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Post Harvest Management Techniques of Few Selected Crop in Assam, India

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Abstract:
Reducing agricultural loss or waste is the ultimate goal of post-harvest management techniques. Post-harvest management has become crucial in the present environment of growing population and declining agricultural land and other resources. Ensuring food security in a manner that is safe for both humans and the environment is currently the world's top priority. The FAO estimates that in order to feed the nine billion people on the planet by 2050, food production would need to rise by seventy percent. Therefore, a deep comprehension of the roles played by agro-ecosystems is necessary. A vast number of agricultural products has been produced in recent years, yet there has been a lack of advancement and uptake of post-harvest technologies, leading to significant post-harvest losses. Agricultural crops have 16–36% post-harvest losses each year due to microbiological, physiological, and mechanical losses. Because most products are highly perishable, they require much more care and strategies to ensure that value addition and processing are encouraged. The value chain for processing has become essential to enhancing national food security and promoting food safety. The value chain in agriculture crops post-harvest management includes pre-harvest variables, harvesting, market preparation (pre-cooling, sorting, grading, packaging, and on-farm storage), transportation, storage, value addition/processing, and by-product waste management. The chapter focuses mostly on few selected fruit, vegetable, and cereal crops while discussing current advancements in post-harvest technology and food crop value addition.

Key words: FAO, ultimate goal, post-harvest management, storage, security, processing.

1. Introduction

Combating food loss and waste presents a triple win scenario. improving food security, helping farmers, and guaranteeing the longevity of agri-food systems. Food loss1 from harvest to retail accounts for 13.2% of global food loss, while food waste2 at the retail and consumer levels accounts for 17%. All told, about 30% of food produced never makes it into a person's stomach (FAO, 2021).

Post-harvest loss has a major effect on the economy, population health, and food security. Annually, about thirty percent of fresh produce is wasted after harvest (Lalpekhula et, al. 2024). Post-harvest loss is the term used to describe the main causes of poor-quality loss that happens after harvest. It begins in the field, following harvest, in the areas designated for grading and packing, in the storage area, during transportation, and in the retail and wholesale marketplaces. Numerous losses can be attributed to inadequate resources, ignorance, poor market performance, poor management, or just plain carelessness on the part of farmers In addition to giving people wholesome, nutrient-dense food, agricultural plants

also increase farmers' profitability. But agricultural plants frequently have soft textures, high humidity, and high perishability. A wholesome, high-quality product can quickly disintegrate in a matter of days or hours if improperly handled.

The goal of post-harvest technology for agricultural crops is to provide safe, nutrient-rich manure by reducing post-harvest losses, preventing spoiling, and maximizing crop use. Using postharvest technologies on harvested crops has three primary goals which includes to preserve food quality (taste, texture, flavour, and nutritional content), to safeguard food safety and in order to reduce losses from harvest to consumption Achieving the intended goals will depend more on effective postharvest management than on the complexity of any one technology. Large-scale enterprises could profit from investing in expensive handling equipment and cutting-edge postharvest treatments, while small-scale handlers sometimes cannot afford these alternatives.

There is a significant discrepancy between total output and total availability because faulty post-harvest practices cause large amounts of crops grown in India to be wasted. Furthermore, less than 1% of crop undergo processing and exported very less in comparison to other nations. Most agricultural produce rots and shrinks 10–15% of the time, decreasing both its market value and acceptability among consumers. Their availability can be raised by lowering these losses without adding more land for cultivation. Tissue damage brought on by improper handling and maintenance can result in physical harm. Physical losses include respiration, colour changes, natural acids, taste, and respiratory changes. Mechanical losses include damage, cracking, cuts, fungal, and bacterial damage.

Food losses of highly variable magnitude, both qualitative and quantitative, happen throughout the entire post-harvest system, from processing and marketing to the ultimate delivery to the consumer. An estimated USD 1 trillion (roughly one-third of the world's food supply) is lost every year in post-harvest procedures and treatments (1.4 billion tons) (FAO, 2016). All of the costs associated with the portion of food produce that was wasted are lost when it is lost. In addition, the farmer makes less money.

Post harvest losses have an influence on the environment in addition to the economy and society because the land, water, and energy (agricultural inputs) needed to produce the lost food are also wasted along with it. Food that is wasted also contributes to increased CO2 emissions, which eventually harm the environment (Ogedengbe et, el. 2023). The different post-harvest handling techniques that preserve few selected agriculture and horticultural crops for extended periods of time so they can be processed and given additional value are the main topics of this review.

2. Pineapple:

2.1. Indices for Harvesting/Maturity

There are several ways to determine when pineapples are ready to be harvested and matured. These include:

- Mature indices for the cultivars are determined by harvesting Kew pineapple at 143-157 days and Queen pineapple at 127-134 days after flowering.
- The two main visual indicators of pineapple maturity are fruitiest flatness and surface colour.
- Calculating the Total Soluble Sugar (TSS), acidity, TSS/acid ratio, internal appearance, etc. are examples of chemical methods.
- It is a compound fruit, made up of multiple separate fruitlets. Fruitlets develop gradually from the base to the top of the fruit. Fruits should have a minimum of 10% near the top and 12% near the base in total soluble solids.

- As pineapples mature, their fruit surface colour changes from green to yellow to reddish-brown. When pineapples are harvested while fully green, they are frequently immature, have little sugar, and have a bad flavour.
- Pineapples are harvested for the domestic market when half of their exterior surface turns yellow.
- Pineapples are harvested at one quarter colour stage for the export market.
- In stage of less than 25% for the long-distance market.
- Typically, pineapples are picked by hand by breaking off the stalk in a downward direction. With a sharp knife, cut the fruit from the stalk just below the fruit's base.
- Common tools include a large canvas picking sack or bamboo basket strapped over the shoulders.
- Fruits can also be collected using field crates made of plastic or wood.

2.2. Processes of pineapple fruit for marketing purposes

- Harvested when they are firm and at a colour pineapple fruit bases are trimmed. Cleaning the fruit's exterior is the first step in getting it ready for the market. Pineapple fruit is cleaned and scrubbed with a brush to get rid of mealy bugs.
- Chlorine as sodium hypochlorite (NaOcl) is a frequently used sanitizer to reduce cross contamination. Sodium hypochlorite (200 mg/litre) should be used to wash the entire pineapple for five minutes.

2.2.1. For domestic market

- Cutting the fruit's base stem to a length of one to two centimetres.
- Removing from the crown any damaged leaves .
- Dust and debris can be gently brushed off the fruit's surface with a dry brush.

2.3. Sorting

- Fruit needs to be sorted based on its size, shape, firmness, colour on the outside, damage from insects, and decay.
- Fruits with obvious damage should be discarded
- The requirements for quality vary amongst markets, so fruits should be graded according to the standards set by each one.

2.3.1. Characteristics of ideal pineapple fruit

- Tidy and devoid of stains.
- Grime fully formed.
- Robust, and mature with eyes that are fully developed (fruitlets).
- With only one crown, free from cuts, wounds, punctures, sunburn, insect damage, and decay.

2.4. Grading

The fruits are sorted based on their size, shape, maturity, and lack of defects and disease. Class A (weight over 500 g), Class B (1100 – 1500 g), Class C (800 – 1100 g), Class D (550 – 800 g), and Baby (weight less than 550 g) are the five classes of grade criteria that are typically used.

