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# Novel technique: Hermetic storage and its application

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**Abstract**
They Food grains manufacturing has been improved everywhere in the global over ultimate decades. Grain is kept in variety of ways, including gunny bags, warehouses, containers, and even mounds on the ground. The interaction of physical, chemical, and organic forces reasons the saved grain to deteriorate. The same amount of grain loss occurs through the attack of insect and pest. Traditional storage methods have some limitations, which is why novel methods, such as heremetic storage, are utilised to circumvent these limitations.
Heremetic storage, additionally recognised as "airtight silos" and "Volcani Cubes," has been growing in popularity for insect manage and grain high-satisfactory preservation from 1980. The goal of this unique grain storage method is to provide guidance for reducing grain post-harvest losses and increasing storage life. Hermetic storage (HS) technology has developed as a viable alternative to existing techniques of preserving goods against insects and mould.

**Keywords:** hermetic storage, modified atmosphere, control atmosphere, grain storage

## Introduction
Food, water and refuge are 3 simple desires of human being. Cereals and legumes typically called grains compose the most essential diet component for the majority of people in the world (Duranti, M. (2006); Rajashekar *et al*., (2016) [10, 28]
Increase in grain manufacturing frequently is because of improvement in distinct current technology beginning from genetically development to progressed cultivation practices. But due to lack of storage facility, insect Rodents and pest infestation occurs due to this losses of grain from 10 to 20 percent of overall production occurs throughout the country. (Phillips and Throne, (2010). (Jonfia-Essien *et al*., (2010) [25, 15]
Natural contamination of food grains in India causes loss about 30 percent of grains on today. (Nwosu., (2016) [23]. FAO Evaluate global annual losses in stored produce had been given as 10 percentage of all stored grain (Parfitt *et al*., (2010) [24].
According to World Bank Report, India is dropping approximately 12- 1 6 million metric tonnes of meals grains every year. Grain is the essential consumer goods for human. Being the a part of each day diet, it in large part modulates economy. Food grain manufacturing is the important thing a part of the monetary and soicial development. Therefore, grain researchers from distinct international locations try to work out advanced scientific grain storage techniques and facilities. A grain saved well is equal to a grain produced. Every year, India produces approximately 259.32 million tonnes of meals grains (FAO, 2012).
Farmers store roughly 60-70 percent of food grains for their own usage. Farmers in India choose to keep meals grains in traditional ways, using various storage structures created from locally available materials. While huge farmers keep meals grains in government-run storage centers such as the Food Corporation of India. There are numerous elements which might be accountable for losses of meals grains consisting of environmental factor, type of storage structure used, length and purpose of storage, method of storing grains. The environmental factor encompass temperature, moisture content material of grains, pH, humidity, etc. Other organic elements are insects, pests, microorganisms and rodents. During storage, vast qualitative and quantitative losses arise because of the ones organic elements. jowar, maize, wheat, barley, paddy, millets, sesame, soybean, groundnut, sorghum, black gram, gram, lintel (tur, arhar) and beans are usually store in storage structure in India. Polythene/plastic bags, fertiliser bags, gunny bags, jute bags, stacks of grains in a room, metal bins, Pucci Kothi, Bukhari, Theka, and underground storage are common grain storage structures.
Weather (40 percent), field damage (33 percent), and storage pests (16 percent) are the three most major reasons responsible for low crop yield and increased food losses in grain examined

by farmers. However, the results of the survey suggest that the food losses are mostly due to farmers' lack of knowledge and abilities in postharvest management (Abbas *et. al*., 2014) [1].

Most of physiological, physical and environmental reasons of postharvest losses are excessive crop decaying ability, mechanical damage, exposure to excessive ambient temperature, relative humidity, rain, infection via way of means of spoilage throuh fungal and bacteria, invasion via way of means of birds, rodents, bugs and different pests and insufficient handling, storage and processing techniques. (Jain *et al*., (2000) [12].

The demand from clients for chemical-unfastened and insect-unfastened products has heightened interest withinside the use of non-residue natural era to protect stored grain. Manipulation of modified atmospheres (MAs) through the use of biogenerated MAs, heremetic storage for insect control and best maintenance of seeds, stored paddy, polished rice, wheat, pulses, cocoa or espresso beans, and excessive moisture corn are most of the new gaseous utility technology which have correctly replaced fumigants. This takes advantage of the gas composition produced by respiratory metabolism in the atmosphere.

