5$
	Millet	<i>Aspergillus flavus sp</i>	$1.7 \times 10^5$
	Sorghum	<i>Aspergillus. niger</i> , <i>Mucor sp</i>	$1.2 \times 10^5$



**Plate I:** *A. niger*



**Plate II:** *A. flavus*



**Plate III:** *Penicilliu*

Table 2 shows the levels of total aflatoxins contamination in grains during storage at Kawo and Kasuwar Bacci Markets. The results indicate that maize sold at Kasuwar Bacci had the highest aflatoxin level (2.676  $\mu\text{g}/\text{kg}$ , while the lowest occurred in sorghum (2.418  $\mu\text{g}/\text{kg}$ ).

At Kawo market, maize recorded the highest aflatoxin level of 2.676  $\mu\text{g}/\text{kg}$  followed by millet (2.449  $\mu\text{g}/\text{kg}$ ) and lowest detected in sorghum (2.418  $\mu\text{g}/\text{kg}$ ).

**Table 2: Aflatoxin Levels in Grains Sold at Kawo and Kasuwar Bacci (April–July, 2025)**

Market	Grains	Total aflatoxin Conc ( $\mu\text{g}/\text{kg}$ )	Regulatory limit ( $\mu\text{g}/\text{kg}$ ) (WHO)
Kawo	Maize	2.502	10
	Millet	2.502	10
	Sorghum	2.464	10
Kasuwar Bacci	Maize	2.676	10
	Millet	2.449	10
	Sorghum	2.418	10

Figure 2 shows the frequency of grains storage and handling practices in Kawo and Kasuwar Bacci. The results indicate that 76.67% of grain vendors stores their grains in covered conditions at Kawo market, while 23.33% were found to store in an open container exposing the grains to sunlight. Similarly, in Kasuwar

Bacci, 78.33% of traders keep their grains covered, and use pesticides while 21.66% practice the later. Survey indicated that most vendors stored grains under covered conditions (over 75%), although a few still used open storage systems, increasing exposure to contamination risks.

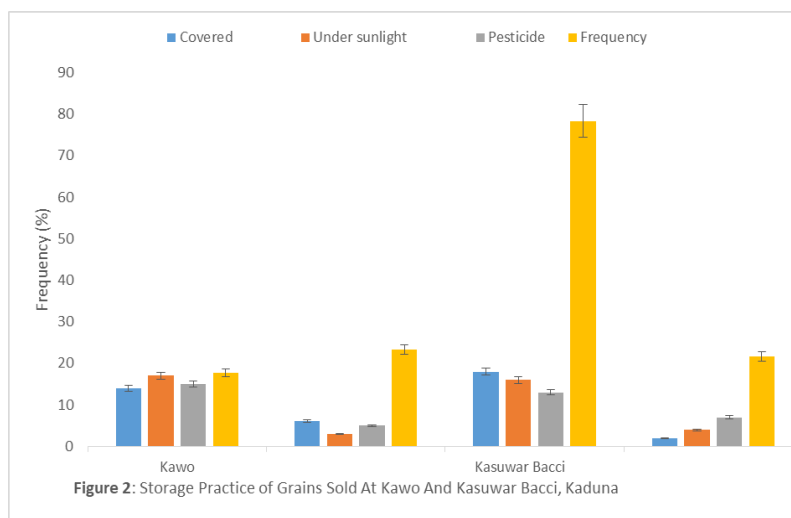


Figure 2: Storage Practice of Grains Sold At Kawo And Kasuwar Bacci, Kaduna

## 5. DISCUSSION

Aflatoxins, a class of toxic secondary metabolites biosynthesized predominantly by filamentous fungi of the genus *Aspergillus*—notably *A. flavus* and *A. parasiticus*—remain a major food safety concern, particularly in developing countries where post-harvest handling and storage infrastructure are often suboptimal. In the present study, aflatoxin B<sub>1</sub> (AFB<sub>1</sub>) and aflatoxin B<sub>2</sub> (AFB<sub>2</sub>) were consistently detected across the analyzed grain samples (maize, millet, and sorghum), albeit at concentrations below the maximum permissible limits of 10 µg/kg established by both the World Health Organization (WHO) and the National Agency for Food and Drug Administration and Control (NAFDAC). This indicates a relatively low acute risk; however, the presence of detectable aflatoxins underscores ongoing exposure pathways within the food system.

Comparatively, a related investigation conducted in Idah between 2020 and 2021 reported higher contamination prevalence, with sorghum exhibiting 35% aflatoxin

occurrence, followed by maize (31%) and millet (26%). Similarly, Adekoya et al. (2018b) documented a low incidence of aflatoxins but elevated fumonisin (FB) concentrations in locally processed maize products (ogi and mahewu) in South Africa, highlighting regional variability in mycotoxin profiles. Furthermore, multi-aflatoxin surveillance of commercial maize by the Southern African Grain Laboratory (SAGL) from 2011 to 2016/2017 cropping seasons, employing a factorial analytical design, revealed the presence of one or more aflatoxin analogues in a significant proportion of samples, reinforcing the persistence of contamination across diverse agro-ecological zones.

The relatively elevated fungal loads and corresponding aflatoxin levels observed in grains from Kawo and Kasuwar Bacci markets may be attributed to a combination of pre-harvest climatic conditions—such as elevated temperature and humidity—and post-harvest factors, including inadequate drying, poor aeration, and prolonged storage. Notably, the higher fungal counts recorded in Kawo relative

to Kasuwar Bacci suggest differential handling practices, possibly involving greater exposure to moisture ingress, mechanical damage, and unhygienic storage environments that favor fungal proliferation and mycotoxin biosynthesis.

Although the aflatoxin concentrations measured in this study fall within acceptable regulatory thresholds, chronic dietary exposure—even at sub-threshold levels—has been associated with cumulative toxicological effects, including hepatotoxicity, immunosuppression, and increased risk of hepatocellular carcinoma, particularly among vulnerable populations such as children and immunocompromised individuals. Consequently, the findings underscore the necessity for integrated mycotoxin management strategies, including improved post-harvest handling, adoption of hermetic storage technologies, routine surveillance using sensitive analytical methods, and early detection systems. These interventions are critical for mitigating contamination risks and safeguarding public health (Ortega-Beltran et al., 2018; Yang et al., 2018).

## CONCLUSION

This study indicated the presence of aflatoxins in maize, millet, and sorghum sold in selected Kaduna markets, although concentrations were within regulatory safety limits. Therefore, continuous monitoring and improved grain handling practices are necessary to sustain food safety standards. Regulatory bodies such as NAFDAC and the Standards Organization of Nigeria should strengthen surveillance systems to ensure the quality and safety of marketed grains.

## ACKNOWLEDGEMENTS

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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