2.5. Waxing

- Fruit should be cleaned, dried, and waxed to maximize its shelf life.
- Pineapples are suitable for application of food grade waxes, which can be sprayed on or dipped in.

- Wax mixtures made of food-grade carnauba and paraffin or polyethylene and paraffin are frequently used on pineapples.
- If the chosen type of wax is intended for an international market, it must be approved by the importing nation.
- Applying wax to the fruit's surface alone is advised; the crown should not be harmed by many waxes.
- The benefits of waxing are 1. a decrease in internal fruit bruising. 2. Reduced loss of moisture 3. Glamorous exterior appearance.

2.6. Packaging

- Fruits are packed loose and in bamboo baskets lined with paddy straw for local markets.
- Fruits are kept in carton boxes. Pineapples are usually packed upright rather than on their sides because they can easily get "pressure sores" from their own heavy weight.
- Labels or stickers that are individually affixed to the produce must not cause skin defects or leave obvious glue residue when removed.
- Packages have to be devoid of any extraneous material.

2.7. Transportation

The marketing of fresh pineapple is primarily dependent on transportation. Ripe fruits aren't good for long-distance markets. For long-distance transportation, fruits with a quarter colour development from the base are appropriate, but for local markets, the fruits can be harvested at a 50% to 75% colour development stage. Fruits that are too young are not transported because they lose their flavour, have lower sugar content, and are more vulnerable to damage from low temperatures. In most of India, transportation of pineapple is typically accomplished via truck or rail. The most crucial thing to remember when transporting pineapples is that they need to be loaded onto an appropriate vehicle and packaged appropriately.

2.7.1. Loading/Unloading

In order to protect the produce from impact and vibration forces in transit and to keep insects and other foreign objects out of the load, proper loading and unloading procedures are essential. Mixing loads requires extra caution when transporting them. Mixed products need to work well together.

2.8. Value added goods from pineapple

2.8.1. Pineapple Juice

It is the pineapple juice that is extracted and bottled in sterile bottles or cans for marketing. The juice's shelf life can be increased to 6-7 months by adding preservative at a specific level (KMS less than 70 ppm or benzoic acid less than 120 ppm).

2.8.2. Squash

When making pineapple squash, use fully ripe, healthy pineapple fruits that aren't contaminated with pests or illnesses of any kind. According to FSSAI guidelines, the necessary amounts of juice, sugar, citric acid, water, essence, colour, and preservative (potassium meta-bisulphate or sodium benzoate) are calculated for the preparation of pineapple squash. When consuming it, dilute it two to three times with water.

2.8.3. Pineapple Ready To Serve (RTS) Beverage

The pineapple RTS beverage is prepared from the extracted pineapple juice, adjusting its soluble solids and acidity as per FSSAI specifications for RTS beverage by mixing the juice with required quantity of

sugar syrup prepared from sugar, citric acid and water. Additionally, colour and essence are added and thoroughly mixed according to the requirements.

2.8.4. Pineapple Jam

One of the most well-liked goods made from pineapple is jam. Pineapple jam is a solid gel composed of pectin and fruit juice or pulp.

2.9. Dehydrated Slices

2.9.1. How pineapple slices are preserved by dehydration

Fruits can become spoiled by enzymatic reactions or food microorganisms. When there is enough moisture, mould, yeast, and bacteria develop and lead to spoiling. Dried fruit spoilage can be avoided by lowering the moisture content of food, which inhibits the growth of microorganisms responsible for these events.

2.9.2. Dehydration Technology

By circulating air heated to different temperatures, dehydration—a totally natural process—removes moisture from products while creating the ideal interior environment for careful, gradual drying without the risk of extreme heat that could harm raw materials. With all of its nutrients and sensory qualities intact, the outcome is of the greatest calibre.

3. Paddy

For end consumers to receive high-quality produce, the paddy post-production phase is crucial. Unscientific post-harvest handling practices lead to significant losses in terms of both quality and quantity.

3.1. Harvesting time

Paddy's harvesting season is frequently dictated by the grain's appearance, colour, and moisture content. Harvesting should take place when

- Grain moisture content (wet basis) ranges from 20 to 25 percent.
- Eighty to eighty-five percent of the grains turn straw (yellow).
- When the grain is compressed between the teeth, it becomes firm but not brittle.

3.2. Post-Harvest operations

Threshing

- It is best to begin threshing right away after harvesting.
- To reduce grain losses, thresh paddy in the field and carry the grains in bags.
- Grain quality is affected by field drying and stacking, so avoid doing so for a few days.
- Reducing post-harvest losses can be accomplished with basic pedal or power operated threshers.
- Place every panicle in a straight line for optimal threshing.
- Grain moisture content should be between 20 and 25 percent for mechanical threshing, but less than 20 percent for hand threshing.
- To prevent contamination, thresh paddy on a concrete floor, tarpaulin, canvas, or bamboo mat.

Cleaning/Winnowing

- Utilize a mechanical winnower (powered, hand/pedal, or both) to increase milling recovery and decrease contamination.
- Use bamboo mats or plastic sheets, etc.

Drying

- Elevated moisture levels encourage the growth of mould and insects, ultimately degrading the quality of paddy.
- After cleaning and threshing, immediately dry the paddy grains.
- Drying can be accomplished using a mechanical dryer or the sun.
- Spread the grain evenly on a plastic sheet or canvas, bamboo mat, or in a layer of concrete that is about 4-5 cm deep. Allow it to dry for two to three hours, making sure it is not exposed to temperatures higher than 45 degrees Celsius. Keep the paddy out of direct sunlight.
- Every thirty minutes, turn the paddy over with your hands, feet, and a garden rake.
- Better drying techniques can be used, such as continuous flow dryers, batch dryers, flatbed dryers, and solar bubble dryers.

Packaging

- Rice is packaged using jute bags and HDPE/PP bags. Jute bags impregnated with polythene, hermetic plastic line bags such as the IRRI super bag, cocoon, and so forth.

Storage

- Bag, bulk, or hermetic (airtight containers) paddy storage systems.
- Rice grains thoroughly cleaned and dried before storing. Try to keep the grains and seeds hermetically sealed.
- Maintain a safe moisture level while storing. Maintain the moisture content between 9 and 12% to store for 8 to 12 months, and 9% or less to store for more than a year. Use 14–18% for short-term storage (two to three weeks) and 12–14% for long-term storage (up to six months).
- Regular cleaning should be done on the floor of the storehouse, godowns, and warehouses, as well as the area around the warehouse.
- Dead stock items and waste materials should not be kept inside the warehouse.
- Apply preventive and curative measures (chemical spraying and fumigation) for rodent and insect control in and around the warehouse on a timely basis.

Six procedures for super bag storage

- Verify that the seeds or grains have dried completely.
- Grain is dried to less than 14% Dry seed to 12% or less.
- Insert the super bag into an already-existing kind of storage bag (such as jute or woven polypropylene bags). Before adding grain or seed, the super bag should be placed inside the jute or plastic bag.
- Stuff the super bag full of grain or dried seeds.
- Take out the extra air. Twist the free plastic section above the grain and fold it in half to seal the opening.
- Use an adhesive tape, jute rope, or a sturdy rubber band to secure the twist.
- Making sure not to puncture the super bag, close the outer bag.

