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12. Post-Harvest Technology of Seed Crops

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Abstract:

The production and storage of healthy seeds and grains have become increasingly important in recent times, as they are vital for achieving high crop yields in subsequent seasons. However, during the storage process, significant losses of seeds can occur due to various biological and nonbiological factors. These losses not only affect the market value of the seeds but also impact their quality. To address this issue, it is crucial to examine the factors that contribute to seed losses during storage.

By understanding these factors, appropriate measures can be taken to minimize losses and ensure the quality and safety of the crop. Implementing careful postharvest handling techniques plays a critical role in maintaining seed quality. To assess losses during the storage process and mitigate them effectively, suitable methods need to be established. These methods should be efficient, cost-effective, and convenient to implement. While the focus of this chapter is on the needs of developing countries, the information provided can also be relevant in more industrialized countries. The chapter provides a comprehensive review of postharvest techniques that can be employed to maintain seed quality. These techniques aim to achieve high-quality seeds that meet both national and international standards, thereby meeting the demands of suppliers. The emphasis is on identifying better, economical, convenient, and productive methods that can be adopted in various contexts.

12.1 Introduction:

Post-harvest technology plays a crucial role in ensuring the quality and safety of cereals, pulses, and oilseeds after they are harvested. It encompasses a range of practices, techniques, and tools designed to minimize losses, enhance storage life, and add value to these agricultural commodities. Cereals, pulses, and oilseeds are staple food crops that are vital for global food security. However, improper handling and storage practices during and after harvest can result in significant losses, both quantitatively and qualitatively.

Factors such as moisture content, temperature, pests, and diseases can contribute to spoilage, degradation, and reduced nutritional value of these commodities. Post-harvest technology aims to address these challenges and maximize the efficiency and profitability of the entire supply chain. One of the primary goals of post-harvest technology is to minimize post-harvest losses. This involves adopting appropriate harvesting techniques, such as using modern machinery to reduce damage to the crops and minimize losses during threshing and cleaning. Additionally, efficient drying methods are employed to reduce moisture content to safe levels, preventing the growth of molds and fungi [1-4].

Storage is another critical aspect of post-harvest technology. Proper storage conditions help maintain the quality of cereals, pulses, and oilseeds over an extended period. Processing is an integral part of post-harvest technology, particularly for oilseeds and pulses. It involves activities such as cleaning, grading, sorting, milling, and oil extraction. These processes help remove impurities, improve hygiene, enhance market value, and create value-added products.

The integration of post-harvest technology in cereals, pulses, and oilseeds not only enhances food security but also contributes to rural livelihoods and economic development. It improves the income of farmers by reducing losses and increasing market opportunities for higher-quality produce [5].

12.2 The Post-Harvest Technology for Cereals:

Cereals are an essential component of human diets worldwide, including in India. They are the seeds or grains of grasses and are cultivated to obtain the fruit or seed, which is commonly known as the caryopsis. The caryopsis consists of three main parts: the germ, endosperm, and bran. Cereals such as wheat, rice, maize, oat, barley, rye, millet, and sorghum are of great importance in India, providing a significant portion of the staple diet for many people, particularly those in low-income groups and rural areas. While each type of cereal crop requires specific post-harvest treatment based on its unique characteristics, there are certain general principles that apply to most cereals. These principles are aimed at preserving the quality, reducing losses, and enhancing the nutritional value of the harvested grains.

One important aspect of post-harvest treatment is the preparation of harvested cereal grains for storage. This involves activities such as cleaning, drying, and conditioning. Cleaning ensures the removal of impurities such as dirt, stones, chaff, and broken grains. Drying is crucial to reduce the moisture content of the grains, as excessive moisture can lead to spoilage and mold growth during storage. Conditioning involves equalizing the moisture levels within the grain mass to prevent moisture migration and subsequent quality deterioration.

Primary processing is another key stage in the post-harvest treatment of cereals. It involves further treatment of the grains to clean them, remove the husk or outer covering, or reduce the particle size. Primary processing steps can include dehusking or hulling, threshing, winnowing, and milling. Dehusking or hulling removes the outer covering of the grain, such as the husk or hull, which is often inedible or undesirable. Threshing separates the grains from the straw or stalk, while winnowing helps remove chaff or lighter impurities through air separation. Milling involves grinding or crushing the grains to produce various products such as flour, semolina, or cracked grains.

