Emerging trends in Indian Post-Harvest Practices of cereals

Vishvendra Singh*[1], Krishna Faujdar[2], Shikha Yadav[3], Kuldeep Tiwari[4], Hoshiyar Singh[5], Kuldeep Sharma[6]

[1,2,3]Assistant Professor, Vivekananda Global University, Jaipur
[4]Associate Professor, Vivekananda Global University, Jaipur
[5,6]Professor, Vivekananda Global University, Jaipur

Corresponding author: vishvendra.ft@gmail.com

ABSTRACT

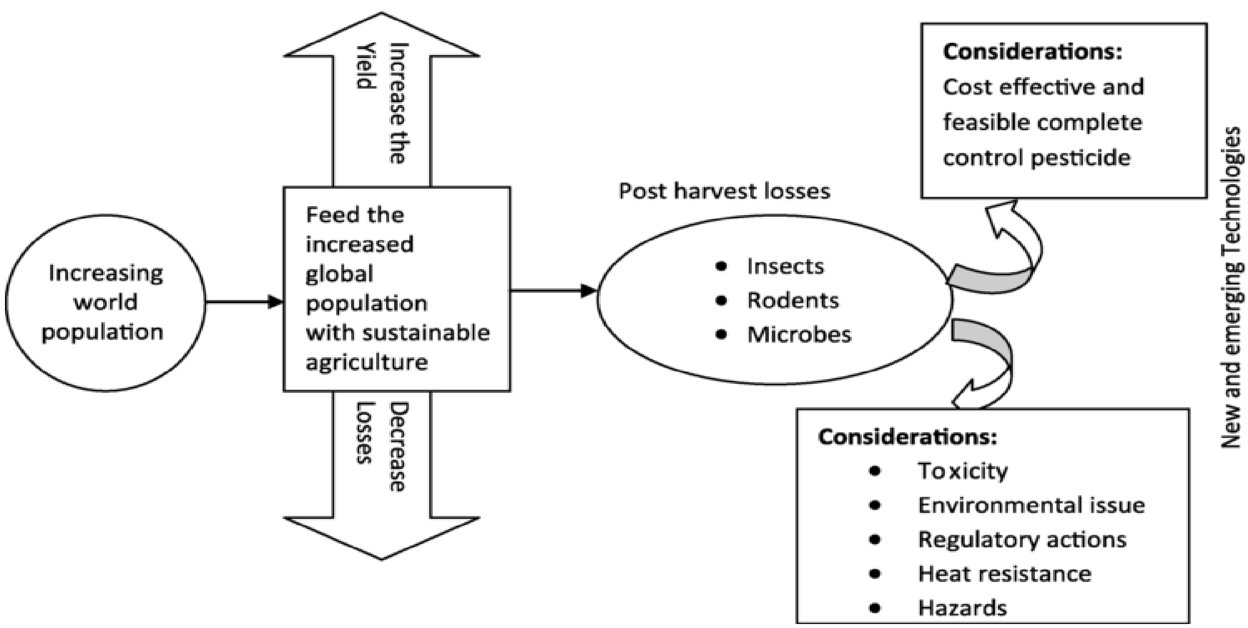
A vital component of human nutrition is cereals. These, which include proteins, calories, vitamins, and dietary fiber, are particularly necessary for their energy source. Cereals are designed to be enjoyed year-round, but they are only grown once. The preservation of this food is required to provide food security and self-sufficiency, particularly given the nation's population expansion. Depending on the location and amount of seeds being stored, many types of buildings are utilized in our area to store grains. These structures are vital to grain conservation because they lessen post-harvest losses. Here we offer information collected universally and carefully from the Living Standards Measurement Study - Integrated Surveys in Agriculture, including farmer-reported post-harvest loss estimates and post-harvest management data. These losses were often attributed to pests and rodents. The majority of grains were stored in bags inside the home, and there were not many better methods in use. Inadequate infrastructure for commodity processing and post-harvest technologies (PHT) is the main causes of post-harvest losses (PHL). The only way to reduce these losses is to use advanced preservation techniques like radiofrequency heating, irradiation, and careful handling, marketing, and processing of agricultural products. In order to improve cereal availability on the market, decrease post-harvest deterioration, and ultimately lower malnutrition for greater food security, it would be helpful to have sufficient knowledge of pre- and post-harvest preservation technologies in addition to adequate and sufficient storage facilities for handling and distributing cereals.

Keywords: Cereal, Dietary fibre, Post-harvest losses, Preservation technologies, Food security.