**Heremetic storage**

Hermetic storage is a subtype of modified atmosphere (MA) that has been used to store agricultural commodities such cocoa beans, coffee, rice, corn, pulses, and seeds. (Navarro *et al*., (1984); (1993); (1995) [20, 18, 21]; Varnava and Mouskos., (1997) [33]; Navarro., (2006) [19]; Sabio *et al*., (2006) [30]. A number of important commodities, such as coffee and cocoa, are now stored in hermetic storage for drying purpose.

Heremetic storage was initially launched in the year 1980, and it is now used in over 80 nations for the storage of high-value commodities. Hermetic storage has become a viable alternative to prior storage methods, particularly in hot, humid areas, due to its "green," chemical-free technology, control of moisture content, pesticide protection, and absence of need for refrigeration.. lt has a 100% “kill” rate for insects and can control mould and free fatty acids (FFA). Due to the lack of oxygen, heremetic storage lowers gas exchanges between the internal and external environments, as well as between the stored grains, maintains the initial moisture level, and keeps pests free. Because of growing concern over the use of pesticides that are dangerous to fumigators, the environment, and purchasers, thats why use of HS has increased in recent years. Airtight or sealed storage is referred to as "hermetic storage" or "sacrificial sealed storage." This kind of bio-generated modified atmosphere storage device is also called as "hermetic silo storage" or "assisted hermetic storage" (MA). The strategy permits insects and other aerobic animals in the commodity, as well as the commodity itself, to produce the modified atmosphere by reducing oxygen (O2) and enhancing carbon dioxide (CO2) concentrations through respiratory metabolism. The respiration of living things creates an atmosphere with 1-2 percent oxygen and around 20% carbon dioxide. (White and Jayas., (2003) [38].

HS is based on the concept of significantly reducing moisture to a sufficient level and allowing for a decrease in oxygen with a sufficient increase in CO2 through the process of grain and insect respiration in the atmosphere system of a sealed storage (calderon *et al*., (l980); Villers *et al*., (2008) [8, 35]

The majority of researchers explore various atmospheric components for grain preservation (Adler *et al*., (2000) [2]; Navarro.,(2006) [34]. Airtight or hermetic storage has been successfully applied to retain grain quality in India, South America (Argentina), and North Africa. Modified atmospheres (MA) and controlled atmospheres (CA) are an alternative to using residue-producing chemical fumigants to control insect pests attacking stored grain, oilseeds, processed commodities, and some packaged goods for managing insect pests. ln addition to preventing fungal development, the CA system ensures product quality.

Molding and fast putrification are caused by harvested grains in humid and warm surroundings. As a result, harvested grain is dried at a safe moisture level to cease microbial activity. Farmer’s in poor nations are unable to dry to these moisture levels. In warm and humid locations, protecting grain at an intermediate moisture level in a hermetic storage environment may be feasible and cost-effective.

The metabolism of pests and insects is affected when grains are stored in an air-free or air-tight environment, as it is in hermetic storage (Bhardwaj., (2015) [7]. Carbon dioxide and oxygen depletion happen in hermetic storage as a result of carbon dioxide collection and oxygen depletion generated by grain breathing or other abiotic or biotic processes. It results in deficiency of oxygen inside the storage so the buffer of carbon dioxide and oxygen exists in the hermetic storage to allow breathing of the grain like wheat.

Heremetic storage treatment are equal to typical fumigants in terms of insect control (over 99.9°/c death) and insect activity losses are minimal. 15-month storage duration) (Navarro *et al*., (1984) [20]; Varnava., (2002) [32].

Insect and mite pests are killed in low O2 and high CO2 environments, while aerobic fungi are prevented from forming (Weinberg *et al*., 2008) [37].

CO2 levels that are too high and 02 levels that are too low will keep grain quality in storage for a long time. Cereals, oilseed grains, pulses, cocoa, and coffee, can be safely stored for months while maintaining good quality and restricting the formation of moulds and mycotoxins.

A natural metabolic process based on insect respiration and in conditions when the commodity has adequate moisture, the respiration of microorganisms within a sealed storage system, produces a sufficiently low oxygen and higher Co2 environment.

Through genetic activity associated to gas exchange of exhaling grains and organisms, the available oxygen in the cetral atmosphere is limited to a lethal level for any living animal, allowing heremetic storage, a technique for reducing insect and fungal attack on stored food. Heremetic storage allows for organic storage without the usage of pesticides. (Bailey *et. al*., (1955). Quezada *et al*., (2006), Rupollo *et al*., (2006) [6, 26, 27]

In addition, the moisture levels in HS stay constant, avoiding grain mould formation. High moisture maize was effectively preserved under hermetic conditions, keeping its quality before being dried or processed into feeds or ethanol.

