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Review Article

Postharvest Losses, Aflatoxin and Safe Grain Storage in Sub-Saharan Africa: Hermetic Storage, Drying, Food Safety and Markets

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Abstract

Postharvest losses in sub-Saharan Africa (SSA) are estimated at more than 30 percent of the total harvest, largely attributed to poor storage infrastructure, inadequate technology, and farmers' limited skills, and grains such as maize, rice, and beans lose 15 to 25 percent to pests, moisture, and poor storage (FAO, 2023; Affognon et al., 2015). Aflatoxin, a toxic compound produced by Aspergillus flavus and Aspergillus parasiticus, contaminates maize and groundnuts at both pre-harvest and post-harvest stages, is classified as carcinogenic, mutagenic, and capable of causing developmental harm, with particularly severe consequences for young children's growth and immune function (FAO, 2023; WHO, 2018). This article synthesises peer-reviewed evidence published between 2000 and 2025 on postharvest losses, aflatoxin, and safe storage in SSA, with emphasis on hermetic storage, drying, and food safety, drawing on comparative lessons from the United States and Australia. Evidence shows that farmers in SSA face losses exceeding 25 percent due to improper storage, that airtight storage held weight loss under 3 percent where ordinary bags lost about 40 percent, and that hermetic bags in Kenya slashed losses by up to 80 percent. In Makueni, Kenya, maize stored in hermetic bags remained free from insect infestation and weight loss due to insect damage was below 1 percent. In northern Benin, maize stored in hermetic bags did not suffer further damage or lose weight due to insects after seven months. In Nigeria, hermetic storage using PICS bags and metal silos cut weevil and moisture losses from 30 percent to under 2 percent. Ghana loses about USD 1.9 billion worth of agricultural produce annually through postharvest losses, with cereals accounting for about USD 141 million. The article reviews causes, technologies, food safety limits, economics, and adoption, and it proposes a practical, low-cost safe storage system for smallholders. The central argument is that postharvest loss is not inevitable, and that drying to below 14 percent moisture, hermetic storage, and simple aflatoxin testing can turn grain from a health risk and a distress sale into safe food, seed, and income that lasts for months.

Keywords: *postharvest losses; aflatoxin; hermetic storage; PICS bags; food safety; sub-Saharan Africa.*

1. Introduction

A farmer who grows a good crop can still go hungry if grain is lost in storage. In SSA, grain that goes into storage too wet, or into a store that lets in moisture, pests, and warm air, loses both weight and value, and damp grain is exactly where aflatoxin, a toxin produced by moulds, gets its start (FAO, 2023). Across SSA, roughly 15 to 18 percent of the maize harvest is already lost after cutting, much of it in storage and much of it avoidable, and in Kenya postharvest losses claim more than a million tonnes of grain a year, worth over Sh33.5 billion.

Yet postharvest loss is often neglected in favour of increasing production. Extension focuses on seed and fertiliser, research focuses on yield, and policy focuses on production, while storage, drying, and food safety receive less attention and funding. The result is that farmers sell grain immediately after harvest, at low prices, to avoid losses, then buy grain later at high prices, losing income twice. Worse, grain that is stored poorly becomes

contaminated with aflatoxin, which causes liver cancer, stunting, and immune suppression, especially in children, and which causes rejection of grain by processors and exporters.

This article asks three questions, from a comparative perspective across Ghana, the United States, and Australia, three countries with very different storage systems but shared food safety principles. First, where and why are postharvest losses highest, and how large are they? Second, how does aflatoxin contaminate grain, and how can drying, hermetic storage, and testing reduce it? Third, what support, in technology, finance, markets, and policy, makes safe storage more likely and more durable, especially for women who manage grain storage? The synthesis concentrates on maize and groundnuts, where evidence is strongest, while drawing on rice, sorghum, and beans where relevant.

2. Where Losses Happen: Harvest, Drying, Shelling and Storage

Losses happen at every stage, not only in storage. At harvest, grain is lost to shattering, birds, and rodents, and to delayed harvest when rains or labour shortages leave grain in the field. At drying, grain is often dried on bare ground, where it is contaminated with soil, stones, and mould, and where drying is slow and uneven. At shelling, grain is damaged by beating, with broken kernels more vulnerable to insects and mould. At storage, grain in traditional barns and non-hermetic polypropylene bags is attacked by weevils and moulds within weeks, while high humidity causes aflatoxin contamination.

