



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

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www.agronomyjournals.com

2024; 7(4): 217-220

Received: 24-02-2024

Accepted: 29-03-2024

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Incidence and management of aflatoxin contamination in groundnut under different postharvest storage systems

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DOI: <https://doi.org/10.33545/2618060X.2024.v7.i4c.4992>

Abstract

When groundnut kernels are cracked open after three months of traditional storage in a West African village, the faint green-yellow fluorescence under UV light tells a familiar story aflatoxin contamination has set in. This research evaluated aflatoxin B1 (AFB1) accumulation in groundnut (*Arachis hypogaea* L.) stored under three postharvest systems traditional jute sacks, improved ventilated structures, and hermetic PICS bags over 12 weeks at two sites in northern Ghana during the 2021–2022 dry season. *Aspergillus* species were identified from kernel isolations at 0, 4, 8, and 12 weeks. Traditional storage reached 112.6 µg/kg AFB1 by week 12, exceeding the EU limit (20 µg/kg) by week 5. Improved ventilated storage reached 21.7 µg/kg, while hermetic bags limited AFB1 to 3.7 µg/kg. *A. flavus* dominated fungal isolations (48.3%), followed by *A. parasiticus* (22.7%). Kernel moisture content was the strongest predictor of AFB1 accumulation ($r = 0.91$). Hermetic storage is a practical, low-cost intervention for keeping groundnut below regulatory limits in smallholder systems.

Keywords: Aflatoxin, groundnut, postharvest storage, *aspergillus flavus*, hermetic storage, pics bags, food safety, kernel moisture, mycotoxin management, ghana

Introduction

It's been observed across multiple surveys that 40–80% of groundnut samples from West African markets exceed safe aflatoxin limits, making this the most contaminated food commodity in the region ^[5, 16]. Aflatoxin B1, produced primarily by *Aspergillus flavus* and *A. parasiticus*, is the most potent naturally occurring carcinogen, classified as Group 1 by IARC ^[1]. Chronic exposure through contaminated groundnut contributes to liver cancer and growth stunting, particularly in children ^[10].

Pre-harvest contamination is driven by drought stress during pod filling, which cracks pod walls and facilitates fungal invasion ^[6, 12]. But the majority of aflatoxin accumulation occurs postharvest, when improper drying and storage allow fungal growth to accelerate ^[3, 8]. Traditional storage in jute or polypropylene sacks permits moisture re-absorption and poor aeration, creating conditions ideal for *Aspergillus* proliferation ^[5, 15]. Hermetic storage technologies like Purdue Improved Crop Storage (PICS) bags restrict oxygen diffusion, suppressing fungal metabolism and insect activity ^[7, 11].

Few studies have tracked aflatoxin kinetics over time in groundnut under contrasting storage systems in West Africa. This research monitored AFB1, fungal populations, and kernel moisture at four-week intervals over 12 weeks across three storage systems at two sites in northern Ghana.

Materials and Methods

Study area description

The research was conducted at two sites in the Northern Region of Ghana: Tamale (9.40° N, 0.84° W) and Yendi (9.44° N, 0.01° W) during November 2021 to February 2022 (dry season). Mean temperature during storage was 31.4 °C with relative humidity fluctuating between 28% (December) and 72% (February). Groundnut variety Samnut 22 was sourced from local farmers immediately after harvest and sun-drying to ~8% moisture ^[9].

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Performance evaluation

AFB1 was quantified at weeks 0, 4, 8, and 12 by HPLC with fluorescence detection following immunoaffinity column cleanup (VICAM AflaTest). Kernel moisture was measured by oven method (130 °C, 72 h). Fungal isolations used dilution plating on *Aspergillus* *Flavus* and *Parasiticus* Agar (AFPA) with identification by colony morphology and UV fluorescence^[2, 14]. Results were compared against EU maximum limits: 4 µg/kg AFB1 for direct consumption and 20 µg/kg for processing^[17].