INTRODUCTION

Grain is a monocotyledon, while legumes are dicots. The grass family, which has more than 300,000 species, includes cereals. Around 50 different varieties, or approximately 51 species, of angiosperms—horticultural plants with more than 190,000 economically viable species—are grown worldwide. The fact that just 18 species of farmed cereals account for more than 91% of the food consumed by people worldwide, however, makes it impossible to overstate the significance of cereals for human nutrition. Grain crops occupy about 74% of the total area of tilled land. The bulk of the cereal seed is composed structurally of the endosperm and the embryo (germ). The ovary wall gives rise to the pericarp (outside wall), which shields the endosperm. The testa, a selectively permeable layer that surrounds the embryo and is derived from the ovary wall, the inner reproductive gland, is located beneath the pericarp. Testa has a high water permeability that promotes seed germination; however, in the presence of salt, the testa may become less vigorous, which would prevent seeds planted in soils containing dissolved salts from germinating. The third crucial layer of cereal grains is the aleurone layer, which has thick-walled cells and is free of starch. The pericarp and testa are referred to as the bran. On the other hand, during the middle of the 17th century, the Latin words legere (to gather) and legumen (seeds harvested in pods) were combined to create legumes, which are flowering plants (dicotyledons) in the Leguminosae family. Among them are pigeon pea, black gram, chickpea, and mung beans, which collectively have between 16,000 and 19,000 species spread across 750 genera. In terms of harvested area and production capacity, Asia comes in first. Conversely, India is responsible for 75 and 96% of the world's total production of pigeon pea and chickpea, respectively Food is an expression When we talk about legumes, we usually mean both the mature, dry seeds that humans eat and the immature pods and seeds. All plants that are classified as legumes according to Food and Agricultural Organization (FAO) guidelines. Legume with a low fat content, like alfalfa, French beans, and lima beans, are called pulses; higher fat content legumes, like peanuts and soybeans, are called leguminous oilseeds. In developing nations, legumes are a significant source of nourishment. The most widely consumed legumes in most nations are lentil, chickpea, dry bean, pea, broad bean, and soybean. Certain nations cultivate different legumes based on their dietary preferences and climate. As far as the economic and nutritional value of human food sources go, legumes come in second only to cereals. Oilseed legumes, like soybeans, are grown for more reasons than just their high protein and carbohydrate content.

In order to produce a high yield in the upcoming season, healthy cereal grains and legumes are the demanding enterprises of the recent past. Maintaining a high-yield crop requires proper storage of the legumes and cereal grainsLarge-scale losses resulting from both biological and non-biological agents can occur during storage. The high rates of cereal and legume losses following harvest in many nations worldwide may be the cause of problems with food security, including hunger, diabetes, and malnourishment, all of which undermine efforts to improve food security. A true and coordinated effort to improve postharvest losses (PHLs) and provide appropriate handling and processing technologies for improved postharvest opportunities is hampered by the effects of low yield, poor quality of produce, and the prevalence of chemical toxicants and mycotoxin contamination. Care must be taken during harvesting to minimize damage and ensure proper postharvest handling techniques in an effort to maintain high-quality crops during postharvest operations (PHOs). While the use of appropriate techniques to minimize loss and guarantee the quality and safety of crops that meet quality standards is desired, it is also important to develop reliable methods for the assessment of postharvest losses. Cereals and legumes are grown and stored on farms in developing nations, including Nigeria. Small-scale farmers are the main producers of these crops. The postharvest losses of legumes and cereals have been attributed to both biological and non-biological agents.



Preservation of food from spoilage

It is theoretically possible for any food preservation technique to stop microbial, enzymatic, and proteolytic spoiling separately. Nevertheless, these expectations have not been entirely met by the industrial innovation methods used today. The most crucial thing to remember when using any preservation technique is to avoid microbial spoilage at all costs. However, the degree to which thermo-bacteriological treatment is effective in preventing enzyme activities, proteolytic reactions, and the destruction of various microorganisms varies. Innovative preservation techniques like encapsulation, pulse electric field, edible coating, infrared, and radiation are not yet able to fully prevent spoiling effects. These commercial techniques use specific preservation principles to stop or stop food from spoiling. In a nutshell, the industrial method of food preservation makes use of the following principles;

- The capacity to eliminate moisture using techniques like concentration, evaporation, and drying.

- The process of removing heat from food products through freezing, refrigerated storage, lyophilization, or freeze concentration.
- Addition of heat: Food products can be sterilized, pasteurized, thermized, or otherwise heated to kill microorganisms or stop their activity.
- Chemical and preservative addition: Certain compounds, known as preservatives, are added to processed food in order to suppress microbiological contamination or stop enzymatic and browning reactions. Additives such as sorbates and benzoates are examples of this type of chemical.
- Fermentation: Microorganisms produce secondary metabolites during fermentation, which helps to preserve food products.
- Stored in a controlled atmosphere: This method modifies the environment around food items to keep them from rotting.

