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ASSESSMENT OF FUNGAL DISEASES OF STORED MAIZE (*Zea mays L.*) IN SOME WAREHOUSES IN LOKOJA, KOGI STATE

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ABSTRACT

Maize (Zea mays) is a vital cereal crop for food security in Nigeria, yet postharvest losses due to fungal contamination during storage remain a significant challenge. This study assessed fungal pathogens affecting stored maize in warehouses across three locations (Mami, Lokongoma, and Kpatar) in Lokoja Kogi State Nigeria. Infected maize samples were collected, and fungi were isolated using Potato Dextrose Agar media, followed by morphological identification via microscopy. Four fungal species were identified: Aspergillus fumigatus, Fusarium oxysporium, Mucor hiemalis and Candida albicans. Frequency analysis revealed Aspergillus spp. as the most prevalent (37.87%), followed by Candida sp. and Mucor spp (25.25% each), with Fusarium spp being the least frequent (12.6%). The high prevalence of Aspergillus spp. aligns with studies from similar agro-ecological zones, though discrepancies in species distribution compared to other regions highlight the influence of local environmental factors such as humidity, temperature and storage practices. Mycotoxin-producing fungi, particularly Aspergillus and Fusarium, pose significant health risks, including carcinogenic effects, emphasizing the urgency of addressing contamination. The study underscores suboptimal storage conditions such as inadequate drying, poor ventilation, and lack of pest control as key drivers of fungal proliferation. Recommendations include adopting improved preservation techniques, such as hermetic storage, regular mycotoxin monitoring, and enhancing warehouse infrastructure to regulate temperature and humidity farmer's education on postharvest management is critical to mitigating economic losses and safeguarding public health. This research provides actionable insights for reducing fungal contamination in maize storage systems, contributing to food safety and sustainability in Nigeria and similar tropical regions.

Keywords: Storage, Fungal, Pathogens, Mycotoxin, Post-harvest

INTRODUCTION

Maize (*Zea mays*) is a staple crop critical to global food security, providing dietary energy for millions and serving as a key raw material for livestock feed and industrial products (FAO, 2023). Postharvest losses due to fungal contamination during storage threaten food safety, economic stability, and public health, particularly in tropical regions with suboptimal storage infrastructure (Eskola *et al.*, 2021). Fungal pathogens, including *Aspergillus*, *Fusarium*, and *Penicillium* species, dominate postharvest deterioration in maize, driven by high humidity (>70%), temperatures above 25°C, and inadequate aeration (Maganira *et al.*, 2023). These fungi degrade grain quality and produce carcinogenic *mycotoxins*, such as *aflatoxins* (B1, B2) and *fumonisins* (FB1), which are linked to liver cancer and stunting in children (Kumar *et al.*, 2022).

The assessment of fungal diseases in maize storage has gained renewed attention due to climate variability, which exacerbated moisture retention in warehouses, and disruptions in supply chains, leading to prolonged storage periods (FAO, 2020). Studies have highlighted that improper storage practices, such as inadequate drying and insufficient pest management, create favorable environments for fungal proliferation (Mesterházy *et al.*, 2020). For instance, *Aspergillus, flavus*, a predominant *aflatoxin* producer, thrives in warm, humid conditions typical of poorly ventilated warehouses in tropical and subtropical regions (Udovicki *et al.*, 2020).

Many warehouses in developing regions lack climate-controlled facilities, relying instead on traditional storage methods that fail to regulate temperature and humidity, creating ideal conditions for fungal growth (Mesterházy *et al.*, 2020). Furthermore, limited awareness among smallholder farmers and warehouse managers about mycotoxin risks and preventive measures perpetuates unsafe storage practices (Hell *et al.*, 2020). Efforts to mitigate these losses require a comprehensive understanding of the fungal species involved, their prevalence, and the environmental factors driving their growth. Recent surveys emphasized the need for integrated management strategies, including the use of bio-control agents like *Trichoderma spp*., improved storage infrastructure, and regular *mycotoxin* monitoring (Logrieco *et al.*, 2020).

Current assessments of fungal diseases in maize storage often focuses on preharvest stages or laboratory conditions, leaving gaps in understanding species-specific prevalence, mycotoxin dynamics, and environmental drivers in real-world warehouse settings (Marín *et al.*, 2020; Udovicki *et al.*, 2020). For instance, the role of warehouse microclimates, pest interactions, and grain moisture content in facilitating fungal colonization remains understudied in many agro-ecological zones. Additionally, the efficacy of bio-control agents and low-cost mitigation strategies, such as hermetic storage or organic antifungal treatments, requires further validation in diverse storage systems (Logrieco *et al*., 2020).

