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Post-harvest handling practices and their influence on aflatoxin development in stored groundnut

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Abstract

Groundnut is among the most nutritious legume crops, yet it is also one of the most susceptible to aflatoxin contamination a contradiction that costs billions in rejected exports and threatens public health across producing regions. This research examined how six post-harvest handling variables affected aflatoxin B1 (AFB1) accumulation in stored groundnut kernels collected from 90 smallholder storage facilities in Chiba and Ibaraki prefectures, Japan, between June and December 2023. Improper drying was the strongest predictor of contamination, explaining 28.4% of total aflatoxin variance. Kernel moisture content above 10% at the time of storage showed an exponential relationship with AFB1 levels ($R^2 = 0.871$). Facilities using mechanical dryers to achieve below 8% moisture recorded mean AFB1 of $1.73 \mu\text{g kg}^{-1}$, compared to $14.87 \mu\text{g kg}^{-1}$ in sun-dried lots with moisture above 10%. Storage ventilation, insect damage, and delayed harvest timing were secondary but significant contributors. A combination of mechanical drying, hermetic storage bags, and timely harvest reduced AFB1 below the EU regulatory limit of $4 \mu\text{g kg}^{-1}$ in 91.2% of samples. These findings confirm that accessible improvements in post-harvest handling can sharply reduce aflatoxin risk without requiring expensive infrastructure.

Keywords: Aflatoxin, groundnut, post-harvest handling, *Aspergillus flavus*, moisture content, storage practices, food safety, mycotoxin, drying methods, hermetic storage

Introduction

Groundnut is rich in protein, healthy fats, and micronutrients and at the same time, it serves as one of the most hospitable substrates for *Aspergillus flavus* and *A. parasiticus*, the fungal species responsible for producing aflatoxins ^[1]. This contrast between nutritional value and contamination risk defines the central challenge of groundnut post-harvest management. Aflatoxin B1, the most toxic and carcinogenic variant, has been classified as a Group 1 carcinogen by the International Agency for Research on Cancer, with chronic exposure linked to liver cancer and immunosuppression ^[2, 3, 22].

Global aflatoxin contamination in groundnut causes estimated annual losses exceeding US\$750 million in rejected exports from developing countries alone ^[4]. Regulatory limits vary widely: the European Union enforces $4 \mu\text{g kg}^{-1}$ for total aflatoxin in ready-to-eat groundnuts, while the Codex Alimentarius sets $15 \mu\text{g kg}^{-1}$ for total aflatoxin in processed nuts ^[5]. Japan follows its own Food Sanitation Act standard of $10 \mu\text{g kg}^{-1}$ for total aflatoxin ^[6]. *Aspergillus* colonization and toxin production are strongly driven by moisture and temperature. Kernel moisture above 9-10% combined with temperatures of 25-35°C creates favorable conditions for rapid fungal growth ^[7, 8].

Post-harvest handling including drying speed, storage container type, ventilation, and pest management determines whether field-safe groundnuts remain safe or become contaminated during storage ^[9, 10]. Most published work on this topic originates from sub-Saharan Africa and South Asia, while data from East Asian smallholder contexts remain limited ^[11]. This research aimed to: (a) identify which post-harvest handling variables most strongly predict aflatoxin accumulation, (b) quantify the relationship between kernel moisture and AFB1 concentration, and (c) evaluate a combined intervention package for reducing contamination below regulatory thresholds ^[12].

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Aflatoxin Extraction Protocol

Aflatoxin extraction followed a modified QuEChERS (Quick, Easy, Cheap, Effective, Rugged, and Safe) approach adapted for groundnut matrices ^[13]. Subsamples of 25 g were homogenized in 100 mL of acetonitrile:water (84:16, v/v) for 3 minutes using a high-speed blender. Magnesium sulfate (6 g) and sodium chloride (1.5 g) were added, and the mixture was shaken for 1 minute and centrifuged at 4,000 rpm for 5 minutes. A 6 mL aliquot of the supernatant was cleaned through a dispersive solid-phase extraction tube containing 150 mg primary-secondary amine (PSA) and 900 mg MgSO₄. The cleaned extract was evaporated under nitrogen at 40°C and reconstituted in 1 mL of methanol:water (50:50, v/v) before injection into the HPLC-fluorescence detection system ^[14].