Additional techniques include irradiation, high-frequency current application, etc. In the food value chain, by-products from grains and legumes can also be converted into chemicals, energy, and other value-added products using additional technologies such pyrolysis, gasification, combustion, and chemical and biochemical processing.

Postharvest pest management

Pests are a major problem for grain legumes throughout distribution, transportation, and postharvest storage. If pests are not managed effectively, grains will be of lower quality and quantity. Due to the associated losses in investment and depletion of profits, pest infestation is a major source of concern for both farmers and food processors. Fumigation and controlled atmospheres of CO2 and N2 is a couple of the classic methods used for grain pest management. Innovative methods have also been developed to address some of the drawbacks of traditional chemical-based pest control methods like fumigation. Some of the newer technologies that have been applied to pest control include fumigation, microwaves, infrared, and radiation. In the grain storage sector, using methyl bromide and treating grain legume storage structures or systems with hot air is also a standard disinfection procedure.

Irradiation (IR)

In order to prolong the shelf life of food, ionizing radiation is utilized in the food irradiation process to eradicate target bacteria. The production of free radicals during irradiation causes damage to DNA and cell membrane integrity, which results in the inactivation of microorganisms. Its effectiveness in suppressing sprouts, getting rid of insects and parasites, destroying spoilage, and getting rid of harmful microbes has been demonstrated.

It has been suggested that legumes be treated with radiation at low to moderate levels to eradicate pests. In addition, the medication has been demonstrated to be beneficial in reducing trypsin and chymotrypsin inhibitors as well as oligosaccharides that cause flatulence. As a result of these radiation-induced changes to anti-nutritional elements in legumes, irradiated beans have higher nutritive quality. Ionizing radiation has been used to successfully cleanse stored product, particularly grains, as it alters their interior structure. In several grains, radiation technology has shown particularly effective in limiting the growth of Aspergillus, Penicillium, Rhizopus, and Fusarium fungus and extending the shelf life by more than six months. Selenium and Co-60 are the typical radiation sources used.

Infrared

With a wavelength ranging from roughly 0.5 to 100 μm, the infrared part of the electromagnetic spectrum lies between the visible and microwave regions. Heat is produced when infrared radiation enters the water molecules and causes vibrations. It has been discovered that infrared-based technologies are environmentally benign and energy-efficient in comparison to other traditional techniques. Numerous other benefits of infrared technology include its fast processing times, consistent results on food materials, minimal energy use, rapid heat transfer, and improved product quality. Infrared-based technologies have been applied to a wide range of food processes, including boiling, heating, drying, peeling, recovering polyphenols and antioxidants, freeze-drying, roasting, microbiological inactivation, sterilizing grains, making juice and bread, and cooking. This is because of some of the features mentioned above. Early in the 1960s and 1970s, the concept of using infrared radiation to disinfect and sterilize grains was developed. Grain companies typically choose it over other chemical techniques for grain disinfection due to its remarkably excellent microbial inactivation properties. Three distinct processes are used in infrared operations to eradicate microorganisms: thermal inactivation, induction heating, and DNA integrity deformation. As food is buried deeper, infrared's efficiency decreases due to its low penetration rate. Therefore, compared to other methods, it is advised for food surface sterilization more frequently. In addition, saw-toothed grain beetles, merchant grain beetles, and rice weevils are managed with the use of catalytic-infrared emitters. Insects that thrive either internally or externally in grains stored in storage facilities may usually be eliminated with a brief exposure of 60 seconds or less.

Microwaves

Compared to other traditional chemical treatments, microwaves—a type of short-wavelength electromagnetic radiation—has an outstanding potential for destroying microorganisms. Today, most grain industries use microwave technology as a highly effective disinfection method. This shields grains against field fungi, storage fungi, and insects. Microwave treatment, however, can have a number of negative impacts on seed germination and can degrade grain quality. The changes in heating brought on by the temperature difference between the hot and cold spots are the cause of these harmful effects of microwaves.

Fumigation

One highly effective pest control method is fumigation. For example, grain pests with a strong resistance ability can be eliminated using phosphone gas, which can destroy them at every stage of their life cycle. However, phosphine gas application levels must be maintained at 300 parts per million (ppm) or above for at least one week at a temperature of 25°C or higher. An alternative method for effectively and efficiently eliminating pests that kill legumes is to maintain a 200 ppm concentration of phosphine gas for ten days at a temperature of 25°C or below. There are two ways that phosphorus is applied: as pills or bag chains. Additionally, each option can be successfully implemented in a guarded gas-proof silo in a variety of ways. Additionally, bag chains are thought to be an extremely safe technology that guarantees neither fumigant residue on the grain nor any kind of injury to the operator. The most popular and extensively utilized form of phosphine is available as tablets. For very large storages over 600 tons, a third method of applying phosphine is available. This method uses a phosphine blanket. The silo used for the fumigation (which needs to be sealed and gas-tight) determines the amount of phosphine to be applied and the concentrations to be utilized. More importantly, the volume of the silo—rather than the amount of grain within—determines the precise phosphine concentration to be employed.