This study aims at assessing the fungal diseases affecting stored maize in selected warehouses, identifying key pathogens, and evaluating storage conditions contributing to contamination, thereby informing targeted interventions to safeguard maize quality and safety.

MATERIALS AND METHODS

Experimental Location

The study was conducted in Lokoja, Kogi State, Nigeria (latitude 7°49' N, longitude 6°44' E), situated on the Niger River's western bank. The region experiences a tropical climate with an annual rainfall of 1,150 mm, average monthly temperatures of 30°C, and high humidity. Three warehouses in distinct locations Mami, Lokongoma, and Kpatar were selected based on accessibility, storage duration (>3 months) and absence of climate-control systems to reflect typical storage conditions in the area.

Sample Collection

Sampling Design: From each warehouse, 15 maize samples (5 samples per warehouse) were randomly collected using a sterile scoop from different depths (top, middle, bottom) of storage bags to ensure representativeness.

Handling: Samples were placed in pre-labeled, sterile polyethylene bags, sealed, and transported to the laboratory within 2 hours under ambient temperature (25–30°C) to prevent further fungal growth.

Documentation: Warehouse conditions (temperature, humidity, visible pests, and moisture levels) were recorded using a digital hygrometer (Model: AZ 8778) and infrared thermometer (Model: Etekcity 774).

Isolation of Fungi from Maize Grains

Potato Dextrose Agar (PDA): Prepared by dissolving 39 g of PDA powder (HiMedia, India) in 1 L of distilled water. The mixture was autoclaved at 121°C, 15 psi, for 15 minutes.

Antibiotic Supplementation: After cooling to ~45°C, chloramphenicol (500 mg/L; Sigma-Aldrich) was added to suppress bacterial growth.

Pouring Plates: Approximately 20 mL of PDA was dispensed into sterile 90 mm Petri dishes under a laminar flow hood (ESCO, Class II) and allowed to solidify. Sterility checks were performed by incubating 5% of plates at 25°C for 48 hours prior to use.

For each location: Five maize grains per sample were immersed in 70% ethanol (v/v) for 2 minutes, followed by three rinses with sterile distilled water to remove surface contaminants.

Grinding: Grains were aseptically crushed using a flame-sterilized mortar and pestle. The resulting mash was transferred to sterile tubes for inoculation.

Inoculation and Incubation

Plating: A sterile inoculation loop was used to streak 0.1 g of mashed sample onto PDA plates in triplicate. For each sample, three plates were inoculated to ensure reliability.

Incubation: Plates were inverted and incubated at 25°C (±1°C) for 5 days in a BOD incubator (Model: Memmert IPP 260) with 70% relative humidity.

Sub-culturing and Purification

Colony Isolation: Distinct fungal colonies were sub-cultured onto fresh PDA using a flame-sterilized loop. This process was repeated twice to obtain pure cultures.

Maintenance: Pure isolates were stored on PDA slants at 4°C for long-term preservation

Fungal Identification

Macroscopic Analysis: Colony morphology (color, texture, zonation) was documented using a stereomicroscope (Leica EZ4 HD).

Microscopic Analysis: *Lactophenol* cotton blue staining was performed on 3–5-day-old cultures. Slides were examined under a light microscope (Leica DMLS) at 100× and 400× magnification. Features such as conidiophores, spore arrangements, and hyphal structures were compared with taxonomic keys (Ali *et al.*, 2022).

Mycotoxin Potential: Species like *Aspergillus* and *Fusarium* were flagged for *mycotoxin* production based on literature (Shephard, 2004).

RESULTS AND DISCUSSION

The fungi isolated from the maize grain samples together with their frequencies of occurrence are presented in tables 1 and 2 respectively. The isolated organisms were identified as *Fusarium sp., Mucor sp, Candida sp.,* and *Aspergillus sp*.

Table 1: Cultural and morphological characteristics of fungal isolates

Isolates	Cultural characteristics	Morphological characteristics.
Aspergillus sp.	Forms colonies that are white to grayish green in colour.	Conidia borne in 360 arrangements covering the upper 2/3 of the conidiophores.
Fusarium sp.	Rapidly growing wooly to cottony lemon and yellow.	Multicellular distinctive sickle shaped macro conidia.
Mucor sp.	Forms colonies that are gray to black in colour, with a powdery or velvety appearance.	Sporangium comes out directly from the hyphal without stolon or rhizoids columella.
Candida sp.	Appears as a smoothy creamy white colony.	True hyphal form, which consists of elongated cells that branch and forms networks. The cells of C.albicans are covered with a thin layer of proteins and polysaccharide called cell wall.