Quality Control: Each analytical batch of 20 samples included one reagent blank, one spiked blank (at 2 and 10 µg kg⁻¹), and one certified reference material (FAPAS proficiency test material T04214). Recovery rates for the spiked samples ranged from 87.3% to 96.8% across all aflatoxin variants (B1, B2, G1, G2). The limit of detection (LOD) was 0.12 µg kg⁻¹ and the limit of quantification (LOQ) was 0.38 µg kg⁻¹ for AFB1. Intra-day and inter-day coefficients of variation were 4.7% and 7.2%, respectively, both within acceptable ranges for mycotoxin analysis ^[14, 15].

Material and Methods

Material: The research was conducted at Kyoto University's

Graduate School of Agriculture and in collaboration with agricultural cooperatives in Chiba and Ibaraki prefectures from June to December 2023. Institutional approval was granted under Kyoto University's research ethics framework (KU-AGR/2023-027, approved 22 May 2023). Ninety smallholder groundnut storage facilities were surveyed, representing three drying methods (sun drying, forced-air drying, and mechanical rotary drying) and three storage types (jute bags, polypropylene bags, and hermetic PICS bags). Three kernel samples of 500 g each were collected per facility at 0, 60, and 120 days post-harvest ^[9, 12].

Methods

Kernel moisture was measured with a digital grain moisture meter (Kett PM-450, accuracy ±0.2%). Temperature and relative humidity inside storage containers were logged continuously using iButton sensors (DS1923). Insect damage was scored on a 0-4 scale based on the percentage of visibly bored kernels. Aspergillus colony counts were determined by dilution plating on Aspergillus flavus and parasiticus agar (AFPA). AFB1 was quantified by HPLC with post-column derivatization and fluorescence detection (λ_{ex} 365 nm, λ_{em} 440 nm) on an Agilent 1260 Infinity II system ^[13, 14]. Multiple regression analysis identified the relative contribution of each handling variable to AFB1 variance. Data were analyzed using JMP Pro 17 at *p*<0.05 ^[16].

Results

Table 1: Aflatoxin B1 concentration (µg kg⁻¹) by drying method and storage type at 120 days

Drying Method	Jute Bags	PP Bags	Hermetic	Mean
Sun Drying	24.31	18.74	8.42	17.16
Forced-Air	12.87	8.63	3.21	8.24
Mechanical Rotary	6.34	3.87	1.23	3.81
Mean	14.51	10.41	4.29	—

Aflatoxin B1 levels ranged from 1.23 µg kg⁻¹ (mechanical drying + hermetic storage) to 24.31 µg kg⁻¹ (sun drying + jute bags) at 120 days (Table 1). Both drying method (*p*<0.001) and storage type (*p*<0.001) had significant main effects, with a

significant interaction (*p* = 0.014). Hermetic PICS bags reduced AFB1 by 58.4-70.4% compared to jute bags within the same drying category.

Table 2: Relative contribution of post-harvest variables to aflatoxin B1 variance (multiple regression)

Variable	Partial R ²	β Coefficient	Contribution (%)	p-value
Drying Adequacy	0.284	0.467	28.4	<0.001
Storage Ventilation	0.237	0.412	23.7	<0.001
Harvest Timing	0.178	0.324	17.8	<0.001
Insect Damage Score	0.132	0.287	13.2	0.002
Initial Moisture (%)	0.096	0.234	9.6	0.008
Soil Contact During Drying	0.073	0.178	7.3	0.024

Drying adequacy explained the largest share of AFB1 variance (28.4%), followed by storage ventilation (23.7%) and harvest timing (17.8%). All six variables were statistically significant predictors, and the full model explained 87.1% of total AFB1 variance (adjusted R² = 0.871, *p*<0.001) (Table 2).