Stacking Strategy (when storing in a bag)

- It is advised to use 15 layers of stack height for paddy bags weighing 51–100 kg and 13 layers of bags weighing less than 50 kg.
- In each layer, stacking is done in two different ways: transversely and longitudinally.
- It is recommended to stack bags in a shed or granary that is covered, such as beneath a roof or waterproof tarpaulin.

- Stacks should have a one-meter space around them and a 1.5-meter buffer between the top of the stack and the roof.
- Plastic bags and jute bags should not be stacked higher than 3 meters and 4 meters, respectively.
- Pallets or any above-ground structure should be used to stack bags, keeping them at least 50 centimetres away from the walls.

Management of Rice Storage Grain Pest

- Insects, rodents, and moulds are the three main pest groups that affect paddy storage grains. Rice weevil, Angoumois grain moth, rice moth, Lesser grain borer, Khapra beetle, saw-toothed grain beetles, rust-red flour beetle, and other major storage insect pests are among them.
- The control measures of the above are:
- To control the crawling insect infestation, apply effective preventive chemicals at recommended doses to the walls, floors, alleyways, and grain bag surfaces (prophylactic control measures).
- Using recommended fumigants at recommended doses (Curative control measures) eliminates the insects.
- One option for rodent control is to use traps. Rat burrows and holes inside the godown and surrounding areas can be effectively fumigated, and the holes can then be sealed with a mud mixture.
- Fungicides that are prescribed for seed treatment should be used to control the growth of mould, a fungal pathogen.
- In order to prevent mold growth, grains should be dried to a safe moisture level before being stored. Physical damage to grains during harvesting and storage should also be minimized, and clean, dry, insect-proof storage conditions should be guaranteed.
- To prevent pest infestation, harvesting and threshing equipment as well as transportation vehicles should be thoroughly cleaned before use.

Milling

- For milling paddy, a moisture content of 16% is ideal.
- Using a mechanical mill (in conjunction with de-stoners, cleaners, and de-hullers using rubber rolls with a polisher and grader) and parboiling the paddy prior to milling can help minimize milling losses.
- Do not mill with steel rollers.

3.3. Value addition in Rice

Rice Flour: Finely ground rice is used to make rice flour. Rice flour is a nutrient-dense food that is widely used to make sweets and fresh rice noodles. In order to obtain a smooth and creamy consistency, it is also utilized in a variety of other applications to thicken coconut milk. Either brown rice or white rice can be used to make rice flour.

In the food industry, rice flour is becoming more and more popular as a raw material for extrusion cooking. One kind of flour that is created from milled rice is called rice flour. It is regarded as a respectable replacement for wheat flour, which frequently impairs the digestive system's ability to function. Rice flour's primary characteristic is its ability to prevent liquid separation, which is why it's used as a thickening agent in recipes meant to be refrigerated

Puffed Rice: To bring the rice's moisture content up to roughly 20%, it is soaked in salt water. For thirty to forty seconds, the moist rice is placed in a hot vessel that is heated to between 250 and 275 degrees Celsius. Suddenly, the rice puffs up. In Assam, Akhoi is a well-liked puffed rice product. Another well-

known puffed rice product is hurum, which is made from Assamese glutinous Bora rice. Typically, it is served as a snack (jolpan) with jaggery and cream or yogurt.

Popped Rice: Another traditional value-added product made from raw paddy is this one. Using sand as a medium and roasting the paddy at a temperature of 150–200 degrees, it is done immediately in iron pans with a moisture content of 12–14%. Popped rice is mostly used in religious ceremonies and events, and its production is relatively small.

Flaked Rice (Seera): Another significant value-added product made from paddy is seera. Traditionally, soaked paddy is used in its preparation, which involves heat treatment and quick flattening with an edge runner flaking machine.

Pithas: Pitha is a type of traditional Assamese cuisine that resembles pancakes, dumplings, or fritters. Pitha is made by steaming, frying, or griddling a dough or batter that can be sweet or salty. The majority of varieties are unleavened and cooked on a stovetop; very few are baked or boiled. Variants might contain a filling.

3.4. Among the Pithas Often Made in Assam from Rice are the Following

Til Pitha : These rice and sesame-filled pithas have a cylindrical shape. On a pan that is essentially made of cast iron and heated, the rice flour is spread out in a circle. After adding sugar or jaggery to the circle, the roasted sesame seeds are rolled up. These have a cylindrical form that resembles sugar.

Ghila pitha: A type of pitha prepared by frying jaggery and Bora rice in mustard oil.

Tel pitha: This is a type of pitha cooked in oil made from mustard.

Sunga pitha: A unique pitha prepared by combining sali and bora rice, adding water and jaggery, and thoroughly churning the mixture. It is then put inside a young bamboo tube, sealed with a banana leaf, and burned. After that, the tube-shaped cake is sliced and served with warm milk.

Tekeli pitha: A unique pitha prepared by combining sali and bora rice with milk, sugar, and coconut. Pitha is cooked in a kettle or earthenware pot that is placed on a hearth.

Kachi pitha: A sickle-shaped pancake filled with ground coconut, jaggery, and sesame seeds, and made from Bora rice.

Uhuwa pitha: Sali and bora rice flour combined with water and jaggery. and gave it a good stir. After flattening and rolling the paste into tiny balls, it is boiled in water.

Ketli pitha: the ingredients and preparation technique are the same as for tekeli pitha; however, a kettle is used in this recipe rather than earthenware.

Additional varieties include kholasapori pitha, xutuli pitha, bhapotdiya pitha, lakhimi pitha, tora pitha, muthiya pitha and so on.

3.5. Products Made from Fermented Rice

Idli : A thick batter consisting of rice and dehulled blackgram dhal is fermented by bacteria over a period of 12 to 18 hours, resulting in the small, white, steamed cake known as idli. Idlis have a pleasant sour flavour and are soft, moist, and spongy. The black gram was finely ground and the rice was coarsely ground for idli.

Dosa: Another fermented food item consumed in India is the dosa. This is made with a fermented rice and pulse batter that has a ratio of 6:1 to 10:1. Unlike the idli batter, which has a coarsely ground rice component, both ingredients are finely ground. Dosas are baked on a hot pan with a very thin batter. The

batter's consistency determines how thick a thin pancake will be. Even though it might stick to the pan, thin batter produces thin pancakes.

Dhokla: Made from rice and Bengal gram, dhokla is a fermented dish. This is well-liked in Gujarat and other parts of West India. This is made with a batter made of Bengal gram and coarsely ground rice. After being steamed in a pie dish, the fermented batter is sliced into diamond shapes and seasoned.

Additional fermented goods Other rice-based fermented products that are popular in the nation include fermented rice (kali), which is leftover cooked rice mixed with water and left to ferment overnight, and ambali, which is made from a thick farmed batter of rice and finger millet flour.

3.6. Rice Standards

The wholesomeness, appearance, colour, foreign matter (both organic and inorganic), damaged and broken grains, immature/shrivelled grains, weevilled grains, admixture, and moisture content are the parameters that determine the quality of paddy.