Table 2: Frequency of fungi occurrence

Site	*C.albicans*	*F.oxysporium*	*M.hiemalis*	*Aspergillus Sp.*	
Mami	+	-	-	+	2
Lokongoma	-	+	+	+	3
Kpatar	+	-	+	+	3
	25.25%	12.6%	25.25%	37.87	

The study analyzed maize samples from three storage sites in Lokoja, Nigeria: Mami, Lokongoma, and Kpatar (Table 2). Microscopic examination revealed four fungal species: *Aspergillus sp, C. albicans, M. hiemalis* and *F. oxysporium*. A total of 8 fungal isolates were identified across all sites.

Site-Specific Fungal Prevalence
Mami: Two fungi were isolated *C. albicans* and *Aspergillus sp*.
Lokongoma: Three fungi were identified *F. oxysporium*, *M. hiemalis*, and *Aspergillus sp*.
Kpatar: Three fungi were detected *C. albicans*, *M. hiemalis*, and *Aspergillus sp*.

Frequency Distribution
Aspergillus sp. dominated, representing 37.87% (3/8 isolates), consistent with its adaptability to suboptimal storage conditions.
C. albicans and *M. hiemalis* each accounted for 25.25% (2/8 isolates), suggesting moderate prevalence linked to localized humidity fluctuations.
F. oxysporium was the least frequent (12.6%, 1/8 isolates), likely due to its primary association with pre-harvest infections rather than storage environments.

Discussions
Fungal identification via standard mycological techniques (potato dextrose agar culturing, *lactophenol* cotton blue staining, and macro/micro-morphological analysis) revealed four toxigenic genera contaminating stored maize in Lokoja, Kogi State: *F. oxysporium*, *M. hiemalis*, *C. albicans*, and *Aspergillus sp*. Spatial heterogeneity in contamination was observed: Lokongoma and Kpatar exhibited the highest fungal diversity (3 species/site), while Mami had the lowest (2 species), correlating with localized differences in storage infrastructure and microclimatic conditions (Olanrewaju *et al.*, 2023). Frequency distributions (*Aspergillus spp*.: 25.25%, *M. hiemalis.*: 25.25%, *C. albicans*,.: 37.87%, *F. oxysporium*.: 12.6%) contrast sharply with prior studies of Temesegen and Teshome (2019), who reported *Fusarium* dominance (73.08%) in Ethiopian maize, likely due to divergent agro ecological drivers (e.g., pre-harvest field inoculum vs. postharvest storage stressors). The prevalence of *Aspergillus spp*. aligns with Onyeze *et al.* (2013) (38%) and Ofgea and Gure (2015) (38.027%) but diverges from Amare (2010), who observed 94% *Aspergillus* incidence in Ethiopian maize, potentially due to extreme humidity (>80%) in traditional storage pits (Tadesse *et al.*, 2023). *Fusarium* lower prevalence here (12.6% vs. 36.36% in Onyeze *et al.*, 2013) may reflect improved postharvest drying practices in Lokoja, as *F. oxysporium* proliferation is moisture-dependent (Aw >0.90) and linked to kernel fissures from mechanical damage during harvesting (Kamano *et al.*, 2022). Notably, *C. albicans* an atypical storage contaminant was isolated at 37.87%, likely due to hygroscopic nutrient leakage (e.g., soluble carbohydrates) from damaged kernels under elevated relative humidity (RH >75%) (Onyedum *et al.*, 2020).

CONCLUSION
The isolation of toxigenic fungal species *F. oxysporium*, *M. hiemalis*, *C. albicans*, and *Aspergillus sp* from stored maize in this study confirms significant postharvest contamination, indicative of suboptimal storage biosecurity. *Aspergillus sp*, a prolific producer of *aflatoxins* and *gliotoxin*, poses acute carcinogenic risks (e.g., *hepatocellular carcinoma*). *M. hiemalis* and *C. albicans*, though less toxigenic, exacerbate grain spoilage through hygroscopic activity, elevating moisture levels (>15%) that favor secondary *mycotoxin* contamination. The dominance of *Aspergillus spp.* (37.87% prevalence) underscores its ecological adaptability to tropical storage microclimates (RH >65%, 28–35°C), which drive *aflatoxin* biosynthesis. Therefore, there is a need for proper preservation techniques and adequate environmental and storage conditions to prevent contamination and economic loss of maize in the study area and Nigeria at large. Also, there is need to avoid physical damage of maize grains during harvesting and storage as this will not only reduce the economic value but also act as vehicle for the transmission of fungal pathogens

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