Hermetic storage of wheat grains and other commodities is achieved in specially constructed plastic enclosures. Flexible plastic foundations have been designed for long-term storage. A growing variety of hermetic containers are being developed specifically for tropical environments. The following are examples of hermetic containers:

1) Super Grainbag, a small-scale storage system for 60kg to 2 tonnes that fits into compact portable containers.
2) Grain Safe II, a bulk storage system with daily grain withdrawals ranging from 1 to 2 tonnes for residential or farm use.

3) Cocoons, which seem to be flexible storage containers with capacities ranging from 5 to 1,050-tonnes and are suited for farmer-cooperative and small trader storage as well as larger commercial and strategic storage facilities.
4) Hermetic Tunnels for long-term storage of bulk materials weighing 10,000 to 20,000 tonnes.
5) Tran Safeliners are used in the intercontinental shipment of bagged commodities in containers to provide quality preservation, insect control, and condensation prevention.

**Storage component design and fabrication**

Using hermetic storage containers such as metal silos (soldered airtight) and super grain sacks, farmers may be able to reduce postharvest losses (made of high density polyethylene to reduce gas exchange). Metal silos are extremely efficient, but they are also extremely costly. The cost per kg of grain kept is high because the metal sheet accounts for half of the cost.

Reduces in proportion to the volume of the container As a result, a cost-benefit analysis is needed to determine the size at which silos become economically viable under various price scenarios. (de Groot and Mazur., 2013) [9].

Storage structures and enclosures were created for hermetic storage. Modern hermetic storage systems (HS) for cocoa and other commodities use very low permeability flexible plastic enclosures. These hermetic storage containers have expanded to store a variety of dry commodities ranging in weight from 60 kg to 10,000 tonnes. They became commercially available in the early 1990s and are presently utilised in more than 38 countries in various configurations. The Cocoon is the most common type of HS (Fig. 1).

**Fig 1:** Cocoon

**Fig 2:** Hermetic warehouse storage of corn

**Advantages of Hermetic Storage Over Traditional Method**

1. The creation of Modified Atmosphere in a way that is both environmentally safe and feasible.
2. In Hermetic storage there is no need for chemical treatment, fumigants, and climate control.
3. Hemetic storage method is easy to use, and they're now backed up by more scientific data and field experience.
4. The installation HS units is easy.
5. HS gives protection against rodents
6. It is cost-effective an low operating cost than other storage method.
7. Relocation is simple, and infrastructural requirements are minimal. (Villers *et al*., (2006) [34]
8. Hermetic storage enables for long-term storage, ranging from weeks to months, as well as global shipping.
9. Hermetic storage maintains moisture levels consistent and protects cocoa beans without the need of chemicals, cold storage chambers, or refrigeration.10. Labour requirements Heremitic storage is lower than other method.
10. Quick handling and all operations can be mechanically operated
11. Requirement for less land area for Hermetic storage.
12. Complete aeration control for this storage system.

**Technology for Hermetic Storage**

The requirement to achieve one or more of the three aims outlined below promotes the use of hermetic storage:

1. Low oxygen, high carbon dioxide conditions to avoid infestations (moulds and insects).
2. Preventing moisture from entering
3. Protection against rodents

**Applications of Hermetic Storage**

Multi-month cocoa storage and trans-oceanic transit are two large-scale applications of hermetic storage. As previously stated, the five most important areas of today's commercial application of hermetic storage are seed protection and the storage of rice, maize, pulses, cocoa, and coffee. There are also a few less typical applications, such as fig storage and disinfestation. (Ferizll & Emekci 2000) [11], injection of CO2 or N2 into narcissus bulbs, and even disinfestation of archaeological objects

**Cocoa**

Cocoa According to the Transport Information Service (TIS 2009) [31], a moisture level of more than 8% in cocoa beans corresponds to a relative humidity of 75% for rapid mould growth. When carrying cocoa beans in containers, it is therefore suggested to insist on a water content of no more than 6%. Insect infestation, the growth of cancer-causing aflatoxins, and the growth of free fatty acids (FFAS) are all issues that must be addressed when storing cocoa. Cocoa was successfully preserved in 150-tonne Cocoons for 9 weeks by the Ghana Cocoa Board (Cocobod) (Jonfia-Essien., (2008a) [13]. They also tested the storage of cocoa beans in traditional 70kg jute bags with hermetic SuperGrainbag (SGB) liners. Except for one single bag in which a few individual insects were alive after 30-days of storage, all cocoa beans stored in all SGB liners showed 100% death of insect populations, with the exception of one single bag in which a few individual insects were alive (Jonfia-Essien., 2008b) [14]. Cocoa is currently hermetically kept in Brazil, Indonesia, and Ghana. The respiration rates of cocoa beans in hermetically sealed

containers at an equilibrium relative humidity of 73 percent at 26 ºC reduced the oxygen content

**Protecting High Quality Coffee**

Heremetic storage firstly used for a green coffee beans commercially from a year 2001 at the Monte De Oro Cooperative in Costa Rica, with 10-tonne Cocoons protecting the green coffee beans for 6 month to a year. Coffee preserved in hermetic Cocoons was widely regarded as excellent.