Materials

Three storage systems were tested: (1) traditional jute sacks stored on bare floor under thatched roof; (2) improved ventilated structures with raised wooden pallets and metal mesh sides; (3)

hermetic PICS triple-layer bags (80 µm polyethylene inner layers + woven outer) stored on pallets. Each treatment had four replicates of 50 kg bags at each site. Total: 3 systems × 4 replicates × 2 sites = 24 experimental units.

Methods

Data were analyzed by repeated-measures ANOVA with storage system as the between-subjects factor and sampling time as the within-subjects factor, using GenStat 20. Means were separated by LSD at *p*≤0.05. Correlation analysis tested relationships between AFB1 and kernel moisture, temperature, and *Aspergillus* colony counts^[9].

Results

Table 1: Aflatoxin B1 (µg/kg) in groundnut under three storage systems over 12 weeks

System	Week 0	Week 4	Week 8	Week 12
Traditional	0.8±0.2a	5.1±1.3a	35.2±8.4a	112.6±21.3a
Improved	0.7±0.2a	1.8±0.5b	7.2±1.8b	21.7±4.6b
Hermetic	0.6±0.1a	0.9±0.3c	1.8±0.4c	3.7±0.8c

Means ± SD (n=8, pooled across sites). Different letters within column = significant (*p*≤0.05)

Table 2: Kernel moisture content (%) and *Aspergillus* colony counts (CFU/g × 10³) at week 12

System	Moisture (%)	<i>Aspergillus</i> (CFU/g × 10 ³)
Traditional	12.4±1.3a	84.7±18.3a
Improved	9.1±0.8b	31.2±7.4b
Hermetic	7.8±0.4c	8.4±2.1c

Different letters = significant (*p*≤0.05, LSD)

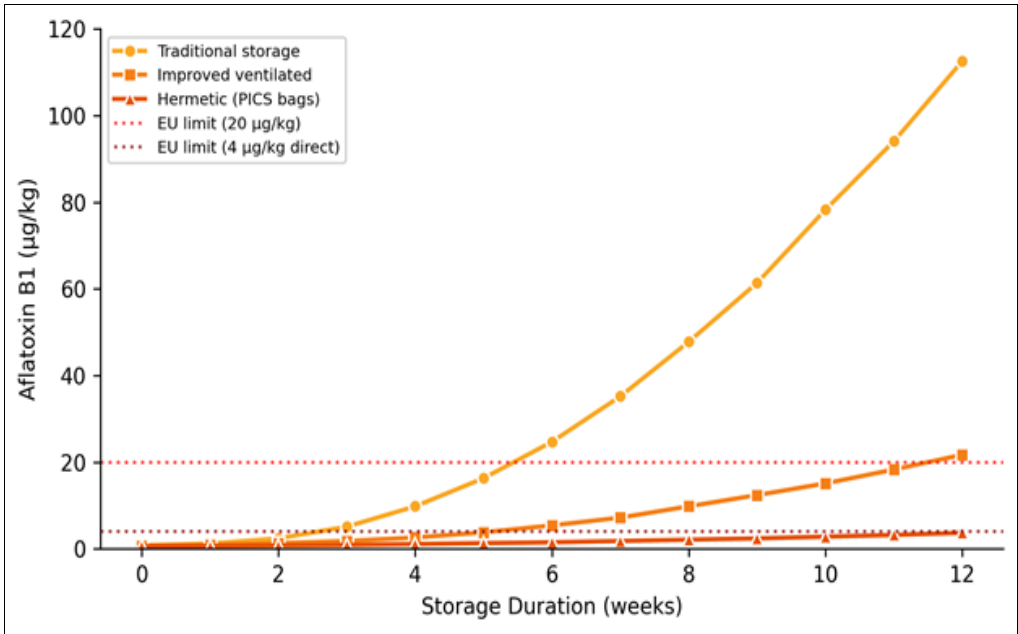


Fig 1: Aflatoxin B1 accumulation over 12 weeks under three storage systems. Dotted lines = EU regulatory limits