Using phosphine tablets and/or bag chains, an airtight-covered silo—especially one that passes the half-life pressure test—must stay sealed for the whole fumigation process to achieve the ideal fumigation outcome. Fumigation is anticipated to last seven days in an airtight sealed silo at a temperature above 25°C and ten days in a temperature between 15 and 25°C. However, pests—especially insects—will become dormant if the silo's temperature falls below 15°C, and phosphine is typically ineffective at such low temperatures. Phosphine application is not advised at temperatures below 15°C due to its ineffectiveness at such lower temperatures. Because it poses a risk to the operator, the silo must be kept closed during fumigation and should only be entered by individuals wearing the appropriate personal protection equipment (PPE). Continuous silo opening reduces the efficacy of the fumigation procedure because it lowers the concentration and absorption rate of phosphine gas below the threshold that is recommended for the elimination of pests. The industry's extensive testing led to the recommendations for the phosphine label; in other words, following the label's instructions will guarantee optimal outcomes. When it comes to controlling pests in grain storage facilities and other agricultural organizations, phosphorus is well regarded as a highly dependable fumigant. Nevertheless, fumigants have been consistently misused, leading to ineffective pest management and the emergence of pest species resistance. Furthermore, continued use of phosphine may result in grain pest resistance, much as ongoing application of herbicides with a similar mechanism of action causes weeds to become resistant. However, in the case of herbicides, the yearly emergence of pest resistance can be thwarted by switching up the chemicals employed. The same cannot be said for fumigating stored grain, as there are few options and those that are accessible are not economical. To put it another way, taking phosphine exactly as prescribed can help you avoid experiencing its resistance.

For stored grain pests, other fumigants and a regulated environment may be employed, but they are frequently expensive. Nevertheless, phosphine sealed in a gas-tight silo should be utilized to prevent resistance of stored grain pests.

Environment under Control

While phosphine is the most widely used gas fumigant, there are additional gas fumigants that can be used to control pests in grain that has been stored. Though these substitutes cost more than phosphine and still need a sealed, gas-tight silo, they provide an additional choice for pest species that are resistant to it. The advantage of nitrogen (N2) and carbon dioxide (CO2) is that they are nonchemical alternatives for regulation. The terms "controlled atmosphere" (CA) relate to nitrogen and CO_2 methods of control, which alter the natural atmospheric gas balance and create a poisonous environment.

Nitrogen

Grains stored in a nitrogen saturated environment ensure the control of insects and preserve product quality without the use of chemicals. Nitrogen-based storage systems maintain the quality of canola and pulses through the inhibition of the respiration process that causes oxidation, which may result in the increase in free fatty acids, loss of color, and seed deterioration. Grain treatment with nitrogen (for the purpose of pest control) is safe, environmentally friendly, and involves the usage of electricity for its major operations. Nitrogen produces no residues when used, so grains can be sold instantaneously whenever decided as against what is practiced for chemical fumigants which have recommendation period for withholding after fumigation. The use of nitrogen as an insect control technique involves the use of Pressure Swinging Adsorption (PSA) technology in adjusting the atmospheric composition of the grain storage system to expel other gases other than nitrogen, thus depriving the pests of the needed oxygen. The method of application entails purging the silo to its base with gas majorly composed of nitrogen. This is done in order to force out from the silo the oxygen-rich air through the top of the silo. Several hours of operation are required for PSA to build up about 99.5% pure nitrogen and before the air composition reduces to 2% oxygen. It is difficult for adult insects to thrive in 2% concentration of oxygen, provided this concentration is maintained for 21 days at 25°C or above for the temperature of the grain. The inhibition of the different stages of the life cycle of insects (eggs, larvae, and pupae) will be difficult below these recommended temperatures and the number of days for grain storage. For grain temperatures below 25°C, this treatment duration should further be extended to a 28-day period. Additional purging of the silo may be needed to get rid of oxygen that has diffused from the grains and it must be re-evaluated 24 hours after fumigation in order to achieve effective and efficient pest control.

Carbon dioxide (CO_2)

When a gas-tight silo is treated with CO2, the air within is replaced with CO2 at levels that are poisonous to grain pests. This calls for a seal that is impermeable to gases, as determined by a pressure test with a minimum half-life of five minutes. The primary grain pests must be eliminated at every step of their life cycles, which requires holding CO2 at a minimum concentration of 35% for 15 days. 30 kg of cylinders are needed for every 15 tons of storage capacity in order to reach a 35% concentration level of CO2 for 15 days. The gas CO2 is colorless, odorless, and non-flammable. It has a weight of about 1.5 times that of air. When food-grade CO2 is discharged from pressurized cylinders, it transforms from a liquid into a gas. The effectiveness of carbon dioxide decreases below 20°C. This is due to the fact that insects are less active at this temperature, necessitating a prolonged duration of CO2 concentration.

