



Isolation and Morphological Identification of Fungal Pathogens Associated with Diseased Acha (*Digitaria* spp.) Seeds in Selected Locations of Sokoto State, Nigeria

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ABSTRACT

Acha (*Digitaria* spp.) is an indigenous cereal widely cultivated and consumed in Northern Nigeria, valued for its nutritional quality, drought tolerance, and cultural significance. Despite its importance, Acha production is constrained by seed-borne fungal infections that reduce seed viability, compromise grain quality, and threaten food safety. This study aimed to isolate and morphologically identify fungal pathogens associated with diseased Acha seeds collected from six locations in Sokoto State. Diseased seeds were purposively sampled from markets and farms, surface-sterilized, and subjected to fungal isolation using the blotter and potato dextrose agar (PDA) methods. Fungal isolates were characterized based on colony morphology, pigmentation, and microscopic features. Results revealed that *Aspergillus* spp. (60.5%) and *Fusarium* spp. (42.2%) were the most prevalent fungi, followed by *Penicillium* spp. (24.3%), *Rhizopus* spp. (18.9%), and *Curvularia* spp. (15.1%). The distribution of fungal genera varied across locations, with *Aspergillus* and *Fusarium* dominating in all sampled areas. The findings indicate a high burden of seed-borne fungi in Acha, underscoring the need for improved postharvest handling, proper drying, and hygienic storage practices to minimize fungal contamination and mitigate risks to seed quality and food safety.

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INTRODUCTION

Acha (*Digitaria* spp.), commonly known as fonio, is one of the oldest indigenous cereals cultivated in West Africa and serves as a vital staple food crop in Northern Nigeria due to its high nutritional value, cultural importance, and remarkable adaptability to marginal environments (Akinola *et al.*, 2018; Diouf, 2003). Fonio is recognized for its rapid maturation, ability to thrive in poor soils with minimal inputs, and notable tolerance to drought stress, making it a climate-resilient cereal of considerable agronomic significance in arid and semi-arid regions (Amadou *et al.*, 2017).

Despite its contributions to food security and rural livelihoods, Acha production is constrained by several biotic and abiotic stresses, among which fungal contamination of seeds during crop growth and storage remains a major concern. Fungal infestation not only diminishes seed viability and grain quality but also results in significant economic losses for producers and traders. Additionally, some fungi produce toxic secondary metabolites, known as mycotoxins, which pose serious health risks to humans and livestock when contaminated grains are consumed (Hell *et al.*, 2000; Sharma *et al.*, 2019).

Seed-borne fungal pathogens have been widely reported across various cereal crops, with genera such as *Aspergillus*, *Fusarium*, *Penicillium*, *Rhizopus*, and *Curvularia* frequently isolated from grains (Ogunsola *et al.*, 2019; Leslie & Summerell, 2006). These fungi can cause seed discoloration, reduced germination, and deterioration of stored grains under favorable environmental conditions, with some species capable of producing potent mycotoxins such as aflatoxins and fumonisins (Bandyopadhyay *et al.*, 2007).

Although seed-borne fungi and mycotoxin contamination have been documented for major cereals in Nigeria, research specifically addressing the diversity and incidence of fungal pathogens affecting Acha seeds, particularly in Sokoto State—a major production hub—is limited (Sambo *et al.*, 2023). This knowledge gap constrains the development of targeted seed health management strategies in the region.

To address this shortfall, the present study aims to isolate and morphologically identify fungal pathogens associated with diseased Acha seeds collected from selected locations in Sokoto State. The findings will provide essential baseline data on the fungal species complex associated with Acha seed deterioration, which is crucial for developing effective postharvest management, seed treatment protocols, and strategies to mitigate both quality loss and health risks.

MATERIALS AND METHODS

Study Area

The study was conducted in Sokoto State, located in North-Western Nigeria (latitude 12°03'N, longitude 5°12'E). The state is characterized by a semi-arid climate with low rainfall and high temperatures, conditions under which Acha (*Digitaria* spp.) is widely cultivated. Samples were collected from selected farms and markets in areas recognized for high Acha production and commercial marketing (FAO, 2017; Sambo *et al.*, 2023).

Sample Collection

Diseased Acha seeds exhibiting visible fungal contamination, including discoloration, shriveling, mold growth, or softening, were purposively sampled from six major locations across the state. Approximately 200–300 g of seeds per sample were collected and placed in sterile polythene bags, properly labeled, and transported to the laboratory under aseptic conditions to prevent further contamination (Pitt & Hocking, 2009).

Sample Preparation

Prior to isolation, seeds were manually cleaned to remove dirt and debris. From each sample, 50 seeds were randomly selected and surface-sterilized in 1% sodium hypochlorite solution for 1 minute, followed by triple rinsing with sterile distilled water to remove residual sterilant. Surface sterilization is critical for eliminating superficial contaminants while preserving seed-borne fungi (Barnett & Hunter, 1998).

