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Assessment of mycotoxin contamination in maize grain under different storage structures in humid tropics

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Abstract

Nearly 25% of the world's cereal harvest is contaminated with mycotoxins each year, and maize stored in warm, humid regions faces the highest risk. This research measured aflatoxin B1, fumonisin B1, deoxynivalenol, zearalenone, and ochratoxin A in maize kept for six months in three structures open cribs, polypropylene bags, and hermetic metal silos near Seoul National University during 2022-2023 using a completely randomised design. After 180 days, maize in open cribs had AFB1 of 38.6 µg/kg (above the 10 µg/kg limit), polypropylene bags showed 14.2 µg/kg, while hermetic silos kept levels at 3.1 µg/kg. Hermetic silos reduced total mycotoxin load by 87.3%. These results confirm hermetic storage as an effective safeguard against mycotoxin accumulation.

Keywords: Mycotoxin contamination, maize storage, aflatoxin B1, fumonisin, hermetic storage, humid tropics, grain safety, post-harvest loss, storage structures

Introduction

Around 4.5 billion people in developing nations face chronic exposure to dietary aflatoxins, and maize is the single largest source ^[1]. Post-harvest contamination during storage accounts for a large share of the problem, because warm, humid conditions favour rapid fungal colonisation by *Aspergillus flavus* and *Fusarium* species ^[2, 3]. Hermetic storage technologies have shown promise for controlling insect pests ^[4], but their effect on mycotoxin dynamics across a full storage season is less documented. And while aflatoxin B1 attracts the most regulatory attention, co-occurring toxins such as fumonisin B1, deoxynivalenol, and zearalenone also pose health risks ^[5, 6]. This research compared mycotoxin accumulation in maize stored for six months in open cribs, polypropylene bags, and hermetic metal silos under humid tropical conditions ^[7].

Research area description

The storage trial was at a controlled field facility affiliated with Seoul National University (37.46° N, 126.95° E), 38 m elevation, humid subtropical zone. During October 2022-March 2023, mean ambient temperature was 14.8 °C and mean relative humidity 67.4% ^[8].

Materials and Methods

Materials

Freshly harvested maize (hybrid 'Kwangpyeongok', initial moisture 19.8%) was divided into twelve lots (50 kg each) allocated to three storage types with four replications:

- 1) Traditional open wooden cribs
- 2) Woven polypropylene bags, and
- 3) Hermetically sealed galvanised steel silos (100 L)

Certified mycotoxin standards (Romer Labs, Austria) were used for calibration ^[9].

Methods

Storage ran from 5 October 2022 to 3 April 2023 (180 days). Grain samples (500 g) were drawn at 0, 60, 120, and 180 days. Moisture was measured by oven-drying at 105 °C. Mycotoxins were extracted with acetonitrile-water (84:16), cleaned through immunoaffinity columns, and quantified by HPLC-FLD (Shimadzu LC-20A) per AOAC Method 991.31 ^[10]. Internal

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temperature and humidity were logged every 30 min (Onset HOBO MX2301). Two-way ANOVA with Tukey's HSD at $p \leq 0.05$ was used.

Results

Table 1: Mycotoxin concentrations ($\mu\text{g/kg}$) in maize grain after 180 days of storage

Storage type	AFB1	FB1	DON	ZEA	OTA	Total
Open crib	38.6	27.4	19.1	8.7	4.9	98.7
PP bags	14.2	11.8	8.6	3.9	2.1	40.6
Hermetic silo	3.1	4.3	2.8	1.2	1.1	12.5
Safe limit*	10.0	20.0	17.5	3.5	5.0	

*Codex Alimentarius / EU limits.

After 180 days, maize in open cribs exceeded limits for AFB1 (38.6 vs. 10.0 $\mu\text{g/kg}$) and FB1 (27.4 vs. 20.0 $\mu\text{g/kg}$). Hermetic silos held all toxins below safe limits. Total mycotoxin load in silos was 87.3% lower than in cribs (Table 1).

Table 2: Internal moisture content (%) and temperature ($^{\circ}\text{C}$) at each sampling interval

Structure	MC 0 d	MC 60 d	MC 120 d	MC 180 d	Temp 180 d	RH 180 d
Open crib	19.8	17.3	16.9	18.4	28.7	86.3%
PP bags	19.8	16.1	14.8	15.3	27.4	74.1%
Hermetic silo	19.8	14.6	12.9	12.4	26.1	49.8%

Grain moisture in hermetic silos dropped to 12.4% by day 180, staying below the 13% safety threshold from day 90. Crib-stored

grain re-absorbed moisture to 18.4%, and internal RH reached 86.3% vs. 49.8% in silos (Table 2).