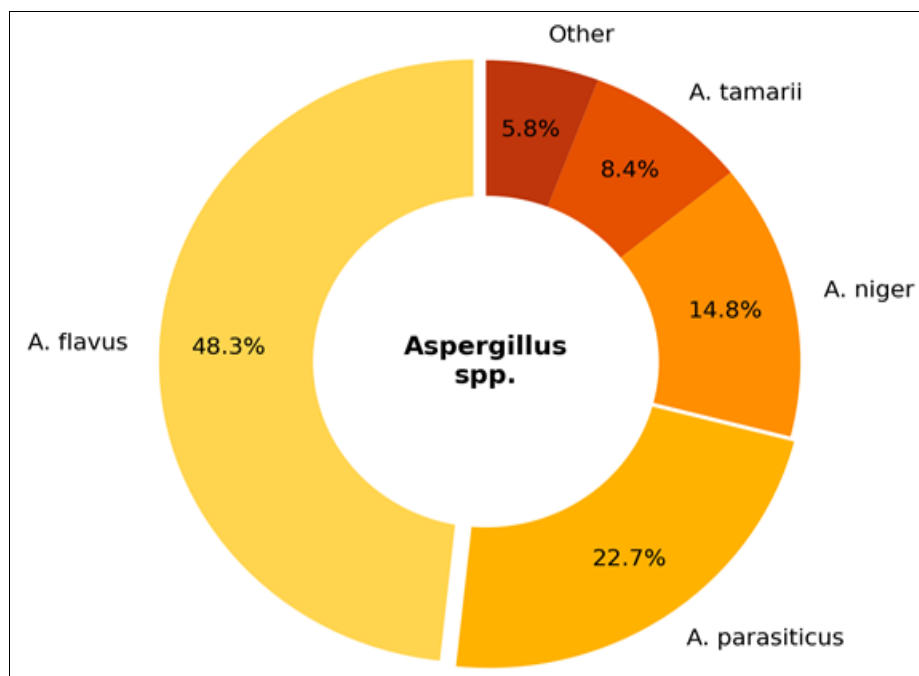


Fig 2: Frequency distribution of *Aspergillus* species isolated from groundnut kernels across all treatments

Comprehensive Interpretation

Traditional storage exceeded the 20 µg/kg EU processing limit by week 5 and reached 112.6 µg/kg by week 12 (Table 1, Figure 1). Improved storage delayed the exceedance to week 11 (21.7 µg/kg). Hermetic bags kept AFB1 at 3.7 µg/kg, below the strict 4 µg/kg direct-consumption limit throughout the trial. Kernel moisture rose to 12.4% in traditional bags versus 7.8% in hermetic bags (Table 2). *A. flavus* dominated isolations at 48.3% (Figure 2). Correlation between moisture and AFB1 was $r = 0.91$ ($p < 0.001$).

Discussion

The 30-fold AFB1 difference between traditional and hermetic storage after 12 weeks underscores the role of oxygen and moisture control in aflatoxin prevention. PICS bags reduce internal O_2 to 2–5% within two weeks, which suppresses aerobic *Aspergillus* metabolism [7]. Murdock and Baoua [7] reported similar results for cowpea, and Villers [8] demonstrated the principle for multiple grain types. The improved ventilated structure performed moderately, suggesting that better airflow alone reduces but doesn't eliminate fungal growth when ambient humidity is high [3, 15].

The dominance of *A. flavus* (48.3%) over *A. parasiticus* (22.7%) matches the typical species distribution in West African groundnut systems [4, 16]. The strong moisture–AFB1 correlation ($r = 0.91$) confirms that maintaining kernel moisture below 8–9% is the most important single factor in aflatoxin management, consistent with Turner *et al.* [11] and Hell and Mutegi [5].

Conclusion

Hermetic PICS bag storage limited aflatoxin B1 to 3.7 µg/kg over 12 weeks well within EU safety limits compared with 112.6 µg/kg in traditional jute sacks. Kernel moisture was the strongest predictor of contamination. PICS bags are a practical, affordable intervention for smallholder groundnut farmers in West Africa, requiring no electricity or chemicals. Extension programs should promote hermetic storage alongside proper sun-drying to below 8% moisture as a two-step strategy for aflatoxin management. Longer-term storage trials (6–12 months) would confirm the durability of hermetic protection.

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