In Ghana, a survey of 800 farmers in forest and savannah zones found that everyday field and storage routines kept aflatoxin risk alive, with differences in how farmers grew, harvested, dried, shelled, sorted, and stored maize related to aflatoxin levels. In Nigeria, grains kept in traditional barns and non-hermetic bags are attacked by weevils and moulds within weeks. In Kenya, grain that goes into storage too wet, or into a store that lets in moisture, pests, and warm air, loses both weight and value. The common thread is moisture: grain above 14 per cent moisture is vulnerable to mould, insects, and aflatoxin, while grain below 14 percent, ideally 12 to 13 percent, is much safer.

Losses are not only quantitative, but also qualitative. Insect-damaged grain loses protein, fat, and vitamins, mouldy grain loses taste and safety, and aflatoxin-contaminated grain loses market value, because processors reject it. In Rwanda, an assessment by a maize processing plant showed it was rejecting 50 percent of maize it received because of aflatoxin contamination, even though Rwanda produces about 500,000 metric tonnes of maize annually. In Nigeria, a 2026 survey detected total aflatoxins in 92.2 percent of 90 composite maize samples, with mean 39.58 micrograms per kilogram, well above the East African limit of 10 micrograms per kilogram and the EU limit of 4 micrograms per kilogram.

3. Aflatoxin: Health, Trade and Limits

Aflatoxin is a toxic secondary metabolite produced primarily by Aspergillus flavus and Aspergillus parasiticus, major contaminants of maize and groundnuts that pose significant food safety and public health risks in SSA (WHO, 2018; FAO, 2023). Aflatoxin contamination of staple grains has been linked to hepatocellular carcinoma (liver cancer) and other adverse health outcomes, and low-resource food environments in SSA are particularly vulnerable. In Niger State, Nigeria, aflatoxins were detected in all maize composites, from 0.03 to 683 micrograms per kilogram, with aflatoxin B1 exceeding EU limits in 75 percent of composites and total aflatoxins exceeding limits in 72 percent. In Zimbabwe, maximum aflatoxin in maize was 1,369 micrograms per kilogram, and in Kenya and Uganda, extreme contamination events exceeding 2,000 micrograms per kilogram have been observed.

Aflatoxin is a moisture problem, but also a pre-harvest problem. Drought stress, insect damage, and late harvest increase aflatoxin in the field, while poor drying and storage increase it after harvest. The problem is most acute in tropical climates with recurrent drought, conditions that favour fungal growth in standing crops. Children are most vulnerable, because they eat more food per body weight, and because aflatoxin impairs growth and immunity. Aflatoxin also affects trade: Kenya caps total aflatoxins in maize at 10 parts per billion, in line with Codex and East African Community standards, and the EU allows just 4 micrograms per kilogram, so grain that exceeds limits cannot be exported or sold to formal processors.

In the United States, aflatoxin is controlled by drying, by testing at elevators, and by blending and diversion of contaminated grain, with strict limits for human food and animal feed. In Australia, aflatoxin is controlled by drying, by monitoring in peanut and maize industries, and by biocontrol with atoxigenic Aspergillus strains, similar to Aflasafe used in SSA. Lessons from both countries are relevant: testing, even simple rapid tests, can prevent contaminated grain from entering food chains; drying is the first line of defence; and biocontrol, such as Aflasafe, can reduce aflatoxin in the field by competing with toxigenic strains.

4. Hermetic Storage: How It Works and How Well It Works

Hermetic storage works by sealing grain in airtight containers, such as Purdue Improved Crop Storage (PICS) bags, SuperGrainbags, AgroZ bags, EVAL bags, or metal silos, which block air and moisture, preventing pest infestations without chemicals (Affognon et al., 2015; Baoua et al., 2014). Insects in sealed grain consume oxygen and produce carbon dioxide, suffocating themselves, while moulds cannot grow without oxygen and moisture. Hermetic bags maintain stable moisture levels, preventing growth of fungi such as aflatoxin, which would otherwise contaminate grain. The Purdue Improved Crop Storage bag, developed by Purdue University in the United States, is now widely used in SSA, with investment in production, distribution, and use of hermetic storage technology.