Coffee is a seasonal crop that requires the ability to keep for up to a year. In hot, tropical conditions, storage degradation is especially noticeable. We all know that coffee is sensitive to high temperatures and requires aeration to cool. However, field data from Costa Rica indicates that simply restricting the entry of external humidity is enough to keep coffee bean quality for up to 9 months. (Aronson *et. al*., (2005) [5].

In a 2005 experiment carried by Café Britt in Costa Rica for a period of 5 month storage of coffee beans he found that waherhouse temperature changes over an 18ºC range and relative humidity changes from 33% to 89%. As a result of these alterations, humidity formed within the control containers, the coffee bags became moist, and fungal contamination and the formation of ochratoxin A (OTA) occurred.

Temperatures inside the Cocoon ranged from 21 to 25.6$^0$Fahrenheit, with humidity ranging from 54.2 to 57.4 %. (Aronson., (2005) [5] Green coffee with more than 8ug/kg of OTA cannot be imported into several countries. Coffee should be dried below the critical moisture level, which is 11.5 percent for green coffee and 12.5 percent for parchment coffee, to ensure safe storage. Small producers and shippers may now store quality coffee in portable, airtight containers thanks to the invention of the SuperGrainbag in 2005. These SuperGrainbags are presently used by a large number of growers in 12 countries, including the mainland United States and Hawaii, Costa Rica, El Salvador, Ethiopia, Guatemala, Honduras, Indonesia, Jamaica, Kenya, and Peru. Although, unlike other commodities, coffee does not undergo a considerable loss in oxygen levels when stored hermetically, the capacity to maintain constant humidity is vital, and volatile retention may also be important. When the TranSafelinerTM was initially introduced in 2008, Neumann Kaffee Gruppe in Guatemala was one of the first to ship coffee in normal 20-foot containers utilising the TranSafeliner, which has been demonstrated to give hermetic protection.

**Hermetic Storage of Rice, Rice Seeds, Rice Bran and Other Seeds**

In a number of Asian countries, hermetic storage is now employed for rice, rice seeds, and rice bran. Rice and maize have been the two most extensively employed uses of hermetic storage since the 1990s, according to IRRI (International Rice Research Institute) in Los Banos, Philippines In 2006, the Philippines Bureau of Post-Harvest Research Extension (BPRE) and the Philippine Rice Research Institute (PhilRice) compared hermetic storage to alternatives after storing a high-performance hybrid rice seed termed Mestizo 01 for up to 9 months.

The results showed that cold room storage and hermetic storage performed similarly. Both were shown to be superior to climate-controlled storage and traditional warehouse storage. According to research in Mexico and Bangladesh, hermetic storage keeps rice and maize seed germination at 85 percent or higher for up to 9 months, while regular storage in jute bags reduces germination to 14 percent to 76 percent after three months. As a result, hermetic storage has become popular among some of the world's top rice seed producers. (Villers *et al* 2008 [35], Sabio *et al* 2006 [30])

After 12 months in Cambodia, head rice yields from hermetically kept grains were 10% higher than those from typical open storage, according to the International Rice Research Institute. They also claim that hermetic storage resulted in a 4 to 5% reduction in damaged kernels after six months in Vietnam in 2003. (Rickman and Aquino, 2004) [29] (Villers and Gummert (2009) [36]. Studies in the last ten years have proved the advantages of preserving rice and rice seeds in hermetic storage, which is now well understood and frequently employed, particularly in Asia. (Villers *et al*., 2006) [34]. Cambodia, East Timor, Indonesia, India, Pakistan, Philippines, Sri Lanka, and Vietnam all have hermetic storage applications has been recently used for rice and rice seed.

Because of extensive research at the International Rice Research Institute (IRRI), the benefits of storing both rice and rice seeds in HS are now well known and widely practised, particularly in Asia. Cocoons are used in capacities ranging from 5 to 1000 tonnes at the moment. SuperGrainbags, which are presently available, have been adopted by IRRI. A 150-tonne Cocoon with corn capacity ranging from 10- to 1000-kg is being closed. Their oxygen permeability varies between 3 and 55 cc/m2/day at 23 ºC, depending on the model. SuperGrainbags are inserts for polypropylene or jute outer bags. illustrates a series of such liners constructed of an ultra-low permeability, co-extruded, multi-layer plastic with an inner layer of a proprietary gas barrier. SuperGrainbag liners can be reused.