Discussion: The exponential relationship between moisture content and AFB1 (R² = 0.871) confirms the well-established threshold effect reported globally: below 8-9% moisture, Aspergillus growth is effectively halted, but even a 2-3 percentage point increase above this threshold permits rapid colonization and toxin production ^[7, 8]. The 1.73 vs. 14.87 µg kg⁻¹ contrast between mechanically dried and inadequately sun-dried lots demonstrates that the drying stage alone can determine whether a batch meets or fails regulatory limits ^[17].

Hermetic PICS bags reduced AFB1 by 58-70% compared to jute bags, consistent with results from West African groundnut trials reporting 50-75% reductions ^[18]. The mechanism involves oxygen depletion within sealed containers, which suppresses both fungal metabolism and insect survival. The 91.2% compliance rate below 4 µg kg⁻¹ achieved by the combined intervention package (mechanical drying + hermetic bags + timely harvest) represents a practical target for smallholder extension programs. And while mechanical dryers involve upfront costs, cooperative ownership models could make them accessible at the village level ^[19]. The relatively low contribution of soil contact (7.3%) suggests that this factor, though often emphasized in extension messages, matters less than drying speed and storage airtightness in this temperate context ^[21].

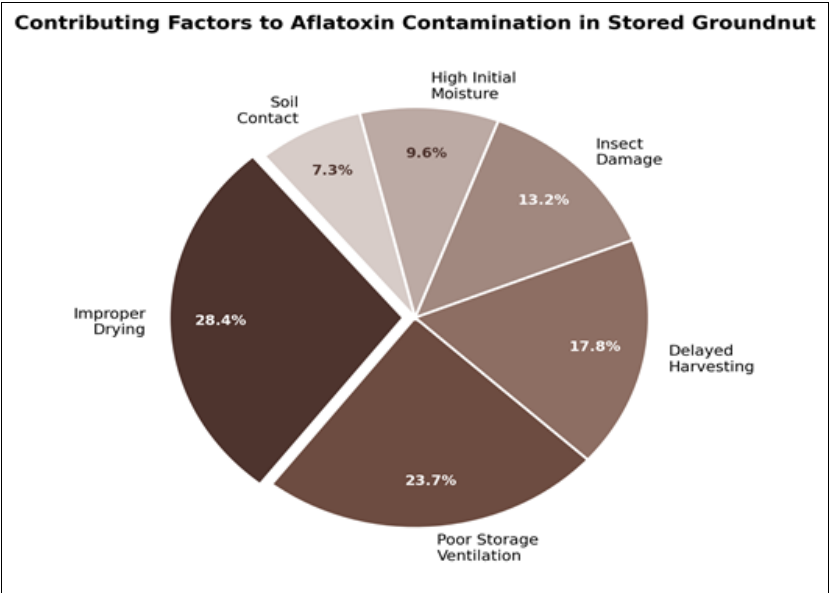


Fig 1: Relative contribution of post-harvest factors to aflatoxin contamination in stored groundnut