1. **Standard that applies to Food Corporation of India (FCI) purchases of paddy uniform requirements for every variety of paddy**

The paddy must be in good enough condition to be sold. It should be free of mould, weevils, offensive odours, Argemone mexicana, Lathyrus sativus, and the addition of harmful substances. It should also be dry, clean, wholesome, and have good nutritional value. It should be uniform in colour and size.

Paddy is classified as “Common” and “Grade A” groups

Specification parameters

Sl No	Parameters	Maximum limit(percentage)
1.	Foreign matter	
	1. Inorganic	1
	2. Organic	1
2.	Grains that are broken, discoloured, sprouted, and weevil	5
3.	Shrunken, shrivelled grains that are immature	3
4.	Mixture of unwanted particles of low class	6
5.	Content of moisture	17

4. **Lentil:** Lentil seed handling, drying, and storage are crucial post-harvest processes because they have a significant impact on the food product's quality.

Time and Care of Harvesting :

- When leaves start to fall, the stem and pod turn brown or straw in colour, the seeds are hard and make a rattling sound when the pods are shaken, the crop is ready for harvesting.
- Overripening results in seed cracking and shattering, as well as pods falling.
- When seeds are harvested, they should have an ideal moisture content of 18–20%.
- Grain weathering brought on by postponed harvesting can significantly raise the risk of mould infection. Elevated mould infection causes the seed coat to become darker.

- Applying a desiccant such as Regione (diquat) at a rate of 2 g/lit of water can help dry the seeds evenly in the field, eliminate green weeds, and enable earlier harvesting. When the crop first turns yellow, it is the ideal time to desiccate it. Depending on the weather, the crop will be ready to be harvested 5 to 10 days after the desiccant is applied.
- In order to avoid breaking losses, harvesting should be done early in the morning.
- Pods should be harvested as soon as they reach maturity.
- Harvesting should ideally take place early in the day.

Threshing and Winnowing

- The crop should be threshed manually, with a bullock, or with a power thresher after being left to dry on the threshing floor for four to seven days.
- For threshing, a moisture content of 16 to 18% is ideal.
- To prevent contamination, threshing should take place on pucca floors rather than kutcha floors.
- Store the tarpaulin or polyethylene sheet ready to cover the crop in the threshing yards in order to protect it from unexpected rain.
- The separated seeds should undergo either mechanical or manual winnowing after threshing.

Drying

- Drying can be accomplished using a mechanical dryer or the sun.
- To bring the grains' moisture content down to 10-12%, sun dry them for three to four days on a clean concrete floor, plastic sheets, tarpaulin, or bamboo mats.
- Lentil seed should only be heated to temperatures lower than 40 degrees Celsius.
- Steer clear of drying lentils on hard surfaces as this can introduce soil or dirt into the grains and promote the growth of mould or fungus.

Packaging

- The packaging material that is used needs to be clean, sturdy, free of insect and fungal infestation, and it shouldn't affect the product's flavour or contain any toxic materials.
- Materials used in packaging. Jute bags, HDPE/PP bags, polythene-impregnated jute bags, and IRRI super bags are all used for lentils.

Storage

- It is best to store lentil seed in a dry environment to avoid oxidation-induced discoloration.
- To minimize splitting and chipping, move lentils as little as possible and handle them gently.
- It is important to thoroughly dry and clean the grain before storing it.
- Lentil seed can be safely stored for up to 40 weeks at 12–14% moisture and 15 degrees Celsius or lower.
- better storage buildings, such as brick built godowns and warehouses, pucca kothi, R.C.C. ring bins, and metal bins. Lentils can be stored in silos, under covers, on plinths, etc.
- Make sure the godown or storage structure is thoroughly cleaned to remove any remaining grains that could harbour pests and contaminate the fresh stock.
- It is not advisable to mix seeds from different years because the oldest seed will cause the entire sample to be downgraded because of browning seed coats.
- To keep moisture from absorbing into the bags of lentil seed, arrange bamboo mats or wooden crates over them and cover them with a polythene sheet.
- Stack the bags far enough away from the walls.

- Make sure that rainwater cannot enter the building from any source.
- In order to prevent cross-infestation and moisture intrusion, structures should not be left open for extended periods of time or opened frequently, especially during the rainy season.
- In order to keep the stocks clean and healthy, check them frequently, ideally every two weeks.

Control of Stored Grain Pest

- Dried lentil seeds should be thoroughly mixed with 3 kg/kg of black pepper seed powder to prevent bruchid infestation.
- Storage building fumigation using aluminium phosphate.
- Fungicides such as Carbendazim and Captan should be used for seed treatment in order to control moulds, which are a type of fungal pathogen.
- Reduce physical damage to the grain during harvesting and storage, dry the grain to a safe moisture content before storing it, and maintain a clean, dry, insect-proof storage environment to prevent the growth of mould.
- To prevent pest attacks, harvesting and threshing equipment as well as transportation vehicles should be thoroughly cleaned before use.

Grading

- Prior to sale, wash and grade the lentil seeds to the producer's level.
- Weevilled/damaged grains, moisture content, immature, shrivelled, and broken grains, as well as the addition of other edible grains, are quality factors for classifying foreign matter in lentils

5. **Ginger:** In most cases, ginger is grown once a year. The entire plant has a crisp, pleasant aroma, but the raw or cooked underground rhizome is what people value most about it as a spice. Because some of its volatile oil evaporates during storage, fresh ginger has a different flavour and aroma from dried ginger.

5.1. Harvesting

Indices of Maturity

The size of the rhizome, leaf age, and foliage senescence are significant indicators that are used to identify the stages of ginger harvesting. When there is no healthy foliage, rhizomes do not grow larger. Increases in fibre content, shorter storage life, faster rate of sprouting, and delaying harvesting until all the leaves have dried all lower the quality of rhizome. Weak harvesting of ginger causes weight loss. For high-quality production ginger, digging usually occurs nine to ten months after seeding. However, after 5–6 months of sowing, large-scale rhizome digging can begin in preparation for off-season sales.

Harvesting Techniques

Ginger is primarily harvested by hand, despite the availability of digging machines for large-scale planting. The process involves loosening the soil surrounding the plant's base with a fork. To prevent harming the rhizomes, the procedure is carried out extremely carefully. If ginger is taken too soon, it will still have a green stem that is growing and needs to be separated from the rhizome. Next, in the field, ginger is pre-graded to remove any unsellable, unhealthy, or damaged rhizomes. It is not ideal to harvest when it is extremely dry or wet.

5.2. Grading for new ginger sales in the local wholesale sector

There are two main kinds of buyers in the ginger wholesale market.

1. Washing ginger is preferred by semi-wholesalers who sell their entire purchased lot on the same day.

2. Retailers prefer to purchase unwashed ginger from wholesalers when purchasing weekly stock at a time. It has an advantage over washed ginger because they wash the necessary amount to be sold in a single day to keep the ginger's shine and prevent browning on the surface. Even though they are of the same grade, washed ginger is more expensive than unwashed ginger because that is what the final consumer ultimately wants.

5.3. Curing and Packaging

Curing will monitor the postharvest deterioration and weight loss. For fresh sales, the ginger needs to be packed in gunny bags after grading and curing. The hinger needs to be cured until the skin starts to thicken.