**Heremetic storage of Maize(Corn)**

After rice, corn (maize) is the second most hermetically preserved product. Hundreds of cocoons are employed to store both shelled and unshelled corn in Rwanda, Ghana, and the Philippines.In Rwanda, Ghana, and the Philippines, dry maize cocoons are commonly used to store both shelled and unshelled maize, with capacities ranging from 50 to 150 tonnes. (Minagri., (2006) [16]. The same quality preservation results were achieved when maize was stored in SuperGrainbags with a capacity of 60 kg. The massive flexible hermetic storage units are generally utilised at the village level, but they can also be used as massive reserves at the district level to avoid malnutrition. (Navarro., 2006 [34]; Montemayor.,2004 [17], Navarro *et al*., 1995 [21]). In 2007, Ghana received 100,000 60kg capacity SuperGrainbags for a variety of uses (mostly maize), including residential use, and they are being available in select retail establishments. Small farmers utilise SuperGrainbags, which have a capacity of 60 kg, for agricultural storage. The SuperGrainbag can be hung or stored in a rodent-proof metal drum or other container. Ghana was given 100,000 SuperGrainbags in 2007 for a variety of uses, including domestic use.

**Preservation of High Moisture Maize**

To avoid microbial activity, harvested grains are usually dried to safe moisture levels. Farmers in developing countries, on the other hand, may not be able to dry their crops to these moisture levels all of the time. In the lab, the effect of different moisture concentrations on the quality of maize grains during hermetic storage under self-regulated changed atmospheres was investigated. (Weinberg *et al*., (2008) [37].

Shelled maize with a moisture content of 26% was stored for 96 days in a Cocoon under hermetic conditions to demonstrate how well it preserved its quality before being dried or processed into feeds or ethanol. Aflatoxin levels in Cocoon high moisture maize began at 59 parts per billion (ppb), increased to 90 ppb after one week of storage, and remained at that level for the duration of the 96-day trial. ((Arnold and Navarro., (2008) [4]. According to experiments, wet maize may be kept for lengthy periods of time without significant increases in aflatoxin or changes in starch content. Another new discovery is that maize with a high moisture content of 37.7% (shelled or unshelled) may be stored for months without aflatoxins accumulating before being used as a source of pelletized animal feed. (Ziggers., 2009) [39].

**Wheat and Barley**

Wheat and barley have been stored for multiple years under hermetic storage of strategic food reserves. (Navarro, 1993) [18]. In Jordan, a 20,000-tonne capacity Bunker was put into service to store wheat in mid-2009. Hermetic wheat storage in "Bunkers" with capacities ranging from 10,000 to 20,000 tonnes was first deployed in the early 1990s. Wheat can be hermetically stored at or below its necessary moisture content of 12.5% for up to two years without significant quality degradation, including the retention of baking qualities. Barley had previously been stored effectively in massive Bunkers in Cyprus and Israel. (Navarro *et al*., 1984; 1993) [20, 18]. Bunkers in Cyprus preserved barley quality for three years, with total losses ranging from 0.66 percent to 0.98 percent and germination rates reaching 88 percent. (Varnava and Muskos., (1997) [33].

**Hermetically Stored Pulses (Beans)**

Storage of Pulses in a Hermetic Environment (Beans) Foreign pests like *Callosobruchus maculatus* and *Callosobruchus chinensis* attack beans in storage, although hermetic storage can help suppress them. Bean storage in Cocoons varying in capacity from 20 to 150 tonnes has allowed farmers in Rwanda and Ghana to keep their crops off the market while waiting for higher market prices. (MINAGRI, 2006) [16].

Foreign pests such as *Callosobruchus maculatus* and *Callosobruchus chinensis,* which are regulated by HS, can be discovered in bean storage. Bean storage in Cocoons has helped farmers in Rwanda and Ghana to keep their crops off the market while they wait for better market pricing, yielding in huge financial gains for farmers that use HS to postpone sales until a better period.

**Conclusion**

Cocoa bean hermetic storage is a very practical and technically possible solution. Hermetic storage is a long-term, cost-effective, user-friendly, and environmentally acceptable technology for seed and post-harvest storage that eliminates the use of pesticides and fumigants. The approach has been used to preserve a wide range of commodities in quantities ranging from a single grain bag to hundreds of tonnes in the past. Hermetic storage applications are expected to rise even quicker in the future as the variety of feasible types of hermetic storage grows and more people experience and appreciate the benefits of this "green" technology.

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