The third stage, known as secondary processing, involves transforming the grains into edible products. This stage typically includes processes such as fermentation, baking, puffing, flaking, frying, and extrusion. These techniques add value to the primary cereal products and offer a wider variety of food options, including bread, cakes, pastries, breakfast cereals, snacks, and more [6].

The post-harvest technology for cereals includes the following methods:

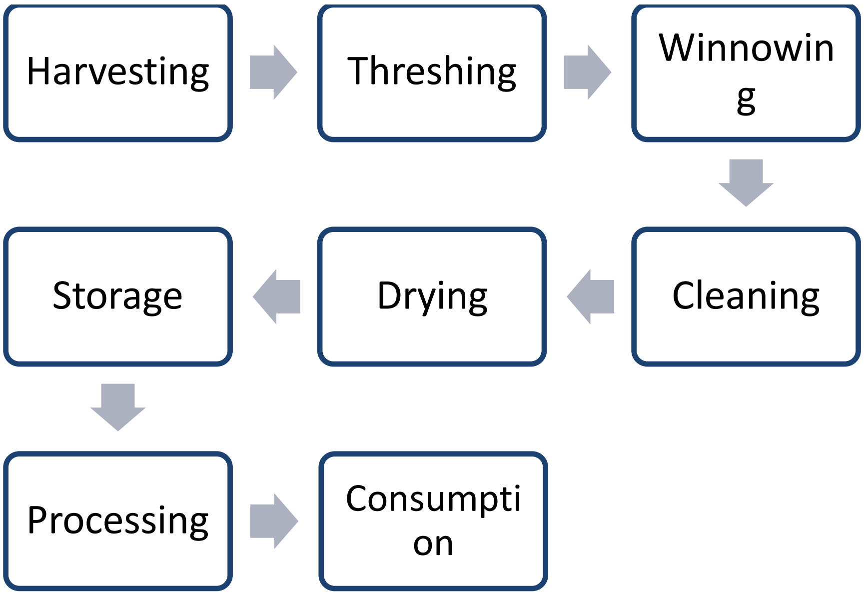

Figure 12.1: The post-harvest technology for cereals flow chart

12.2.1 Harvesting:

The timing of cereal crop harvesting is crucial and should be determined based on the crop's maturity stage and the prevailing climatic conditions. The timing of harvest can greatly impact the quality and storage characteristics of the grain. Harvesting cereals typically begins before the grains reach full maturity. Harvesting too early can result in underdeveloped grains with lower yields and reduced quality. However, allowing the crop to remain in the field until it is fully ripe can increase the risk of mold growth, insect infestation, and unfavorable weather conditions, which can lead to grain damage and deterioration.

Figure 12.2: Mechanical and manual harvesting of wheat

12.2.2 Milling:

Traditional milling technology involves several steps:

- **A. Washing:** The grains are washed or rinsed briefly to soften the outer layers and then hulled in one step. This helps remove dirt, dust, and impurities from the grains.
- **B. Pounding:** The hulled grains are pounded in a wooden mortar to detach the hulls and bran from the grain. This process involves manual labour and is typically done for a few minutes.
- **C. Sun-drying:** The pounded grains are spread out in a shallow layer to dry in the sun. This helps reduce moisture content and facilitates the subsequent winnowing process.
- **D. Winnowing:** The dried grains are subjected to winnowing, which involves tossing them in the air or using wind to separate the lighter hulls and bran from the heavier grains. This process relies on the difference in weight and density between the grains and the husks.
- **E. Washing:** After winnowing, the grains are washed again, this time for a longer duration. This washing step removes any remaining hulls through flotation and also increases the moisture content of the grains.
- **F. Resting:** The washed grains undergo a conditioning period where they are exposed to the sun for a brief period of time, typically 1 to 2 hours. This step helps stabilize the moisture content and further prepares the grains for the subsequent steps.
- **G. Pounding:** The conditioned grains are pounded once again to remove any remaining hulls or impurities. This step is similar to the initial pounding but may be shorter in duration.
- **H. Sieving:** The flour produced from the previous pounding step is hand-sieved to separate any coarse particles or residue. The collected flour is retained, while the residue is returned for further pounding.