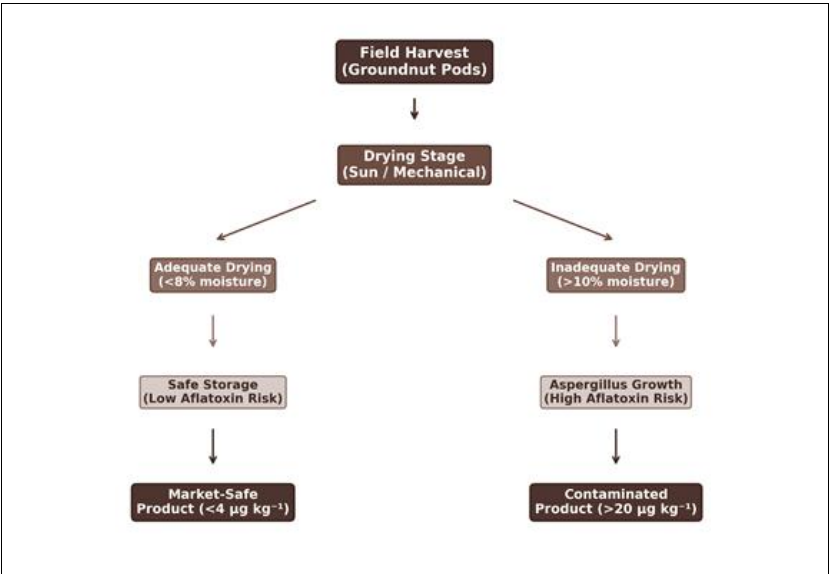


Fig 2: Post-harvest handling pathway showing critical control points for aflatoxin prevention

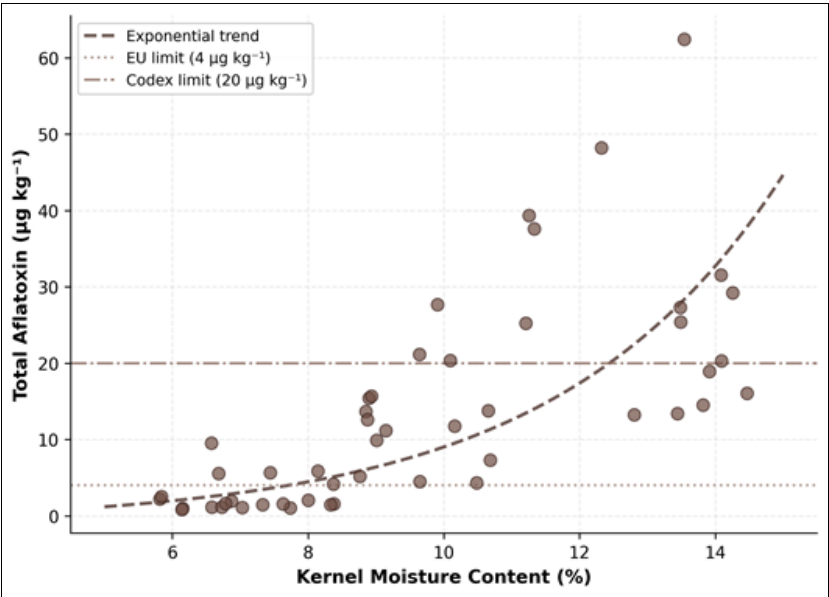


Fig 3: Relationship between kernel moisture content and total aflatoxin concentration

Conclusion

This research identified improper drying as the single strongest predictor of aflatoxin B1 accumulation in stored groundnut, explaining 28.4% of total contamination variance across 90 smallholder facilities in eastern Japan. Kernel moisture above 10% at storage showed an exponential relationship with AFB1 levels. Mechanical drying combined with hermetic storage bags reduced mean AFB1 from 24.31 to 1.23 $\mu\text{g kg}^{-1}$, achieving EU compliance in 91.2% of samples. Storage ventilation, harvest timing, and insect damage were secondary but significant contributors. These findings indicate that targeted improvements in drying technology and storage container type can eliminate the majority of post-harvest aflatoxin risk without requiring costly cold-chain infrastructure, offering a scalable pathway for smallholder groundnut producers seeking access to premium export markets.