Evidence for hermetic storage is strong and consistent. Scenario studies with standard storage, standard storage

with pesticides, and hermetic bag storage show significant losses by insects after 100 days for standard and standard with pesticides, whereas with hermetic bags, losses are kept to a minimum of 2 percent. In Kenya, hermetic bags slashed losses by up to 80 percent, with greatest gains for maize, and farmers can keep grain pest-free for over two years without chemicals. In Makueni, Kenya, maize stored in hermetic bags remained free from insect infestation and weight loss was below 1 percent. In northern Benin, maize in hermetic bags did not suffer further damage or lose weight after seven months, with no weight loss or insect damage in hermetic bags compared with damage in polypropylene bags. In Tanzania, AgroZ hermetic bags recorded lowest weight loss of 0.6 percent and grain damage of 1.35 percent over 180 days.

Hermetic storage also preserves seed viability, reduces aflatoxin contamination, maintains grain quality, and allows farmers to store grain for months and sell when prices are higher, rather than selling at harvest at low prices. If starting contamination is low and maize is dried to below 14 percent, aflatoxin does not cause problems in regular bags, but hermetic bags provide an extra safety margin, especially when drying is imperfect. The key is to dry first, then seal: hermetic bags cannot make wet grain safe, and wet grain sealed in hermetic bags can still develop mould and aflatoxin.

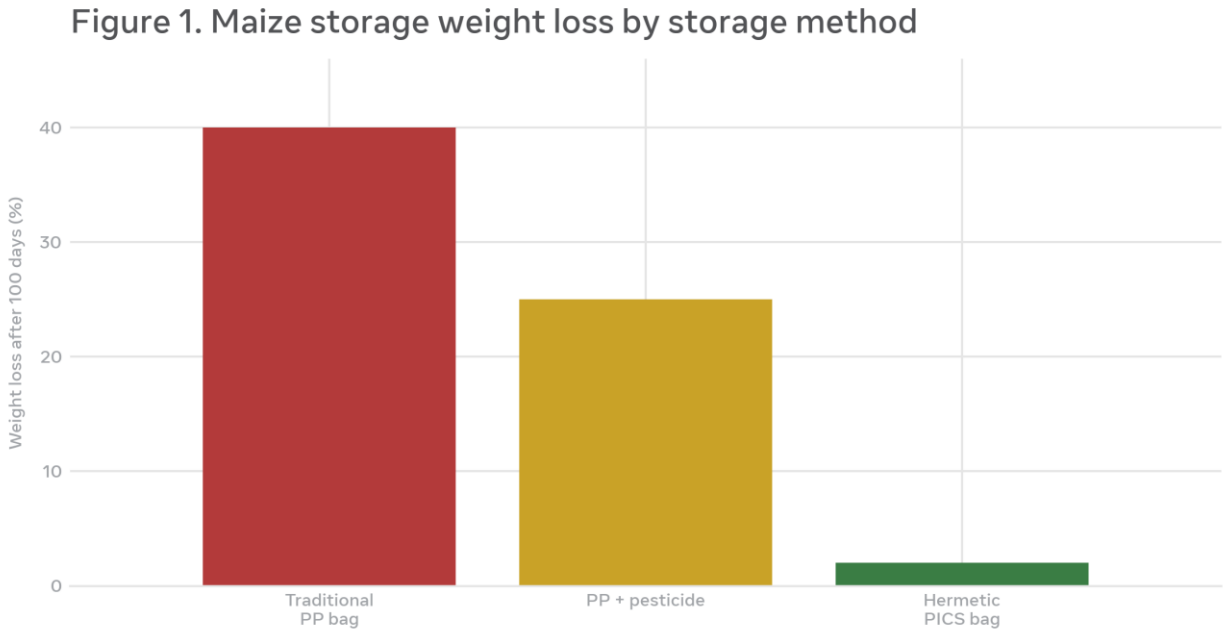


Figure 1. Maize storage weight loss by storage method. Traditional polypropylene bags lose about 40 percent after 100 days, while hermetic PICS bags lose only about 2 percent.

5. Drying, Sorting, Testing and Other Technologies

Drying is the first and most important step. Grain should be dried on clean tarpaulins, raised platforms, or solar dryers, not on bare ground, with regular turning, and with moisture tested by bite test, salt test, or moisture meter. In Ghana, hermetic bags proved most ef fective in reducing insect-damaged kernels, maintaining stable moisture, and preserving protein and fibre in maize, compared with other storage packages. In the United States, grain is dried with heated air dryers to 13 to 14 percent, with moisture meters at elevators, while in Australia, grain is dried in silos with aeration, with moisture monitoring and temperature control. For smallholders, a simple moisture meter, shared by a cooperative, can be more valuable than a new bag, because it prevents sealing wet grain.