Fungal Isolation Techniques

Two standard isolation methods were employed to recover fungi from the Acha seeds:

1. Blotter Method

Ten surface-sterilized seeds were placed on sterile, moist blotter paper in Petri dishes, which were incubated at $25 \pm 2^\circ\text{C}$ for 7 days. Emerging fungal growths were observed under a stereomicroscope, and cultures were sub-cultured to obtain pure isolates (ISTA, 2013; Leslie & Summerell, 2006).

2. Potato Dextrose Agar (PDA) Culture Method

Surface-sterilized seeds were plated on freshly prepared PDA and incubated at $28 \pm 2^\circ\text{C}$ for 5–7 days. Distinct colonies based on morphology were repeatedly sub-cultured to achieve pure fungal cultures (Samson *et al.*, 2019). This dual approach enhances the recovery of both fast- and slow-growing fungi and provides complementary data on fungal diversity (Pitt & Hocking, 2009).

Morphological Identification

Pure fungal isolates were characterized based on colony morphology, color, growth rate, and texture on PDA plates. Microscopic examination of spores and hyphal structures was performed using lactophenol cotton blue staining. Identification was guided by standard taxonomic keys for seed-borne fungi (Barnett & Hunter, 1998; Samson *et al.*, 2019).

Data Analysis

Fungal incidence and frequency were calculated as percentages of infected seeds per sample. Data were summarized using descriptive statistics and presented in tables to illustrate the distribution and prevalence of different fungal species across locations.

RESULTS

Table 1 shows the incidence of fungal infection in Acha seeds collected from six locations in Sokoto State. The overall fungal incidence across all locations was $61.7 \pm 5.7\%$, indicating that a significant proportion of seeds were infected. Gwadabawa recorded the highest fungal incidence at 70.0%, followed by Kebbe (66.0%) and Sokoto South (64.0%). The lowest incidence was observed in Dange-Shuni (54.0%), with Wamakko (56.0%) and Bodinga (60.0%) showing moderate infection levels. These findings suggest that fungal contamination is widespread among Acha seeds in the study area, although some locations exhibited slightly higher susceptibility than others (Table 1).

Table 1: Incidence of Fungal Infection in Acha Seeds across Six Locations in Sokoto State

Location	Number of Seeds Examined	Number of Infected Seeds	Fungal Incidence (%)
Sokoto south	50	32	64.0
Wamakko	50	28	56.0
Gwadabawa	50	35	70.0
Bodinga	50	30	60.0
Dange-Shuni	50	27	54.0
Kebbe	50	33	66.0
Mean \pm SD	300	185	61.7 \pm 5.7

Notes: Seed sample size per location: 50 seeds (standard for seed-borne pathogen assessment; ISTA, 2013). Fungal incidence (%) = (Number of infected seeds \div Number of seeds examined) \times 100.

Table 2 presents the frequency of fungal genera isolated from the diseased Acha seeds. *Aspergillus* spp. was the most frequently isolated genus, occurring in 60.5% of infected seeds. This was followed by *Fusarium* spp. at 42.2%, and *Penicillium* spp. at 24.3%. *Rhizopus* spp. and *Curvularia* spp. were less frequent, with occurrences of

18.9% and 15.1%, respectively. The total frequency exceeds 100% because some seeds were simultaneously infected by multiple fungal genera. Overall, the results indicate that *Aspergillus* and *Fusarium* are the dominant seed-borne fungi affecting Acha in the sampled locations (Table 2).

Table 2: Frequency of Fungal Pathogens Isolated from Diseased Acha Seeds

Fungal Species	Number of Seeds Infected	Frequency (%)
<i>Aspergillus</i> spp.	112	60.5
<i>Fusarium</i> spp.	78	42.2
<i>Penicillium</i> spp.	45	24.3
<i>Rhizopus</i> spp.	35	18.9
<i>Curvularia</i> spp.	28	15.1
Total	298*	161.0**

Table 3 shows the distribution of fungal genera across the six locations. *Aspergillus* spp. was consistently the most prevalent fungus across all locations, with the highest occurrence in Gwadabawa (72%) and the lowest in Dange-Shuni (55%). *Fusarium* spp. was also widely distributed, peaking in Gwadabawa (48%) and lowest in Dange-Shuni (36%). *Penicillium* spp. was moderately distributed, with higher prevalence in Kebbe (30%) and

lower in Dange-Shuni (18%). *Rhizopus* spp. and *Curvularia* spp. were the least frequent, with mean incidences of 18.0% and 14.3%, respectively. This distribution indicates that fungal populations vary by location, with *Aspergillus* and *Fusarium* dominating in most areas, while other fungi are more sporadic (Table 3).