Modern milling techniques may involve additional steps such as tempering, debranning, conditioning, grinding, and sifting, depending on the specific requirements and desired end products. These processes are often integrated into a continuous flow system, where the grains move through various stages without manual intervention, resulting in higher throughput and consistent product quality.

12.2.3 Threshing:

Threshing is an important step in the cereal production process, specifically in separating the grains from the rest of the plant material. It typically involves three main operations:

- **a. Separating the grain from the panicle:** In this step, the harvested cereal crop, which includes the panicles (seed heads) containing the grains, is subjected to mechanical or manual methods to detach the grains from the panicle. Traditional methods include beating the panicles with sticks or threshing flails, which separate the grains through impact or mechanical agitation. Modern threshing machines, such as combine harvesters, use a combination of rotating drums and concaves to separate the grains from the panicles more efficiently.

b. Sorting the grain from the straw: Once the grains are separated from the panicles, they are still mixed with straw, stalks, and other plant debris. The next step involves separating the grains from this material. Mechanical methods like shaking or vibrating machines, known as straw walkers or sieves, are commonly used in modern threshing machines to separate the straw from the grains. The straw is usually discharged from the machine while the grains continue through the system for further processing.

c. Winnowing the chaff from the grain: After the straw is separated, the grains are still covered with an outer protective layer called chaff. Winnowing is the process of separating the chaff from the grains. Traditionally, this was done by tossing the grains and chaff in the air, allowing the wind to blow away the lighter chaff while the heavier grains fell back down. In modern farming, mechanized winnowers or air separators are employed. These machines use air currents to blow away the chaff, while the grains, which are heavier, fall down and are collected for further processing or storage.

12.2.4 Drying:

Drying is an essential step in preparing cereals for storage or further processing. Proper drying helps reduce the moisture content of the grains, which is crucial for preventing mold growth, spoilage, and maintaining their quality [10,11]. While sun drying is a cost-effective method in which involves spreading the cereal grains in a thin layer on clean and dry surfaces, such as concrete pavements, drying beds, or mats.

The grains are exposed to the sun's heat and air circulation, allowing moisture to evaporate. Sun drying is often used in regions with abundant sunlight and low humidity [6,9]. Cereal grains must be dried to 10-15% moisture before storage.

Figure 12.3: Mechanical and Sun Drying of Wheat

12.2.5 Storage:

Storing dried cereal grains properly is crucial to maintain their quality and prevent spoilage. Here are some key points regarding the storage of cereal grains:

a. **Inspection and moisture content testing**: Regular inspection of stored grains is necessary to detect any signs of spoilage, such as mold growth, insect infestation, or unusual odors. Additionally, monitoring the moisture content of the grains is essential. Moisture levels should be periodically tested using moisture meters to ensure they remain within the recommended range for safe storage.
b. **Redrying:** If stored grains have picked up moisture and their moisture content exceeds the safe storage range, they must be re-dried to prevent spoilage. Re-drying can be done using artificial dryers, as mentioned earlier, to lower the moisture content back to the appropriate level for storage.
c. **Insect and rodent control:** Cereal grains are susceptible to insect infestation and rodent damage. To protect the stored grains, insecticides may be used to control insects and prevent their proliferation. These insecticides should be applied following approved guidelines and regulations to ensure food safety. Additionally, it's crucial to store the grains in rodent-proof containers or structures to prevent access by rodents, which can cause contamination and significant losses.
d. **Temperature and ventilation**: Proper temperature and ventilation conditions in the storage area are important for maintaining grain quality. Generally, cool temperatures (around 10-15°C or 50-59°F) are recommended to slow down biological activities and reduce the risk of spoilage. Adequate ventilation helps prevent the accumulation of moisture and allows for air circulation, helping to maintain grain quality and reduce the risk of mold growth [8].
e. **Good storage practices:** Other good storage practices include maintaining cleanliness in the storage area, preventing cross-contamination between different grain batches, and implementing a first-in, first-out (FIFO) system to ensure that older grain is used before newer batches. Additionally, periodic monitoring of stored grains, including temperature, moisture content, and pest activity, is essential to identify any issues early and take appropriate actions [13].