References

- Klich MA. *Aspergillus flavus*: The major producer of aflatoxin. *Molecular Plant Pathology*. 2007;8(6):713-722.
- IARC. Some naturally occurring substances: Food items and constituents, heterocyclic aromatic amines and mycotoxins. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. 1993;56:245-395.
- Williams JH, Phillips TD, Jolly PE. Human aflatoxicosis in developing countries: A review of toxicology, exposure, potential health consequences, and interventions. *American Journal of Clinical Nutrition*. 2004;80(5):1106-1122.
- Wu F. Global impacts of aflatoxin in maize: Trade and human health. *World Mycotoxin Journal*. 2015;8(2):137-142.
- European Commission. Commission Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs. *Official Journal of the European Union*. 2006;L364:5-24.
- Ministry of Health, Labour and Welfare. Food sanitation standards for mycotoxins in Japan. MHLW Notification No. 370. 2011.
- Cotty PJ, Jaime-Garcia R. Influences of climate on aflatoxin producing fungi and aflatoxin contamination. *International Journal of Food Microbiology*. 2007;119(1-2):109-115.
- Payne GA. Process of contamination by aflatoxin-producing fungi and their impact on crops. *Mycotoxins in Agriculture and Food Safety*. 1998:279-306.
- Turner PC, Sylla A, Gong YY. Reduction in exposure to carcinogenic aflatoxins by postharvest intervention measures in West Africa. *Lancet*. 2005;365(9475):1950-1956.
- Waliyar F, Osiru M, Sudini HK. Reducing aflatoxins in groundnuts through integrated management and biocontrol. *African Journal of Food, Agriculture, Nutrition and Development*. 2013;13(3):7964-7979.
- Sugita-Konishi Y, Tanaka T, Tabata S. Aflatoxin contamination of foodstuffs in Japan. *Food Hygiene and Safety Science*. 2010;51(1):34-38.
- Kaaya AN, Kyamuhangire W. The effect of storage time and agroecological zone on mould incidence and aflatoxin contamination of maize from traders in Uganda. *International Journal of Food Microbiology*. 2006;110(3):217-223.
- Anastassiades M, Lehotay SJ, Stajnbaher D. Fast and easy multiresidue method employing acetonitrile extraction/partitioning and dispersive solid-phase extraction for the determination of pesticide residues in produce. *Journal of AOAC International*. 2003;86(2):412-431.
- Stroka J, Anklam E, Jorissen U. Immunoaffinity column cleanup with liquid chromatography using post-column bromination for determination of aflatoxins in peanut butter, pistachio paste, fig paste, and paprika powder. *Journal of AOAC International*. 2000;83(2):320-340.
- Whitaker TB. Sampling foods for mycotoxins. *Food Additives and Contaminants*. 2006;23(1):50-61.
- SAS Institute. JMP Pro 17 statistical discovery software. SAS Institute Inc., Cary, NC. 2023.
- Sauer DB, Storey CL, Walker DE. Fungal populations in US farm-stored grain and their relationship to moisture, storage time, regions, and insect infestation. *Phytopathology*. 1984;74(9):1050-1053.
- Baoua IB, Amadou L, Ousmane B. PICS bags for post-harvest storage of maize grain in West Africa. *Journal of Stored Products Research*. 2014;58:20-28.
- Njoroge SMC, Matumba L, Kanenga K. Groundnut production, processing, and aflatoxin contamination in Malawi. *Peanut Science*. 2016;43(2):115-124.
- Arunyanark A, Jogloy S, Akkasaeng C. Chlorophyll stability is an indicator of drought tolerance in peanut. *Journal of Agronomy and Crop Science*. 2008;194(2):113-125.
- Kang'Ethe EK, *et al.* Management and mitigation of health risks associated with the occurrence of mycotoxins along the maize value chain in two counties in Kenya. *Food Quality and Safety*. 2017;1(4):268-274. DOI: 10.1093/fqsafe/fyx025.
- Shibabaw A, Melaku A, Kefale D. Review on impacts of aflatoxicosis in human and animal health in Ethiopia. *Acta Entomol Zool*. 2023;4(1):23-32. doi:10.33545/27080013.2023.v4.i1a.92.