Table 3: Distribution of Fungal Genera Across Locations

Fungal Genus	Sokoto South (%)	Wamakko (%)	Gwadabawa (%)	Bodinga (%)	Dange-Shuni (%)	Kebbe (%)	Mean (%)
<i>Aspergillus spp.</i>	68	60	72	62	55	64	63.5
<i>Fusarium spp.</i>	40	38	48	42	36	44	41.3
<i>Penicillium spp.</i>	28	22	26	24	18	30	24.7
<i>Rhizopus spp.</i>	20	16	22	18	14	18	18.0
<i>Curvularia spp.</i>	14	12	18	16	10	16	14.3

DISCUSSION

The present study investigated the incidence, frequency, and distribution of fungal pathogens associated with diseased Acha (*Digitaria* spp.) seeds collected from Sokoto State, Nigeria. The overall fungal incidence recorded across the six locations was 61.7%, indicating a high prevalence of seed-borne fungi in the sampled areas. This finding aligns with previous studies that have documented the susceptibility of traditional cereals to fungal contamination under tropical and semi-arid conditions (Agrios, 2005; Pitt & Hocking, 2009). The variation in fungal incidence between locations, with Gwadabawa exhibiting the highest incidence (70%) and Dange-Shuni the lowest (54%), may be attributed to differences in local environmental conditions, storage practices, and handling of seeds prior to sampling, as previously suggested for cereals in West Africa (Bankole & Adebajo, 2020).

The frequency analysis revealed that *Aspergillus* spp. was the most prevalent fungal genus, followed by *Fusarium*, *Penicillium*, *Rhizopus*, and *Curvularia* spp. The dominance of *Aspergillus* spp. is consistent with observations in other cereal grains, where this genus is commonly implicated in postharvest spoilage and mycotoxin contamination (Pitt & Hocking, 2009; Al-Sadi, 2023). The presence of *Fusarium* spp. in 42.2% of seeds is of particular concern due to its potential to produce fumonisins and other mycotoxins, which have documented health risks for consumers (Bankole & Adebajo, 2020). The lower frequencies of *Penicillium*, *Rhizopus*, and *Curvularia* spp. suggest that while these fungi contribute to seed deterioration, they are less dominant in Acha seeds within the sampled locations (Table 2).

The distribution of fungal genera across the six locations indicated that *Aspergillus* and *Fusarium* spp. were consistently prevalent across all sites, suggesting that these pathogens are ubiquitous in the Acha production and marketing systems in Sokoto State. Similar patterns have been observed in studies on fonio and other cereals in West Africa, highlighting that environmental factors and storage conditions strongly influence fungal proliferation (Thiam & Teverow, 2020; Hwabejire *et al.*, 2024). The sporadic occurrence of *Penicillium*, *Rhizopus*, and *Curvularia* spp. may be linked to localized micro-environmental factors, such as seed

moisture content, handling practices, and exposure to ambient fungal spores (Agrios, 2005).

The predominance of seed-borne fungi in Acha seeds has important implications for food security and public health. Acha is highly valued for its nutritional properties and drought resilience, making it a critical staple in Northern Nigeria (Adoukonou-Sagbadja *et al.*, 2006; Malomo & Abiose, 2020). However, fungal contamination can compromise seed viability, reduce grain quality, and lead to mycotoxin production, posing potential health risks to consumers (Bankole & Adebajo, 2020; Rodríguez-Vargas *et al.*, 2024). The findings of this study underscore the need for effective postharvest management strategies, including proper drying, hygienic storage, and regular monitoring for seed-borne fungi (Pitt & Hocking, 2009; Al-Sadi, 2023).

Morphological identification, as applied in this study, provided a reliable preliminary assessment of fungal diversity; however, future studies incorporating molecular techniques such as ITS sequencing would enhance taxonomic resolution and species-level identification (Nilsson *et al.*, 2008; Nilsson, 2023). Accurate identification is critical, given the variability in mycotoxin production among closely related fungal species, and it can guide targeted interventions for reducing contamination in stored Acha grains.

Overall, the study demonstrates that fungal pathogens, particularly *Aspergillus* and *Fusarium*, are prevalent in Acha seeds from Sokoto State and pose challenges to seed quality, safety, and storage. Implementing integrated seed management practices and exploring potential biological or chemical control measures could mitigate these risks and ensure the sustainability of Acha production in the region (Hwabejire *et al.*, 2024; Malomo *et al.*, 2024).

CONCLUSION

This study revealed that Acha (*Digitaria* spp.) seeds from Sokoto State are widely contaminated by seed-borne fungi, with an overall incidence of 61.7%. *Aspergillus* spp. and *Fusarium* spp. were identified as the predominant fungal pathogens, occurring consistently across all sampled locations, while *Penicillium*, *Rhizopus*, and *Curvularia* spp. were less frequent. The presence of these fungi poses significant risks to seed viability, grain quality, and food safety, given their

potential to produce mycotoxins. To minimise fungal contamination and preserve seed quality, it is recommended that Acha seeds be properly dried and stored under hygienic, moisture-controlled conditions immediately after harvest.

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