5.4. Loading, Stacking and Transportation for Domestic Market

In order to transport produce, the vehicle needs to be thoroughly cleaned and sanitized before loading up. Never move ginger in a car that has been used to move poisonous materials, herbicides, or live animals. Gunny bags in good condition should be used, and stacking should be done so that lots and grades of unloading can be completed for sale in the wholesale market.

5.5. Post Harvest Diseases

In ginger, post-harvest disease is typically caused by handling and harvesting techniques that are too rough, injuring the rhizome's flesh and skin. Postharvest decay of ginger will be accelerated if it is kept at a temperature and relative humidity (RH) below ideal levels. Careful harvesting and handling procedures, sanitized washing water, curing the rhizomes to seal cuts, and storing them between 12 and 18 degrees Celsius and 70 and 75 percent relative humidity can all help reduce decay

5.6. Post Harvest Disorders

S**prouting:** At temperatures higher than 15.6 degrees Celsius, ginger rhizomes will begin to sprout. Depending on the temperature, sprouting may occur. A temperature increase accelerates the sprouting process. For ginger, there isn't a reliable chemical sprout inhibitor.

Chilling injury: If stored below 12 degrees Celsius, ginger rhizomes are extremely susceptible to low temperature breakdown or chilling injury.

Shrivelling: A common postharvest illness in ginger stored at low relative humidity (RH) levels (less than 65% RH) is called "shrivelling." After the rhizome loses more than 10% of its initial harvest weight, shrivelling of the plant becomes apparent. Conversely, at a relative humidity of greater than 90%, surface mould will start to grow, and a temperature of 16 degrees Celsius or higher will encourage sprouting. Ginger should be stored in an ideal relative humidity range of 70 to 75% to prevent surface mould growth and minimize weight loss.

5.7. Secondary Processing of Ginger

Dried Ginger

In terms of trade, dried ginger ranks second only to fresh ginger. The basic ingredient for making ginger powder, ginger oil, and oleoresin extraction is dried ginger. It is produced by drying fully developed rhizomes that are picked between the ages of eight and nine months. 16–25% of the green or fresh ginger is produced as dry ginger. Dried ginger comes in a variety of forms, including slices, splits, and whole pieces. The drying process has a significant impact on the dried ginger's quality.

Ginger Powder

Curry powder contains ginger powder as one of its main ingredients. It is also used in ginger wine, ginger beer and baked goods. Grind the dried ginger to make ginger powder. Herbal medicines can be made with ginger powder and used as pharmaceuticals. Additionally, it is a food additive.

Ginger Paste

Good fresh ginger is used to make paste. Ginger-garlic paste, which is highly popular in India, is typically made using traditional methods with 50% macerated and sliced ginger, 35% garlic, and 15% salt.

6. Maize

6.1. Harvesting

Indices of Harvest

When corn reaches full maturity that is, when the husk turns yellow and the grains become tough enough to withstand 25–30% moisture maize it should be harvested.

Harvesting Techniques

1. **Cob plucking:** It involves removing the ears or cobs from the standing plants, piling them so they will open in a day, and then spreading them out to dry in the sun. Stalks can be used as green fodder in this method.
2. **Stalk Cutting:** After two to three days of harvesting, the plants are chopped, piled in the shade, and the cobs are taken out. Hay is made from the dried plants.
3. Harvesting right out of the shower is not a good idea.
4. Following harvest, drying needs to be done right away in order to reduce moisture to 13-14%.
5. The best way to shell or store unshelled ears (cobs) is to let them dry completely in the sun.
6. Use tarpaulin or dry maize on a cement floor to lessen the possibility of contamination.
7. Move them right away to the drying area (such as the crib).
8. The grains can be cleaned, dried for three to four days, and then stored at 8 to 10% moisture content.be sun-dried and then shelled to retain 12–15% moisture.

6.2. Post Harvest Operations

Shelling and Storage

a. Following harvesting, the cobs' husk and hair must be removed.
b. For 5-7 days, ears and cobs can be sun-dried, then shelled to retain 12–15% moisture.

Packaging

For ease of handling, transportation, and storage, use proper packaging. The corn is moved in gunny bags from the field (threshed floor) to the market for storage. Either new or used, high-quality gunny sacks that have been properly treated are essential to preventing spoiling and shielding the corn from moisture and pest damage.

Characteristics of Quality Packaging Ingredients for Maize

1. Well-protected maize cobs are essential.
2. It must be robust enough to support weight while being handled and transported.
3. It needs to be manageable.
4. A single person should be able to easily lift and handle the package thanks to size restrictions.
5. It ought to be tidy, appealing, and infestation-free.
6. It needs to be labelled with the following information: the commodity's description, the packer's name

and address, the quantity, the variety, the quality (grade), and the packing date.

6.3.Storage

Storing in sealed receptacles lessens the harm caused by vermin and insects. The grain needs to stay clean and dry while being stored. Grain storage can be extended up to 2 years without any significant reduction in quantity and quality. However, because they expect to lose food during storage, most farmers sell their maize grains for a low price as soon as they are harvested, and they later purchase food at much higher prices. Better storage structures exist that can extend the period of storage until grain prices are favourable.

6.4.Transportation

1. From fields to markets, and from markets to mills and other terminal markets, maize is transported. The amount to be transported, the distance, the road's connectivity, etc., all influence the mode of transportation.
2. Since individual farmers in tribal areas typically sell very small quantities, the produce is transported by head load or on pack animals.
3. Both bags and bulk are used to carry maize from the fields to the marketplaces. While it is carried in bags from markets to mills and other terminal markets.

6.5.Products with added value

Corn Starch

- Corn starch is used in the food industry in a variety of ways:
- thickening pie fillings, gravies, puddings, and sauces
- makes cake-loving hard wheat flooring
- to give ice cream cones the right amount of strength
- Sweeteners and synthetic honey
- Agents that retain moisture in breads
- Agent for dispersing in concentrates for instant drinks
- **Corn Flour:**

- Corn flour is used in the food industry in a variety of ways:

- Pancake and waffle mixes
- Beverages
- Alcohol
- Confectionary toppings
- Confections
- Baby foods
- Snacks
- Bakery dustings
- Bread and batters

- **Corn puffs / Kurkure/Curls:** These are corn-based extruded products. The cost of machines ranges from 3 to 10 lakh, and their hourly capacity is between 50 and 100 kg.
- **Corn Flakes and Poha :** In various parts of India, small-scale production of corn flakes, chocolate flakes, honey flakes, and so forth is done. Similar products with strong export demand include makka

poha, which is used in the snake industries, as well as mixture namkeen and corn grits. India can become a major exporter of cornflakes in this way.

- **Baby Corn**: Baby corn has similar nutritional value to other major vegetables. It is a good source of fibrous protein and one of the richest sources of phosphorus. Additionally, it is readily absorbed and largely devoid of pesticide residue. Among the goods made with baby corn are soups and different dishes, pickle, murraba, vegetable recipes, baby corn pakora, canned baby corn etc.

7. Banana:

After mangos, bananas are India's second-most important fruit crop. Every class of people's favourite fruit due to its year-round availability, affordability, variety range, taste, nutritional value, and medicinal properties. It has several minerals and vitamins in it.