Drying technologies

Because fossil fuel prices are constantly rising and greenhouse gas emissions are increasing, scientists worldwide are constantly looking for new and efficient ways to employ renewable energy sources. Every twenty years, the amount of energy consumed worldwide doubles, and as a result, fossil fuels are now the primary source of pollution and other environmental issues. One processing method for preventing food deterioration and preserving food products is drying. The process of drying agricultural goods uses around 3.62% of the energy produced worldwide.

Right now, there is a demand for new drying technology that encourages higher-quality products to be dried more quickly and efficiently. Because of their adaptable drying results, low energy needs, and minimal environmental impact, hybrid drying systems have become a highly valued approach. Recently, a number of hybrid solar dryers have been created that are more effective when used in conjunction with other heating sources to lower drying costs and energy usage.

After harvesting, grain legumes are often dried before being kept in storage facilities. The key to storing grain legumes safely is to dry them to the recommended safe moisture level. On the other hand, overly quick drying of nuts can cause the grain core to solidify and the interior to become poor, while extremely slow drying can cause microbial development and deterioration of quality. In order to utilize the heated air more effectively and produce a product of a satisfactory quality, the sun drying air is recirculated.

Pulses must be dried since, at the time of harvest, they have a high moisture content of about 18–25%, and the ideal moisture content for safe storage is between 9–12% to prevent mycotoxin development. Regardless of the drying technology used, it is imperative that the grain be dried as rapidly as possible to a safe moisture level to prevent degradation. Grain drying under the open sun using hot air can be done in a number of ways that are not natural. Spouted bed drying, fixed bed drying, moving bed drying, fluidized bed drying, and thin-layer drying are a few of these drying techniques. Apart from some of these specialized dryers used for grain drying, all-purpose grain drying systems can as well be used in the drying of grain legumes. Generally, as documented by dryers or drying systems are categorized depending on the following:

- The flow of grain wherein the dryers are denoted as - batch, recirculating and continuous dryers.
- The relative motion of the grains and the circulating air used for drying. Concurrent, counter-current, cross/mixed flow dryers are found in this category.
- The source of heat: solar, propane, and electrical dryers are examples of dryers in this category.

Regardless of the type of dryer used in drying grains, the concurrent heat energy transfer and moisture loss principle/process is the same for the drying of grain legumes and equally for other grains. When grains are dried, free moisture is lost, and the grain must be dried until its equilibrium moisture content is reached. The final moisture content the grain reaches at a predetermined relative humidity and temperature is implied by the equilibrium moisture content of the grain. The cardinal factors that influence the drying rate of grain legumes are temperature, grain moisture content, relative humidity, and air velocity.

Legumes can also be dried via the use of solar dryers. Grain can be dried using a variety of solar drying technologies, including direct, non-direct, and solar. One issue with solar dryers is that in situations when there is low insulation or no solar radiation during the night, the dehydration process can cease and the grain quality will suffer. The addition of thermal storage materials, phase change materials, and a range of direct and indirect heating modes are just a few of the solutions that have been proposed thus far to address the issues with solar systems. Numerous varieties of sun dryers have evolved as a result of this. When solar radiation is present, thermal storage materials have the capacity to store thermal energy, which they can subsequently utilize when the sun is not there. There are three primary types of solar dryers that differ in terms of size, shape, and power.

Storage of grain legumes

Achieving optimal and safe storage requires cleaning grains to remove impurities and unwanted elements. It was shown that cleaning grains before to storage affects the grain's quality. Cleaning entails removing undesirable foreign matter (straws, sand, stone, etc.) from the grain. Grain legume storage is an essential step in handling legumes after harvest. It's crucial since failing to maintain the best conditions for their safe storage could result in significant postharvest losses. Grain legumes can be destroyed by several pests and bacteria during storage, transportation, or after harvest to different destinations of interest. Postharvest losses of grain legumes are reported to be between 40 and 50 percent in many impoverished countries and approximately 9% in the United States, depending on the dominant intrinsic and external causes.

