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Popular Article

Grain storage practices: Past, Present, and the Future

Tharigoppula Hinduja[1], Banoth Lavanya[2]

[1]M. Sc Scholar, [2]M. Sc scholar, Department of Entomology, College of Agriculture, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India, 751003.

Abstract

Grain storage practices have evolved significantly over time, influenced by both traditional methods and technological advancements. In the past, practices such as solarization, seed treatment with ash, and the use of salt, lime, and natural materials like pongam and neem leaves were commonly employed to protect grains from various stored grain pests. Solarization utilized sunlight to prevent fungal growth, while ash served as an admixture. Salt and lime-controlled moisture and pests, while pongam and neem leaves acted as organic repellents against insects. In contrast, modern grain storage has seen the introduction of controlled atmosphere storage (CAS), which regulates oxygen, carbon dioxide, and temperature to extend grain shelf life. The use of traps and fumigation systems has improved pest control, making bulk storage more efficient and reducing the need for harmful chemicals. Looking to the future, smart storage solutions integrating sensors will enable real-time monitoring and precise control of storage conditions. Advanced preservation techniques like modified atmosphere packaging will further enhance grain longevity. Additionally, robotics and drones will play a critical role in automating inspection and maintenance, improving efficiency, and reducing labour costs. The integration of traditional practices with cutting-edge technologies will create more sustainable, efficient, and environmentally friendly grain storage systems, reducing food waste and optimizing global supply chains.

INTRODUCTION

Grain storage has been crucial for preserving harvests and ensuring food security for generations. In India, postharvest handling and storage losses are estimated at 15% annually, while the FAO reports 10% global losses each year. Pulses are more vulnerable to insect damage (5%) compared to wheat (2.5%), paddy (2%), and maize (3.5%) (Deshpande and Singh, 2001). A lack of farm-level storage facilities contributes to waste and value loss (Ramesh, 1999). Storage losses affect both quantity and quality, with pests, rats, mites, and microbes consuming grain, while infestation reduces seed germination, increases moisture, and lowers protein content. These quality losses result in farmers receiving lower prices for their crops (Ipsita *et al.,* 2013). Over time, various strategies, from traditional methods to modern technology, have been developed to minimize these losses and protect grain quality.

Traditional grain storage practices:

Solarization: Solarization is a simple sun-drying technique to reduce grain moisture content. To check if the grains are sufficiently dried, they are chewed, and the drying time is adjusted accordingly. Exposing grains to the sun for 24 hours kills *Callosobruchus chinensis* eggs and grubs in infested green gram, with complete grub mortality in black bags (Kiruba *et al.,* 2008).

Seed treatment with Ash: The sorghum seeds were mixed with ash at a 1:4 ratio and sealed in jute gunny bags. Farmers believed ash application reduced storage losses by up to 80% (Karthikeyan *et al.,* 2009). This technique allowed farmers to store sorghum for 6 months without pest issues. Ash also controls pulse beetle (*Callosobruchus maculatus*) in stored pulses for up to 8 months.

Usage of salt: According to Jeeva *et al.,* (2006), *Cajanus cajan* and *Phaseolus vulgaris* were stored in salt for 6-8 months. 1 kg of each legume was mixed with 200 g of salt and sealed in jute bags. The salt's abrasive action inhibits insect movement, preventing infestation and population growth inside the storage container.

Use of Pongamia leaves: Pongamia leaves reduce stored grain pests due to their natural bioactive compounds like flavonoids and alkaloids. These leaves act as repellents to rice weevils (*Sitophilus oryzae*) and rice grain moths (*Sitotroga cerealella*).

Usage of camphor: Camphor emits volatile compounds that are believed to have neurotoxic effects on pests, disrupting their behaviour, reproduction, and feeding. Typically, 1 g of camphor is added to 5 kg of grains (Karthikeyan *et al.,* 2009).

Use of Neem leaves: Storage pests, including pulse beetles (*Callosobruchus maculatus*) and lesser grain borers (*Rhyzopertha dominica*), are attracted to oilseeds and pulses. To address this, farmers stored neem (*Azadirachta indica*) leaves in gunny bags with their grain (Bala, B., & Neon, p. 21.).