7.1. Indexes of maturity, harvesting and transportation method of banana:

- Drying of upper leaves, a shift in fruit colour from dark green to light green, and the fruit's tendency to fall off when touched gently are signs that a banana is mature. When the fruit reaches maturity, it gets plump and all the angles are filled in.
- Harvesting low-growing cultivars involves slicing through the bunch stalk approximately 30-35 cm above the top hand. For taller varieties, however, the bunch will be brought down within the reach of the harvester by partially cutting through the plant's stem, after which the bunch stalk will be chopped.
- Farmers should assess the fruits' maturity prior to harvesting and transferring raw bananas to chemical-free banana ripening units or for sale in wholesale markets.
- Growers need to deliver their green or raw bananas to the ripening units in plastic crates. Banana leaves should be used as padding between the vehicle's wall and the banana bunch as well as between different business layers if farmers wish to transport their entire bunch, that is, without cutting into people's hands.

7.2. De-handling:

Following harvest, de-handling needs to be done with a clean, sharp knife, cutting as close to the stem as possible.

7.3.Cleaning, de-latexing and fungicide treatment:

Cleaning refers to chlorine washing of the banana fruit for the removal of undesirable material including latex, adhering soil particles, chemicals along with the microorganisms. Fruits from banana trees are submerged in water for approximately half an hour. A good solvent for reducing microbial infection is sodium hydrochloride (.5–1%). De-latexing is the process of cleaning off the sticky latex.

Banana hands are sprayed with fungicide to treat the crowns, which protects fruit from fungal attack that causes crown rot during transportation or shipment, particularly during the rainy season.

7.4.When applying fungicides, exercise following caution:

Only the appropriate dosages should be used when using permissible fungicides. Care i.e. It is imperative to wear appropriate protective clothing when applying fungicides.

7.5.Sorting: When a banana is sorted, overripe, bruised, rotten, diseased, infected, and cut fruits are removed.

7.6.Grading: Fruit is categorized according to the size and number of fingers on each hand when it comes to bananas.

- Fruits are graded primarily based on their size, colour, and maturity.
- For uniform ripening, smaller fruits are kept apart from larger ones.
- Fruits that are damaged, diseased, overripe, or immature are thrown away.
- Harvested produce will be sequentially cleaned, sorted, and graded according to availability.
- We'll keep each lot apart so we can sort and grade it separately.
- To facilitate easy accountability for sale later on, a uniform weight per crate must be maintained.

7.7.Ripening:

- The best way to accelerate ripening without sacrificing fruit flavour and quality is to apply ethylene.
- Lower dosages of Ethrel are used to ripen mature fruits so that their colour develops uniformly.
- Under controlled conditions, slow ripening should be preferred, with a temperature range of 15 to 18 degrees Celsius.

7.8.Minimum Requirements for Quality Need for Fresh/Green Fruits

A banana must be

- Whole (using the finger as a guide).
- Solid, unblemished, tidy, and devoid of any apparent foreign objects.
- Crown is cleanly cut, unbruised, and not ripped or bevelled.
- Devoid of pests that compromise the overall appearance of the produce.
- Without banding, fungal damage, or desiccation, and with the stalk whole.
- Without any deformity or irregular finger curvature.

Techniques for unloading:

- The transport needs to be parked beneath the shed.
- It is important to unload the bundles or crates onto the platform at the assigned location.
- When unloading crates, care must be taken to handle them properly.
- For every consignment, lot-wise stacking must be completed independently and without combining any materials.
- Sorting and grading must be done in accordance with the established guidelines.

Techniques for assessing quality:

- Take a sample out of this same car to verify quality.
- Examining external and other flaws in order to accept the product as is.

Produce Handling at the Ripening Unit :

- Produce that has been sorted will be moved into the ripening chambers for chemical ripening. Lot-by-lot stacking is the recommended method for the ripening chamber. Before moving into the chamber, a tag or sticker containing the details (date, grade, quantity, and chamber number) must be placed on each crate.

- At last, crates with the standardized and graded weight for ripening are moved to the designated chamber.
- The chamber position needs to be checked on a regular basis in accordance with the schedule to guarantee that the banana ripens properly.

Produce Sale Packing, Stacking, and Withdrawal:

- Bananas should be packed grade-wise using the appropriate packing materials and pack sizes.
- Withdrawals must be made in accordance with orders placed and demand generated.
- The stacking process will follow established guidelines. The withdrawn produce will be shipped the same day, ideally ahead of schedule.
- Produce that has been grade-standardized and packed must be kept in inventory.

7.9.Packaging

Banana in crates should normally be packed horizontally in two rows, with the fruit tips pointing toward the centre of the crate and the crown end toward the side.

7.10. Storage

Banana must be stored at 13 degrees Celsius with 85 to 95% relative humidity. Fruits that are stored below 13 degrees Celsius are susceptible to low temperature damage, or chilling, which causes the fruit's surface to become discoloured, dull, and the flesh to brown.

7.11. Transportation: Recommendations for safe banana transportation

- With bananas, caution must be used.
- They can't be thrown or dropped on top of one another.
- Fruit damage is increased when the transport vehicle is overloaded. Therefore, it is important to avoid overloading.
- It is not recommended to use the bananas at the bottom of the transport vehicle as steps to enable stacking higher up. To avoid heat buildup, air circulation in the produce stacks or piles is essential. The act of leaving space between stacks facilitates this.
- It is strongly advised to use stackable plastic crates as transport containers because they offer sufficient protection for bananas while in transit.
- Air circulation through the stack needs to be allowed if canvas is used to cover the banana. Since it will reflect heat, light-coloured material is preferred for covers.
- Every piece of transportation gear needs to be inspected for cleanliness: It's important to routinely clean the load compartment.
- The transporting vehicles' floors, walls, doors, and ceilings should all be in good shape.

7.12. Addition of Value in Banana

There is a great deal of potential for adding value to nearly every part of the banana plant. Several value-added banana products in Assam include:

1. Chips made from bananas: Unripe peeled bananas are usually cut into thin slices, dipped in a solution of sodium or potassium meta-bisulphate, deep-fried in vegetable oil at 180 to 200 degrees Celsius, and then sprinkled with salt and an antioxidant.

2. Powdered banana: It is frequently used as a raw ingredient in ice cream, baby food, and milk shake recipes. Additionally, the pharmaceutical and cosmetics industries use it.

8. Turmeric

8.1.Index of Harvesting

Drying of the stem and plant, which can happen anywhere from seven to ten months after planting, depending on the soil, cultivar, and growing circumstances.

8.2.Method of harvesting

Either the soil is initially loosen with a small digger and clumps are manually lifted, or the rhizomes are meticulously excavated by hand using a spade. Prior to lifting the rhizomes, it is preferable to trim the leaves. After soaking in water, the rhizomes are cleared of any remaining soil, and their long roots and leaf scales are extracted.

8.3.Curing

Rhizomes of turmeric are cured before drying. Boiling the rhizomes until tender is the curing process. It is done to get rid of the fresh earthy smell and to promote more uniform drying. The colouring material is evenly dispersed throughout the rhizomes during this process. Boiling in water for 45 minutes to an hour is recommended to release the typical aroma of turmeric and cause froth to form at the surface. The colour can be enhanced by boiling in alkaline water with.05% to 1% sodium carbonate or lime. Boiling batches of rhizomes of the same size is crucial for the curing process, as varying sizes of material call for different cooking times. To prevent rhizome spoilage, curing must be completed two or three days after harvest and should not be postponed.