Increased moisture and warmth can induce quick changes in grain legume quality, including reduced color, oil quality, and germination capacity, among other quality factors. Aspergillus, Fusarium, and Penicillium species of molds can grow in high moisture content and high grain temperatures. These conditions can also cause the molds to create mycotoxins such ocharatoxin A, aflatoxins, and patulin. The invasion of several insect species (granari weevil, grain borer, grain moth, grain beetle, etc.) that feed directly on grains causes a decrease in grain quality and quantity. High moisture content and temperatures above ideal levels also contribute to this infestation. Fungi infestation of grains lowers the nutritional value, the quality of the proteins that form gluten, and the capacity of the grains to germinate. Additional impacts include an increase in total soluble solids, a decrease in non-reducing disaccharides and oligosaccharides, a decrease in starch content, and an elevation in free fatty acids. Hot spot growth can potentially scorch the grains, and fungus contamination can result in the production of mycotoxins, which poses serious risks to public health. About 25% of grains produced worldwide are tainted with mycotoxin, a poison generated by mold.

Postharvest preservation technologies

Grain and legume pests can ruin up to 33–50% of the world's output while it's being stored. This illustrates the severity of insect infestation and attack on grains in the event that appropriate control measures are not implemented. In certain cases, quality decline during storage might result in a 60% reduction in the total amount of leguminous grains worldwide. The main causes of these losses are rodent attacks, insect infestation, mold growth, and disruptions to the grains' natural physiology. It is common knowledge that eating grains can expose a person to harmful microorganisms, insects, mice, and other toxins. Using appropriate packaging and packing materials when storing grains from leguminous crops is essential to getting effective postharvest management outcomes for leguminous grains. Additionally, packaging is crucial for marketing and delivery (maintaining quality).

Grain, especially pulses, is still stored in traditional storage buildings made of woven threads or natural materials in rural areas of developing and even wealthy countries. Basket silos, plastic containers, underground pits, and thatched roof storage are typical examples of traditional storage systems. These indigenous buildings are inexpensive to build and maintain, but their lack of durability makes them vulnerable to pests and insects, which lowers the quality of the grain and legumes. Currently, developing countries are keeping vast amounts of grain in warehouse-style storage buildings.

The temperature and moisture content of storage buildings are directly influenced by the materials used in their construction. Often, materials such as bamboo, concrete blocks, wood, metal (steel or aluminum), and cement are utilized to construct grain storage buildings.

Silo

Silos make up over 79% of all on-farm grain storage facilities in Australia and are today a highly widespread type of grain storage facility used in many other nations. For grain legumes (pulses), silos are a great solution for storage, especially the cone-based variety that allows for very simple grain unloading and discharge with very little risk of seed damage. Aeration cooling systems and the usage of gas-tight sealable storage are required for long-term storage lasting more than three months. These measures are advised for successful and efficient fumigation regimens in controlling and attaining optimal quality control. To lessen the development of hot spots, augers and ventilators for grain aeration are incorporated into the construction of metal silos. Considered to be cutting edge grain storage solutions, metal silos with ventilators and augers can prolong the shelf life of grain legumes by creating an environment that is inhospitable to a variety of pests that prey on grain legumes.

Silos should always be filled and emptied through the openings in the middle of the silos. Because most grains have a high bulk density, loading or unloading outside of the central aperture at the center will impose an uneven strain on the structure and increase the risk of the silo collapsing. This is particularly crucial when dealing with grains.

Different types of metal silos made of repurposed oil drums or galvanized iron have been designed as an affordable, practical, and efficient container-storage solution. These silos are ideal for storing grains and grain legumes for an extended period of time in a hermetically sealed, water-resistant environment. Grains kept in metal silos are excellent pulse storage solutions because they shield the grains from water, rodents, and insects. Silos must be shielded or protected from the sun's rays and other heating sources that could raise the grain's temperature within in order to prevent condensation. Instead, to prevent the silos' temperature from rising, they might be placed in shaded, well-ventilated places. It should be mentioned that although metal silos are very useful and efficient for storing grain, they can be costly.

Convectional flow currents may arise if silos are directly exposed to sunlight or if the outside air temperature is lower than that of the grain-containing silos. The moist air is being forced through the grains by the convectional air currents that are created. The wet air will condense and dampen the grain as it moves and comes into contact with cooler surfaces, such as the walls of the silo. This damping phenomenon is a common issue with grains kept in steel silos, which are especially used for storage in hot climates with daily clear skies. High day temperatures and cool night temperatures are a result of a clear sky. The problem of elevated temperatures can be mitigated in small silos by providing a shield in form of a roof or a hat, to prevent direct contact of sun rays with the surface of the silos. Solutions for larger silos may involve grain silo ventilation or transferring of the grains from the silo with a high temperature to another one that has a cool condition. Grain movement tends to provide grains with more uniform moisture content when they are transferred to another cool silo.