Dipping of jute gunny bags in NSKE: According to Karthikeyan *et al.,* (2009), 10 kg of neem seed kernels were ground and steeped in 100 L of water for 24 hours. The extract was then filtered, and jute gunny bags for storage were soaked in the NSKE solution for 30 minutes and shade-dried. Seed materials of cereals, pulses, and oilseeds were stored in these treated bags.

Use of lime: Farmers dusted 10 grams of lime per kg of grain, mixed it well, and stored the grains in jute bags. The lime's unpleasant odour repelled insects and protected the grains. For example, lime effectively protects rice grains against the 1st instar larvae of *Sitotroga cerealella* (EI-Wareth, A. 2016).

Modern grain storage practices:

Controlled atmosphere storage: Low O_2 atmospheres, used to disinfest grain, typically contain less than 1% O_2, with the remaining gases being N_2, CO_2, or inert gases. Their main feature is the O_2 deficiency, and the other gases mainly affect the atmosphere's anoxic nature. It was once believed that CO_2 in low O_2 atmospheres played a role, but this has been disproven. In contrast, insecticidal high CO_2 atmospheres have enough O_2 to sustain life if CO_2 is replaced by N_2 and typically contain at least 20% CO_2, often more than 60%. Insects show a shift at around 3% O_2, with atmospheres under this threshold displaying low O_2 characteristics, not high CO_2. CO_2 effects on molds and grain seem independent of O_2 levels, allowing atmospheres like 95% CO_2 and 5% air (1% O_2) to be both low O_2 and high CO_2 (Banks & Annis, 1990).

Use of traps in storage: Collins *et al.,* (2008) evaluated a multi-species bait to attract various grain beetle pests using two types of dispensers in real-world conditions. The beetles tested were *Cryptolestes ferrugineus*, *Sitophilus granarius*, and *Oryzaephilus surinamensis*. Over six weeks, the lures were placed in grain and surrounding areas, and the amount of attractant released was measured. The first dispenser attracted *O. surinamensis* and *C. ferrugineus*, but fewer *S. granarius* than control traps. The second dispenser released attractants more steadily, drawing *O. surinamensis* and *C. ferrugineus* in grain bulk traps, and *O. surinamensis* and *S. granarius* in surrounding traps.

Fumigation: Fumigation is a widely used method for controlling pest infestations in grain storage. It involves applying chemical gases, or fumigants, that penetrate the grain to eliminate insects, mites, and other pests. Phosphine and methyl bromide are the most commonly used fumigants in this context. Phosphine is particularly favoured due to its effectiveness against a broad range of storage pests, low toxicity to humans when used correctly, and its ability to dissipate without leaving harmful residues.

Advancing grain storage practices:

Smart Storage Solutions: The future of grain storage lies in smart storage systems. These systems will rely heavily on smart devices to monitor environmental conditions in real time, adjusting the conditions automatically. Sensors can track moisture levels, temperature, and even pest activity, ensuring optimal storage conditions and minimizing waste. Automated alarms can be used to identify the rodents as well as bird pests in large storage structures.

Advanced Preservation Technologies: Research into non-chemical preservation methods, like nanotechnology and radio-frequency treatments, could provide ways to preserve grains without the need for harmful chemicals. These technologies would prevent pest infestations and spoilage without impacting grain quality.

Robotics and Drones: Drones or robots might be used for monitoring large storage facilities or for automating the movement of grains in and out of silos, reducing the need for manual labour and improving efficiency. Robots/drones could also be used for targeted pest control inside storage facilities, reducing the need for chemicals and pesticides.

CONCLUSION

Grain storage practices have undergone a significant transformation, moving from traditional, organic methods to advanced, technology-driven solutions. While past methods focused on using natural materials and environmental factors to preserve grains, modern innovations have introduced controlled environments and automated systems to optimize storage conditions. The future of grain storage holds promise with smart technologies such as nanotechnology, which will further improve grain preservation and efficiency. By combining the best of both traditional and modern approaches, the future of grain storage promises to be more sustainable, cost-effective, and capable of addressing global food security challenges.

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