8.4.Grading

Rhizomes in bulk are categorized as fingers, bulbs, or splits. While splits and bulbs are the result of cutting bulbs into quarters or halves before they cure, fingers are the secondary branches that grow from the mother rhizome. The fingers are more expensive than the more fibrous bulbs and splits because they are easier to grind and are 2 to 8 cm long and 1 to 2 cm wide.

8.5.Polishing

The exterior of dried turmeric is rough, dull, and covered in scales and bits of root. It looks ugly. By rubbing the outside smooth and polished using a machine or by hand, the appearance is enhanced. The better approach uses a manually operated barrel or drum with expanded metal mesh on the sides that is positioned on a central axis. Power-operated drums are used for the automated polishing process. Between 15% and 25% of the raw materials are converted into polished turmeric.

8.6.Slicing

Cutting the rhizomes into slices shortens the drying process and produces turmeric with better curcuminoid extractability and a lower moisture content.

8.7.Drying

Dried fingers or bulbs have a moisture content of 5–10%. Sun drying could take a week or two. To reduce the amount of direct sunlight that causes surface discolouration, the rhizomes should be spread out in layers that are 5-7 cm thick. Using mechanical dryers is more advantageous because the active compounds have a light sensitivity. The ideal temperature for drying is sixty degrees Celsius.

8.8.Packaging

Rhizomes can be shipped overseas in wooden boxes or lined corrugated card board boxes, while they can be packed in jute stacks for the domestic market.

8.9.Storage

In order to avoid moisture absorption and chemical deterioration, bulk rhizomes should always be stored in a cool, dry environment. Store the powdered and rhizomes of turmeric in a dry, dark place away from light.

8.10. Addition of value in Turmeric

Dried rhizomes

The quality of rhizomes is determined by their smooth, clean skin, consistent flesh and skin colours, and clean snap when broken.

Turmeric powder

The two main markets for ground turmeric are retail and food processors. Rhizomes are ground to a particle size of between 60 and 80 mesh. Turmeric's colour components are susceptible to deterioration when exposed to light and heat, so it's critical to store ground turmeric properly and pack it in UV-resistant packaging. One of the main ingredients in curry pastes and powders is turmeric powder.

Oleoresins

The ground or chopped rhizome is extracted with a solvent to produce extractives, also known as oleoresins, from turmeric. This process produces around 12% of an orange/red viscous liquid. The amount of colouring material—curcuminoids, the volatile oils that give the product its flavour—and non-volatile fatty and resinous materials vary depending on the type and cultivar of turmeric, the extraction solvent, and other factors.

9. Potato

Potatoes are grown in the plains during the winter and in the hills during the summer because they require a cool climate to grow. Although the crop matures in 100–120 days, tubers can be harvested at any point after roughly 60 days.

9.1. Indices of Maturity

- Mature potatoes are indicated by their drying of the aerial portion of the plant, also referred to as vine senescence.
- Mature potatoes are also indicated by how resistant the tubers are to abrasion during harvest.
- When the tubers reach maturity, their starch content should be higher and their sugar content should be less than 150 mg per 100 g.

High-quality indicators

A good plant should have a good form, a bright colour (yellow, red, or white depending on the variety), uniform bulk, firmness, no soil adhesion, no bruises, no microbial or pest infestation, no diseases, and no sprouting or greening.

9.2. Harvesting

- The ideal soil temperature for harvesting is between 12 and 18 degrees Celsius. Bruising may occur from harvest temperatures above 25 degrees Celsius or below 8 degrees Celsius.
- Faucet irrigation fifteen days prior to dehaulming.

- When the plant begins to turn yellow at about 80–90 days, it is time to perform the dehaulming practice, which involves cutting the aerial or above-ground portion of the plant with a sickle or machine. This should be done 10–15 days before harvest.
- To prevent bruises, harvesting needs to be done carefully, in dry weather, and at the appropriate maturity level.

Methods for excavating potatoes

- Picking potatoes by hand using a shovel or plough is possible.
- Tractor-drawn potato diggers are the most widely used harvesting machinery. It distributes the tubers across the manually selected soil surface.
- There are also harvesters that combine digging and collecting of the tubers, which can then be bagged or loaded onto trollies.

9.3. Curing, sorting, and drying

- After harvesting, if the potatoes are exposed to rain or moisture, bulk storage must be avoided without drying.
- After harvesting, potatoes must be shed dried; however, sunlight exposure should be avoided to prevent greening
- The potatoes are dried and then combined for curing at a temperature of about 25 degrees Celsius and 90% relative humidity. This helps the potatoes heal their bruises and get tighter skin.
- Spreading the tubers under the fan will help manage the sweating that occurs during the curing process.
- Sorting will allow the damaged, green, and diseased tubers to be disposed of.

9.4. Grading

Potatoes are kept in heaps for 10 to 15 days following harvest in order to give minor bruising time to heal before grading. Tubers can be mechanically or manually graded.

9.5. Handling

- Tubers are sold unwashed or after being washed with water to remove any soil adhering to them for the fresh market, without any chemical treatment.
- After grading, seed tubers are typically treated with a 30-minute dip in a 3% boric acid solution.

9.6. Packaging

- Potatoes are typically packaged in 50 kg capacity jute and leno/nylon bags.
- Potatoes intended for export and high-quality retail are packaged in 10 kg capacity corrugated boxes with holes.
- Graded baby potatoes can be properly sealed and packed in 1, 2, and 5 kg perforated LDPE packing material.

9.7. Transportation

- Transportation vehicles need to be well-ventilated, shaded, not allow over stacking, and bug- and rodent-free.

- When transporting potatoes, it is imperative that the vehicle be cleaned on a regular basis and that any internal moisture be removed.
- Vehicles with refrigeration are ideal for long-distance travel.

9.8. Storage

- Tubers can be kept in cold stores for three to nine months, or they can be kept on the farm for two to three months.
- Immediately following harvest, short-term storage is used to bridge the low-price period. A layer of rice straw, 10 to 15 cm thick, is spread over the piled tubers. The heaps contain perforated pipes for gas exchange. Either a field with trees providing shade or a room can be used to create the heaps. Potatoes for processing and table are kept in short-term storage.
- Potatoes for table, processing, and seed are stored. Here, tubers are kept cold and at varying temperatures based on their intended usage. - Table potatoes at 7 °C. -Cooking potatoes at 8 to 12 degrees Celsius - Potato seeds: 2-4 degrees Celsius.
- When potatoes are stored at 7–12 degrees Celsius, sprouting suppressants such as isopropyl N-Chlorophenyl Carbamate (CIPC) are used to prevent most sprouting problems.

9.9. Principal Post-Harvest Diseases

Disease Symptoms of a Tuber Moth Infestation: **Description:** The moth eats away at the inside of the eyes, causing weight loss. **Propagating** via the eggs of tuber moths. **Treatment:** Cover stored potatoes with lantana or eupatorium, avoid spreading harvested potatoes on the field overnight, and fumigate them with methyl bromide for three hours at a rate of 4.8 kg/100 cubic meters.