Hermetic bags/cocoon

In grain and legume storage systems, foreign pests such as Callosobruchus maculatus and Callosobruchus chinensis may still be present if proper pest management practices are not rigorously followed. Farmers in various nations have benefited greatly from the storage of grain legumes in hermetic bags or cocoons, which allows them to hold onto their harvest longer until times when the price and value of the produce are higher. As a result, farmers who employ hermetic bags or cocoons to store their goods longer and hope for longer sales periods have seen higher financial returns. A more popular method for both on- and off-farm locations, the hermetically sealed polyethylene silo bag method is a good substitute for protecting grain legumes that are kept in commercial storage facilities.

CONCLUSION

Important food crops, legumes provide a substantial proportion of plant-based protein to human diets. Grain legumes suffer postharvest losses if they are not handled, processed, and stored correctly. Some of the notable postharvest handling practices adopted to preserve and extend the shelf life of legumes include drying, pest control, and storage.

Pest control in harvested grains can be achieved through emerging technologies like irradiation, radio frequency ionization, infra-red, and microwave technology. Pest management can also be done through the age-long chemical means of fumigation as well as controlled atmosphere technology as an alternative.

Grain legumes dried in the conventional manner—openly spreading out in the sun—don't dry well. Grain legumes are best dried artificially using solar dryers of various types or hot air dryers. The necessity to lower the amount of greenhouse gases that non-solar dryers generate, the high cost of fuel to operate non-solar dryers, and the requirement for a renewable energy source—unlike non-solar dryers—have all contributed to the significant evolution of solar dryers.

To maintain a fairly optimal storage environment for grain legumes, grain legumes are stored in silos for large-scale commercial reasons and hermetic bag storages for smaller-scale storage.

REFERENCES

[1]. FAO. World Food Situation. Netherlands: Food and Agriculture Organization of the United Nations; 2021. Available from: https://www.fao.org/worldfoodsituation/csdb/en/

[2]. Beverly RL. Safety of food and beverages: Cereals and derive products. Encyclopedia of Food Safety. 2014;3:309-314

[3]. Stoskopf NC. Cereal grain crops. Reston: Reston Publishing Company, Inc.; 1985

[4]. Yousaf Z, Saleh N, Ramazan A, Aftab A. Postharvesting techniques and maintenance of seed quality. In: Araujo S, Balestrazzi A, editors. New Challenges in Seed Biology - Basic and Translational Research Driving Seed Technology. London: IntechOpen (Internet); 2016. Available from: https://www.intechopen.com/books/5218

[5]. Delouche JC, Caldwell WP. Seed vigor and vigor tests. Proceeding of Association of Official Seed Analyst. 1960;50:124-129

[6]. Gregg BR, Billups GL. Seed Conditioning Technology Part A. In: Seed Quality. Vol. 2. USA: Science Publishers; 2010. pp. 1-2

[7]. Greeley M. Pin-pointing postharvest losses. Cereals. 1982;15(1):30-37

[8]. Mohapatra D, Kumar S, Kotwaliwale N, Singh KK. Critical factors responsible for fungi growth in stored food grains and non-chemical approaches for their control. Industrial Crops and Products. 2017;108:162-182. DOI: 10.1016/j.indcrop.2017.06.039

[9]. Ling B, Cheng T, Wang S. Recent developments in applications of radio frequency heating for improving safety and quality of food grains and their products: A review. Critical Reviews in Food Science and Nutrition. 2020;60(15):2622-2642. DOI: 10.1080/10408398.2019.1651690

[10]. Hallman GJ. Control of stored product pests by ionizing radiation. Journal of Stored Products Research. 2013;52:36-41

[11]. Vadivambal R, Jayas DS, White NDG. Wheat disinfestation using microwave energy. Journal of Stored Products Research. 2007;43(4):508-514. DOI: 10.1016/j.jspr.2007.01.007

[12]. Knox OGG, McHugh MJ, Fountaine JM, Havis ND. Effects of microwaves on fungal pathogens of wheat seed. Crop Protection. 2013; 50:12-16. DOI: 10.1016/j.cropro.2013.03.009

[13]. Ramaswamy R, Krishnamurthy K, Jun S. Microbial decontamination of food by infrared (IR) heating. In: Demirci A, Ngadi A, editors. Decontamination in the Food Industry. 1st ed. USA: Woodhead Publishing; 2012. pp. 450-471. DOI: 10.1533/9780857095756.2.450

[14]. Australian Government Grains Research and Development Corporation - GRDC. Vetch Section 13 Storage: How to Store Vetch on-Farm, Aeration during Storage and Stored Grain Pests. Australia: Grain Research and Development Corporation (GRDC). 2018. pp. 1-25. Available from: https://grdc.com.au/__data/assets/pdf_file/0024/370707/GrowNote-Vetch- North-13-Storage.pdf [Accessed: September 13, 2021]

[15]. Trostle R. Global Agricultural Supply and Demand: Factor Contributing to the Recent Increase in Food Commodity Price. Outlook Report No. WRS-0801. USA: Economic Research Service, U.S. Department of Agriculture; 2018