12.3 The Post-Harvest Technology for Pulses:

Pulses are the dried edible seeds of plants in the legume family, which includes crops like lentils, chickpeas, beans, and peas. These crops are primarily cultivated for their dry seeds rather than their fresh produce.

One of the key benefits of pulses is their ability to fix nitrogen from the atmosphere into the soil with the help of symbiotic bacteria. This nitrogen fixation process improves soil fertility and reduces the need for synthetic fertilizers, making pulses environmentally sustainable crops. Pulses come in various shapes, sizes, and colours, depending on the specific type of legume. They can be consumed in different forms, including whole or split, and can be prepared in various culinary dishes around the world. Pulses can also be ground into flours, which are used in baking and cooking, or further processed to obtain specific fractions such as protein, fiber, and starch, which have diverse applications in the food industry.

Post-harvest technology for pulses involves a series of processes and techniques to handle, store, process, and preserve pulses after they are harvested. The main objectives of post-harvest technology for pulses are to maintain their quality, prevent losses, and enhance their value.

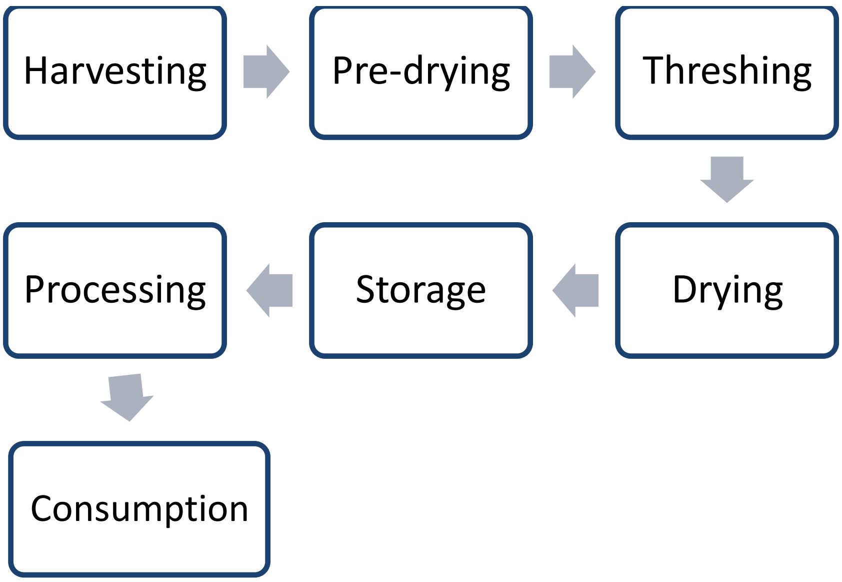

Figure 12.4: The Post-Harvest Technology for Pulses Flow Chart

12.3.1 Harvesting:

Harvesting of pulse crops can be done by hand or by machines, depending on the scale of cultivation and available resources. Hand harvesting is a common practice, where the plants are pulled up and allowed to pre-dry in the sun. This is typically done early in the morning when the dampness of the night helps minimize shattering losses. In some cases, chemical defoliants may be applied to the plants before harvesting. This treatment helps speed up the drying process and reduces the quantity of plant matter, making threshing operations more efficient.

Pulses are an essential component of a vegetarian diet, particularly in countries like India where they are a major source of protein. Pulses such as Bengal gram (chickpeas), pigeon pea, black gram, green gram, and lentils are widely consumed. These pulses are often dehusked and split, as this processing method helps enhance their digestibility and makes them rich in proteins.

12.3.2 Pre-Drying:

Pre-drying is an important stage in the post-harvest system of pulses. It refers to the process of drying the harvested product before proceeding with the next operation, which is typically threshing. The purpose of pre-drying is to ensure that the harvested pulses are adequately dried to facilitate efficient threshing and minimize the risk of spoilage.

Proper drying is crucial to prevent the growth of molds, fungi, and bacteria, which can lead to quality deterioration and loss of the crop. During pre-drying, the harvested pulses are exposed to air and sunlight to reduce their moisture content. This can be achieved by spreading them in thin layers on clean surfaces, such as drying mats, concrete yards, or tarpaulins. The pulses are turned regularly to ensure uniform drying and prevent the formation of hotspots or moisture pockets.