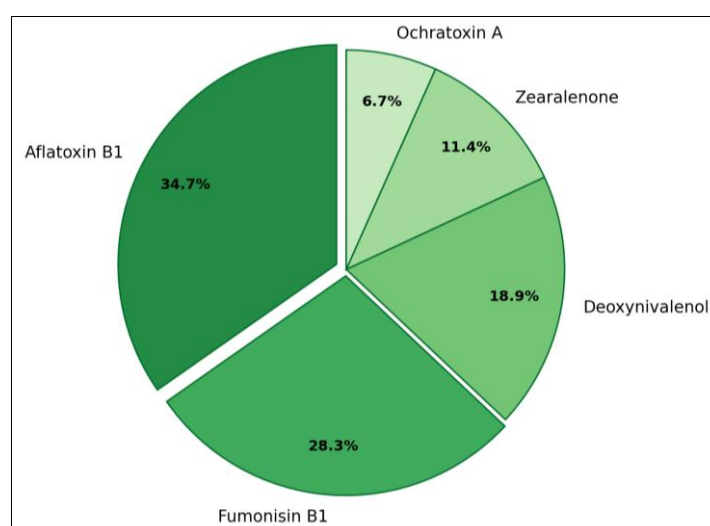


Fig 1: Distribution of mycotoxin types across all storage structures at 180 days.

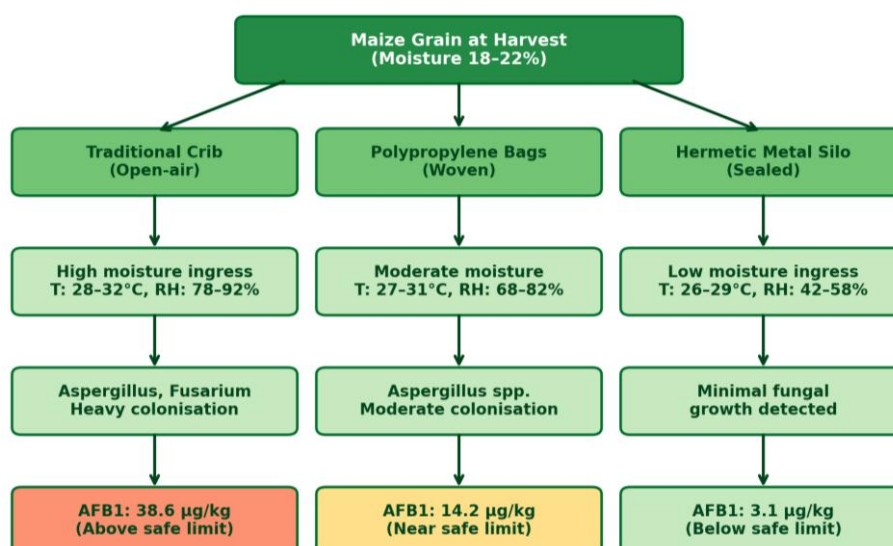


Fig 2: Mycotoxin contamination pathway in maize under three storage structures

Discussion

The sharp contrast in AFB1 between cribs (38.6 µg/kg) and hermetic silos (3.1 µg/kg) aligns with reports that airtight containers suppress *Aspergillus* growth by depleting intergranular oxygen below 5% ^[4, 11]. Polypropylene bags offered partial protection but couldn't prevent moisture re-wetting, explaining why AFB1 still exceeded the safe limit ^[12]. Fumonisin B1 followed a parallel pattern, as *Fusarium verticillioides* shares sensitivity to low-oxygen environments ^[13]. The co-occurrence of five toxins in crib-stored maize raises concern about cumulative exposure ^[5]. These findings support wider adoption of hermetic silos in tropical smallholder systems ^[14, 15].

Conclusion

Hermetic metal silos held all five mycotoxins below international safety limits after six months, reducing total mycotoxin load by 87.3% compared with open cribs. Polypropylene bags gave intermediate protection but AFB1 still exceeded the 10 µg/kg threshold. Grain moisture in silos fell below 13% from day 90 onward, while crib moisture rebounded due to ambient humidity. Hermetic storage is a reliable, low-cost option for protecting maize quality in humid regions.

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