Sorting and cleaning also matter. Damaged, broken, and mouldy kernels should be removed before storage, because they are the source of insects and mould. Hand sorting, winnowing, and sieving can remove 50 percent or more of aflatoxin, because aflatoxin is concentrated in damaged and discoloured kernels. Testing, even simple rapid tests, can identify contaminated grain before it is eaten or sold. In Rwanda, processors now test maize and reject contaminated lots, showing that testing can create incentives for farmers to dry and store properly, if they are paid a premium for safe grain.

Other technologies include metal silos, which are durable and rodent-proof but expensive, plastic drums, which are airtight but limited in size, and biocontrol, such as Aflasafe, which uses atoxigenic Aspergillus to outcompete toxigenic strains in the field. Aflasafe has been shown to reduce aflatoxin by 80 to 90 percent in Nigeria, Kenya, and other countries, and it is now commercially available in several SSA countries. Combining Aflasafe in the field, with drying, sorting, and hermetic storage after harvest, gives the best protection against aflatoxin.

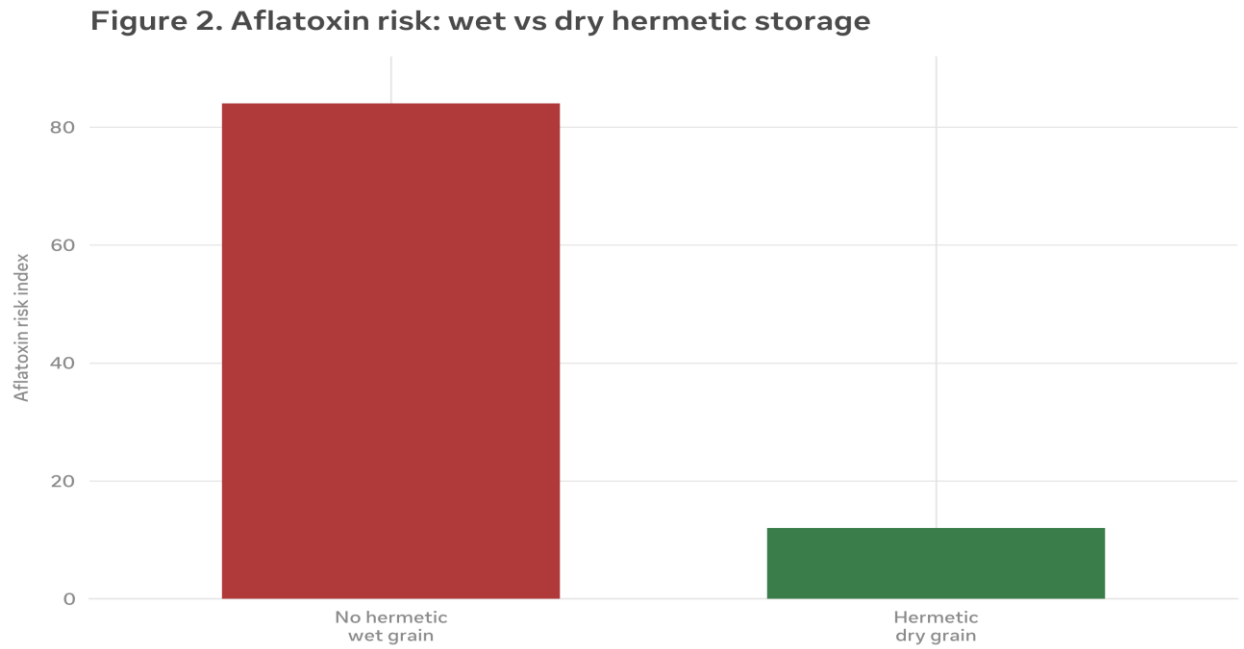


Figure 2. Aflatoxin risk: wet grain without hermetic storage has high risk, while dry grain in hermetic storage has low risk. Drying first is essential.

Table 1. Postharvest technologies for safe grain storage.

Technology	What it does	Cost / suitability
Drying on tarpaulin / solar dryer	Reduces moisture to <14%	Low, all farmers
Sorting / winnowing	Removes damaged, mouldy grain	Low, labour, all farmers
PICS / hermetic bags	Seals grain, kills insects, keeps moisture	Low-medium, smallholders
Metal silo	Airtight, rodent-proof, durable	High, groups / cooperatives
Aflasafe biocontrol	Reduces aflatoxin in field	Medium, maize / groundnut
Moisture meter / rapid test	Tests moisture / aflatoxin	Medium, cooperatives

Source: Synthesis of evidence reviewed in Sections 4–5. Moisture target is below 14% before sealing.