12.3.3 Threshing:

Threshing is the process of separating the grains from the plants after harvesting. It is a critical operation in the post-harvest handling of pulses and needs to be carried out carefully to preserve the quality of the product and minimize losses.

Threshing can be performed using various methods, including manual, animal-powered, or machine-powered techniques.

- **a. Manual threshing:** Manual threshing involves beating the harvested plants to separate the grains. This can be done by hand using tools like sticks, flails, or by trampling the plants underfoot. The aim is to remove the grains from the plants while minimizing breakage and damage.
- **b. Animal-powered threshing:** In some traditional agricultural practices, animals such as bullocks or horses are used to trample or walk over the harvested plants. The weight and movement of the animals help to separate the grains from the plants.
- **c. Machine-powered threshing:** Modern agricultural practices often employ threshing machines like combine harvesters or specialized threshers. These machines use mechanical means, such as rotating drums or blades, to separate the grains from the plants. Machine threshing is usually faster and more efficient, particularly for larger-scale operations.

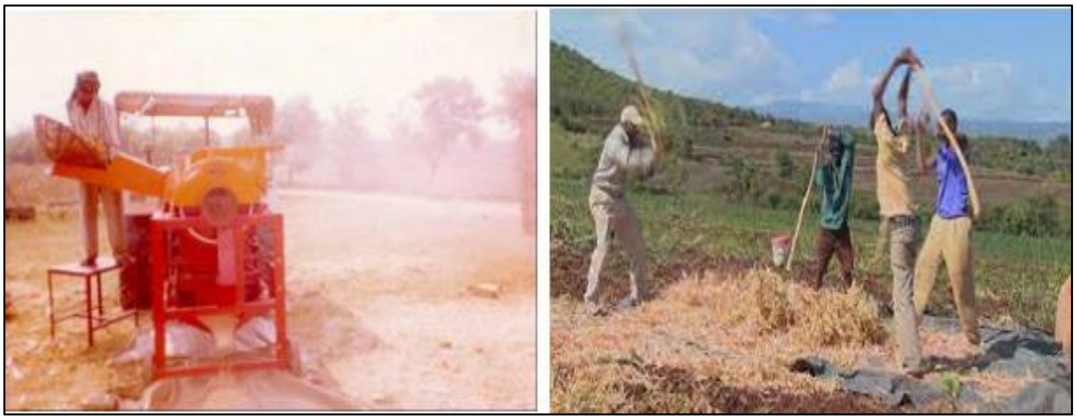

Figure 12.5: Mechanical and Manual Threshing of Wheat

Regardless of the method used, care should be taken during threshing to avoid excessive breakage of grains or husks. The objective is to separate the grains intact while minimizing damage, as broken grains are more susceptible to insect infestation and mold growth.

12.3.4 Drying:

After threshing, the moisture content of grains is often higher than the desired level for safe storage, typically around 13-14%. The drying process is crucial to reduce the moisture content of the grains to the appropriate level for storage and processing.

There are two primary methods used for drying grains:

A. Natural drying: Natural drying involves exposing the threshed grains to air, either in the sun or shade. The grains are spread in thin layers on a drying floor or platform, allowing them to come into direct contact with the air.

The duration of natural drying can vary depending on factors such as weather conditions, initial moisture content, and the desired moisture level for safe storage. Regular turning of the grains is necessary to ensure uniform drying. Natural drying is commonly practiced in areas with adequate sunlight and low humidity [7].

B. Artificial drying: In situations where natural drying is not feasible or practical, artificial drying methods are employed. Artificial drying involves the use of equipment to facilitate the drying process [12]. There are two main types:

a. **Heated air drying:** This method utilizes heated air to rapidly remove moisture from the grain. Grain dryers, such as batch dryers or continuous flow dryers, blow heated air through the grain mass, promoting evaporation and drying. The temperature and airflow are controlled to ensure efficient and uniform drying while avoiding damage to the grains.
b. **Unheated air drying (dehumidification**): In this method, unheated or slightly heated air is circulated through the grain mass using dehumidifiers or fans. The air's relative humidity is reduced, allowing it to absorb moisture from the grain, resulting in drying. Unheated air drying is suitable for regions with high humidity or when temperature-sensitive crops are being dried.