[16]. Bibin C, Kishore K, Baskar K, Akshay J, Sharma J. Performance analysis of a diesel engine fuelled with Punnai oil methyl ester and its diesel blends. International Journal of Trendy Resources Engineering Technology. 2018;2(5):74-79

[17]. Sirohi R, Tarafdar A, Gaur KV, Singh S, Sindhu R, Rajasekharan R, et al. Technologies for disinfection of food grains: Advances and way forward. Food Research International. 2021;145:110396. DOI: 10.1016/j.foodres.2021.110396

[18]. Babar OA, Tarafdar A, Malakar S, Arora VK, Nema PK. Design and performance evaluation of a passive flat plate collector solar dryer for agricultural products. Journal of Food Process Engineering. 2020;43(10):e13484. DOI: 10.1111/jfpe.13484

[19]. Kundu KM, Das R, Datta AB, Chatterjee PK. On the analysis of drying process. Drying Technology. 2005;23(5):1093-1105. DOI: 10.1081/DRT-200059140

[20]. Jayas DS, White NDG. Storage and drying of grain in Canada: Low cost approaches. Food Control. 2003;14:255-261. DOI: 10.1016/S0956-7135(03)00014-8

[21]. Kumar P, Singh D. Advanced technologies and performance investigations of solar dryers: A review. Renewable Energy Focus. 2020;35:148-158. DOI: 10.1016/j.ref.2020.10.003

[22]. Sodha MS, Chandra R. Solar drying and their testing procedures: A review. Energy Conversion and Management. 1994;35:219-267. DOI: 10.1016/0196-8904(94)90004-3

[23]. Tomar V, Tiwari GN, Norton B. Solar dryers for tropical food preservation: Thermophysics of crops, systems and components. Solar Energy. 2017;154:2-13. DOI: 10.1016/j.solener.2017.05.066

[24]. Nukulwar MR, Tungikar VB. A review on performance evaluation of solar dryer and its material for drying agricultural products. Materials Today: Proceedings. 2020;46(1):345-349. DOI: 10.1016/j.matpr.2020.08.354

[25]. Chauhan PS, Kumar A, Gupta B. A review on thermal models for greenhouse dryers. Renewable and Sustainable Energy Reviews. 2017;75:548-558. DOI: 10.1016/j.rser.2016.11.023

[26]. Bucklin R, Thompson S, Montross M, Abdel-Hadi A. Grain storage systems design. In: Handbook of Farm, Dairy and Food Machinery Engineering. New York, USA: Elsevier Incorporated; 2013. pp. 123-175. DOI: 10.1016/B978-0-12-385881-8.00007-0

[27]. Uebersax MA, Siddiq M. Postharvest storage quality, packaging and distribution of dry beans. In: Siddiq M, Uebersax MA, editors. Dry Beans and Pulses Production, Processing and Nutrition. 1st ed. New Jersey, USA: John Wiley & Sons, Incorporated; 2013. pp. 75-100

[28]. FAO. Grain crop drying, handling and storage. In: Rural Structures in the Tropics: Design and Development. USA: IOWA State University Extension and Outreach; 2018. pp. 363-386

[29]. Kumar S, Mohapatra D, Kotwaliwale N, Singh KK. Efficacy of sensor assisted vacuum hermetic storage against chemical fumigated wheat. Journal of Stored Product Research. 2020;88:101640

[30]. Paul A, Radhakrishnan M, Anandakumar S, Shanmugasubdaram S, Anandharamakrishnan A. Disinfection techniques for major cereals: A status report. 2020;19:1125-1155

[31]. Eskola M, Kos G, Elliott CT, Hajšlová J, Mayar S, Krska R. Worldwide contamination of food-crops with mycotoxins: Validity of the widely cited “FAO estimate” of 25%. Critical Reviews in Food Science and Nutrition. 2020;60(16):1-17. DOI: 10.1080/10408398.2019.1658570

[32]. Mobolade AJ, Bunindro N, Sahoo D, Rajashekar Y. Traditional methods of food grains preservation and storage in Nigeria and India. Annals of Agricultural Sciences. 2019;64(2):196-205. DOI: 10.1016/j.aoas.2019.12.003

[33]. Shendge SN, Pawar VS, Kale PR. Novel technique: Hermetic storage and its application. The Pharma Innovation Journal. 2021;10(8):451-456

[34]. Silva MGC, Silva GN, Sousa AH, Freitas RS, Silva MSG, Abreu AO. Hermetic storage as an alternative for controlling Callosobruchusmaculatus (Coleoptera: Chrysomelidae) and preserving the quality of cowpeas. Journal of Stored Products Research. 2018;78:27-31. DOI: 10.1016/j.jspr.2018.05.010