6. Economics, Gender, Markets and Adoption

Economics must be explicit. A PICS bag costs a few dollars, a metal silo costs tens to hundreds of dollars, and a moisture meter costs tens of dollars, yet the return from reduced losses, higher prices, and safer food can be substantial. In Kenya, hermetic bags slashed losses by up to 80 percent, and in Nigeria, hermetic storage cut losses from 30 percent to under 2 percent, allowing farmers to store grain for 6 to 12 months and sell when prices are 30 to 50 percent higher than at harvest. A farmer who stores 500 kg of maize in hermetic bags, instead of losing 40 percent to insects, saves 200 kg, worth more than the cost of bags many times over.

Markets are as important as technology. Farmers who sell individually, in small quantities, and immediately after harvest, receive lower prices than those who sell through cooperatives, with grading, testing, and bulk transport, at peak demand. Processors and exporters who test for aflatoxin and pay a premium for safe grain create incentives for farmers to invest in drying and hermetic storage , while processors who do not test create no incentive. In Ghana, hermetic storage is described as an untapped solution to postharvest losses, with WFP estimating losses of USD 1.9 billion annually, yet adoption remains low because bags are not always available, farmers lack training, and markets do not always reward quality.

Gender matters. Women often manage grain storage, drying, and sorting, yet they may not control decisions about bag purchase or grain sale. Programmes that channel bags, training, and credit through women's groups, and that ensure women have rights to stored grain and income, are more likely to reach those who actually manage storage and to sustain adoption. In the United States, women farmers are increasingly managing grain storage and marketing, while in Australia, women are active in grain handling and quality assurance, showing that gender-inclusive storage programmes are relevant globally.

Table 2. Barriers to safe storage adoption and what helps.

Barrier	Why it matters	What helps
Wet grain sealed	Mould still grows	Dry to <14% before sealing
Bags not available	Cannot buy at harvest	Stock before harvest, cooperatives
No testing / premium	No reward for quality	Processors test, pay premium
Cost of silo / meter	Too expensive alone	Group purchase, shared meter
Knowledge	Wrong use of bags	Extension, demo, farmer-to-farmer

Pests boring bags	Prostephanus truncatus	Double bags, metal silo, inspect

Source: Synthesis of evidence reviewed in Section 6.

7. Research and Policy Priorities

Several gaps remain. First, long-term, multi-location trials that measure not only weight loss but also aflatoxin, nutrition, income, and health over multiple seasons are still scarce. Second, research on hermetic bag durability, on Prostephanus truncatus boring, and on aflatoxin in hermetic storage with different moisture levels should be prioritised. Third, research on Aflasafe, on drying, and on testing should be embedded in postharvest programmes, not treated as separate. Fourth, research on gender, labour, and economics should be embedded in storage trials.

Policy should align incentives with safe storage. Public investment should support extension, demonstration, and training on drying, sorting, and hermetic storage, with bags and moisture meters available at village level. Food safety policy should enforce aflatoxin limits, with testing at markets and processors, and with premiums for safe grain. Trade policy should harmonise aflatoxin limits across East, West, and Southern Africa, so that safe grain can move across borders without rejection. Regional coordination, through FAO, WHO, and national programmes, can ensure that food safety is not a project, but a permanent part of food systems (FAO, 2023; WHO, 2018).

8. Conclusion

Postharvest losses and aflatoxin are not inevitable, and safe storage offers a practical, low-cost, and high-return path to more food, safer food, and higher income for smallholders in SSA, with lessons from the United States and Australia showing that drying, testing, and hermetic storage are the foundation of food safety everywhere. Hermetic bags can cut losses from 40 percent to under 2 percent, preserve seed viability, reduce aflatoxin, and allow farmers to sell when prices are higher, while drying to below 14 percent, sorting, and Aflasafe can further reduce aflatoxin risk (Affognon et al., 2015; Baoua et al., 2014). The challenge is not a lack of technology; it is the challenge of making bags, dryers, meters, and markets available to millions of smallholders, especially women who manage grain storage. If that is achieved, postharvest storage can turn from a source of loss and poison into a source of safe food, seed, and income that lasts for months.

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Conflict of Interest

The authors declare no conflict of interest.

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