12.3.5 Storage:

The storage process is crucial for maintaining the quality and preserving the edible condition of pulses. However, pulses are more challenging to store compared to cereals because they are more susceptible to damage from insects and microorganisms.

This can lead to both quantitative losses (reduced quantity) and qualitative reduction (diminished nutritive value) of the stored pulses. Insects, particularly weevils, are a common cause of damage to stored pulses. Weevils are prolific pests that breed rapidly and can cause serious deterioration in the nutritive value of the grains.

Insect infestation not only results in grain losses but also increases milling losses due to breakage and powdering of the grains. The storage conditions play a vital role in preventing infestation and maintaining the quality of stored pulses. Here are some key considerations:

a. Temperature: Pulses should be stored in cool conditions, preferably below 15°C, to slow down insect activity and reduce the risk of mold growth.

b. Relative humidity (RH): Maintaining low humidity levels is crucial, as higher humidity promotes the rapid proliferation of insects. The ideal RH for pulse storage is below 70%. Using dehumidifiers or moisture control methods can help maintain suitable humidity levels.

c. Clean and dry storage structure: The storage structure should be clean, dry, and free from pests, molds, and other contaminants. Regular cleaning and fumigation of storage facilities are important to prevent infestation.

d. Packaging: Pulses should be stored in appropriate packaging materials that provide protection against moisture, insects, and rodents. Common packaging options include jute bags, polypropylene bags, or hermetically sealed containers.

e. Pest control measures: Integrated pest management practices, such as the use of pheromone traps, insecticides, or natural pest control methods, can be employed to prevent and control insect infestation.

f. Monitoring: Regular monitoring of stored pulses is essential to detect any signs of infestation or quality deterioration. This can involve visual inspections, sampling, and checking moisture content.

By implementing proper storage practices and maintaining suitable conditions, the shelf life of pulses can be significantly extended, minimizing losses and preserving their nutritive value [13].

12.4 The post-harvest technology of Agriculture Oil Seeds:

Oilseeds are indeed seeds that are primarily cultivated for the production of edible oils. They are considered high-value agricultural commodities due to their use in the production of refined edible oil products.

With the increasing global population, there is a growing demand for high-quality seed oils. Sesame is an important oilseed crop because of its excellent health effects, primarily attributed to the presence of polyunsaturated fatty acids in sesame oil.

These fatty acids are beneficial for human health. Sesame oil adds nutritional value to the diet by providing high-quality protein and vegetable oil, along with oil-soluble vitamins such as vitamin A.

In India, some major oilseeds include groundnut (peanut), soybean, rapeseed mustard, linseed, sesamum (sesame), and castor. Among these, groundnut and rapeseed mustard are the dominant oilseeds, accounting for approximately 85 percent of the total oilseed production in the country [13].

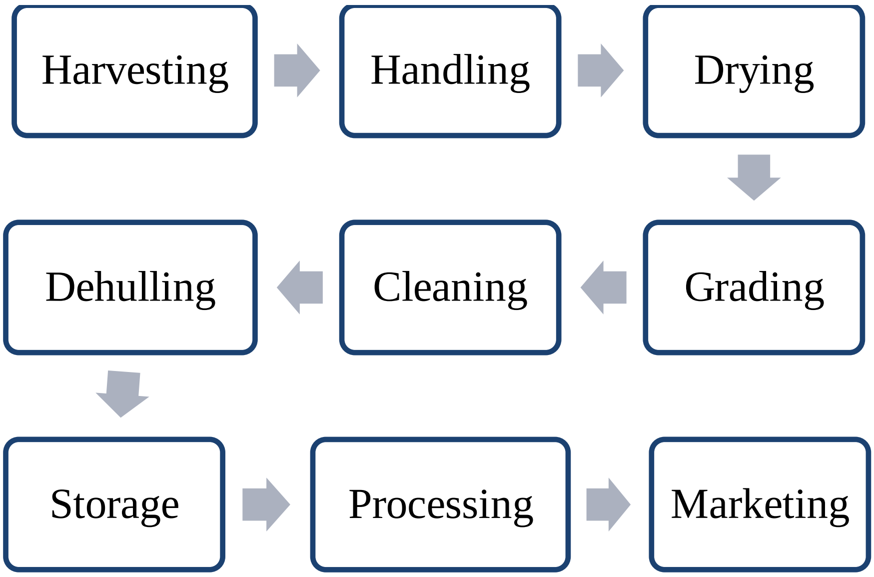

Figure 12.6: The post-harvest technology for Oil Seed flow chart

Post-harvest technology of oilseeds encompasses various techniques and practices aimed at reducing losses and enhancing the quality and value of oilseed crops and their products. Some important aspects of post-harvest technology for oilseeds include:

12.4.1 Handling, Drying, and Storage:

Proper handling, drying, and storage are indeed crucial for oilseeds to maintain their quality and prevent deteriorative processes, enzyme action, and microbial spoilage. Here are the key aspects of handling, drying, and storage for oilseeds:

A. Grading:

Grading of oilseeds is essential to assess their overall quality, moisture content, freedom from impurities, and to evaluate their milling quality in terms of oil yield and quality. Grade specifications for different oilseeds consider factors such as non-prime seeds (damaged, insect-infested, slightly damaged, shrivelled, immature), impurities or foreign matter, moisture content, oil content, and quality indices of the extracted oil (colour, acid value, iodine value, etc.).

B. Cleaning:

Oilseeds often contain various foreign materials such as sand, stones, stalks, weed seeds, and foliage, which are accumulated during harvesting, handling, and transportation. It is important to clean the seeds before storing them. Cleaning processes may involve mechanical separation techniques like sieving, winnowing, aspiration, or using specific equipment like gravity separators, destoners, and sieves to remove impurities and foreign matter.

C. Drying:

Proper drying of oilseeds is essential to reduce their moisture content to a safe level for storage and processing. Drying helps prevent microbial growth, enzyme activity, and the onset of deteriorative processes. The specific drying methods may vary depending on the type of oilseed and available resources. Natural drying, involving exposure to air and sunlight, can be suitable under favorable weather conditions. Artificial drying methods, such as heated air dryers or dehumidifiers, may be used in situations where natural drying is not feasible or rapid drying is required. Care should be taken to ensure that the drying process does not adversely affect the quality of the oilseeds.

D. Storage:

Proper storage conditions are crucial for maintaining the quality and preventing spoilage of oilseeds. Here are some important considerations:

- **a) Temperature and humidity:** Oilseeds should be stored in cool and dry conditions to minimize the risk of microbial growth, insect infestation, and oil rancidity. The ideal storage temperature depends on the specific oilseed but is generally below 15°C.
- **b) Moisture control:** Oilseeds should be dried to a safe moisture content level before storage. The moisture content for different oilseeds may vary, but it is generally recommended to keep it below the critical level that allows microbial growth and oil deterioration.
- **c) Packaging:** Oilseeds should be stored in clean, moisture-proof, and insect-proof containers such as jute bags, polypropylene bags, or hermetically sealed containers to protect them from external contaminants and pests.
- **d) Pest control:** Implementing pest control measures, such as regular monitoring, proper cleaning, fumigation, and using insecticidal treatments, can help prevent insect infestation and protect the stored oilseeds.

Regular monitoring of stored oilseeds is essential to detect any signs of spoilage or quality deterioration. By following proper handling, drying, and storage practices, the quality of oilseeds can be preserved, ensuring better processing and production of high-quality oil products.

12.4.2 Processing:

Oilseeds can undergo various processing techniques such as crushing, extraction, refining, and packaging. Mechanical pressing or solvent extraction methods are commonly used to extract oil from oilseeds.

12.4.3 Value Addition:

post-harvest technology enables the production of value-added products from oilseeds. This can include the production of edible oils, protein-rich oilseed meals for animal feed, oilcake-based products, and oilseed by-products such as lecithin.

12.4.4 Quality Control:

Implementing quality control measures throughout the post-harvest process helps ensure that the oilseed products meet the desired standards in terms of purity, oil content, and nutritional value [13].

12.5 Conclusion:

The post-harvest technology of cereals, pulses, and oilseeds plays a vital role in preserving the quality and nutritional value of these agricultural commodities after they are harvested. It involves a series of practices and techniques aimed at reducing losses, enhancing storage life, maintaining food safety, and maximizing economic returns. By implementing these techniques, farmers, processors, and consumers can benefit from improved economic returns, safe and nutritious food products, and sustainable agricultural practices.

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