Charcoal Rot: Description: Soaked areas of dark material. **Spreading:** Through bruises, insect-damaged skin, or soil. **Treatment:** Early harvesting, avoiding bruising during harvest and handling after harvest, and storing at low temperatures are all necessary.

Late-stage blight Potato: Description: Wet rotting during storage, with a developing brown u. **Transmission:** By means of seeds, tubers, and contaminated soil. **Treatment:** Steer clear of bruises when harvesting.

Description of Soft Rot/Black Leg: Infection of tubers through wounds. **Spreading**: Infected soil and tuber, spread by flies, 21–29 degree Celsius ambient temperature, and 94% relative humidity. **Treatment:** Before being stored, seed tubers and stored tubers are treated with 3% boric acid for 30 minutes and then rinsed with chlorinated water.

Dry rot symptoms include sunken, dry patches with uneven rings, browning internal tissues, and light-coloured, shrivelled tubers. **Spreading:** Contaminated air, floor of contaminated tuber storage, soil, and tubers. **Treatment:** To prevent tuber injuries, potatoes should be properly dried before storage. During the first two to three weeks of storage, a low temperature of 10 to 15 degrees Celsius, adequate ventilation, and 95% relative humidity are ideal for the healing of wounds and prevention of disease.

10. Mustard

Three stages make up the oil seed post-harvest phase: (1) conditioning or processing; (2) packing; and (3) storage. The seed lot's physical quality, maintaining a safe moisture content, eliminating foreign objects, spurious seed, and undesired seed components, and enhancing the seed's planting condition through the application of chemical protectants are all under the purview of seed conditioning. The seed goes through

several processes in this phase, including chemical treatment, grading, cleaning, drying, and humidification.

10.1. Mustard-Rapeseed and its losses in post harvest

- Rapeseed and mustard losses happen during post-harvest activities like handling, shipping, and storing at the producer, trader, and wholesaler levels.
- Weight loss happens during the dry season.
- Improper harvesting practices and disregarding harvesting stage symptoms lead to a decline in the quality of mustard-rapeseed seeds.
- Workers using too many hooks when handling or lifting bags can result in spills and losses.
- Because of rodent attacks on bags, which cause waste to spill and losses during storing period.

10.2. Harvesting

A crop can reach maturity in 110–140 days, depending on the variety.

When 75 percent of the pods turn a golden yellow colour, harvesting is done. At this point, the seeds will have a moisture content of 25–28%. At the level of the lowest pods, the crop is harvested. Because the crop is prone to breaking, it is best to harvest it early in the morning, right before the pods open, to prevent losses.

Steps to be taken during harvesting

- When the pods start to turn yellow, it's time to harvest the toria and mustard. Sarson is less likely to break, so it can be harvested at a relatively dry, ripe stage and left in the field for a longer amount of time.
- When harvesting by hand, care must be taken to gather the entire plant by using sickles to pull it out or uproot it, or a few centimetres above the ground.
- Harvesting should take place early in the morning because the moisture that collects overnight keeps the pods from splitting.
- Harvesting crops should occur when the pods have lost their green colour, not when they are fully ripe as this could break the pods.
- When grown in combination with a food grain, the two crops ought to be harvested independently.

10.3. Threshing and Drying

To achieve a moisture level of 12–15% for consistent seed maturation, the harvested plants are piled and sun-dried for five to seven days. We refer to this as swathing. The immature pods containing green seeds mature during swathing. After ten to twelve days, threshing is done by hand with a stick. Using appropriate-sized sieves, winnowing and sieving are used to clean threshed seeds.

Steps for Grading

- Cleaning and Sorting: Upon arrival, all produce should be thoroughly cleaned and sorted, either by hand or by machine, to remove any foreign objects, dust, dirt, and stone particles, as well as any poisonous seeds, husks, immature split, shrivelled, damaged, and diseased grains, as well as rodent hair and excrement.
- Seed that has been cleaned needs to be sun-dried for four to five days, or until the moisture content drops to 8%.

10.4. Packaging:

Produce that has been uniformly cleaned and sorted should be placed into gunny bags before being sealed and packed. The packaging material's quality should meet the specifications outlined in the FSSAI standards, which are periodically amended. The pack's dimensions must adhere to the guidelines set forth by the current standards. Adequate aeration facilities should be present in the packing material. It is best to limit stacking height to six or ten tiers.

Materials utilized in rapeseed-mustard packaging

Plastic film bags: For packaging purposes, two types of polythene films are available: low density polyethylene film (LDPE) and high-density polyethylene film (HDPE). However, LDPE is typically utilized in rapeseed-mustard packaging as plastic film bags. It shields the oilseeds from moisture, dust, and grime. It works well for packing oilseeds in smaller quantities, such as 1 kg, 5 kg, and 10 kg packs.

Corrugated fibreboard boxes: These cardboard boxes are meant to hold the plastic bags containing the mustard and rapeseed mixture. The oilseeds are shielded from dust, dirt, and moisture to some extent by it.

Jute bags: Producers, dealers, processors, and others frequently use jute gunny bags to package mustard-rapeseed. Oilseeds are kept in go-down by traders who stack them in gunny bags. Mustard-oilseed seeds are typically packed in 95 kg capacity jute bags. Additionally, 50 kg jute bags are occasionally used to store oil seeds.

10.5. Labelling

The following marking needs to be correctly applied to the mustard-rapeseed packages:

- The product name, brand name, or trade name for the produce.
- Seed that has been cleaned needs to be sun-dried for four to five days, or until the moisture content drops to 8%.
- Name, address, and net weight of the contents in the package of the packer/farmer.
- No. of batch, lot, or code.
- The packaging date, along with the month and year.
- Year of harvest (if known).
- The material's grade in accordance with national grade standards.
- The producing nation's name, which must be stated in the event of an export.

10.6. Storage

To guarantee long-term preservation, seeds are sun-dried to a moisture level of 8–9%. Mustard seeds can be safely stored in cotton or gunny bags for a maximum of one year when kept in an open storage environment. The seeds will continue to respire at a comparatively high rate for up to six weeks after being originally placed in the trash. As a result of respiration, heat and moisture will raise the possibility of spoiling. There should be two steps to the drying process when the moisture content exceeds 15%. Prior to allowing the grain to cool to outside temperatures, it should be dried down to 13% moisture content. After allowing the grain to cool and drying to 8–9%, it can be inserted into the gunny bags or bin. Air temperature during drying should not be higher than 45 degrees Celsius. It is crucial to keep in mind that mustard seed has a higher density than cereal seed and that in order to propel air through the crop, two to three times more static pressure will be needed.

Since mustard is an oilseed, insect pests rarely cause issues for it while it is being stored. The majority of the time, fungal development linked to damp circumstances and poor storage conditions are the causes of insects found in mustard that has been preserved. They are not harmful to the commodity per se, but they are a sign of fungus development. The fungus development can be inhibited and the fungal feeding insects eliminated by cooling and lowering the moisture content of the storage container. Reduce the likelihood of spoiling by turning at least one-third of the mass in the bin, if at all feasible.

Conditions for storing seeds safely

Choosing a godown: Mustard seed sacks should be kept in enclosed spaces that are shielded from moisture, intense heat, pests, and rodents. To avoid soil wetness and humidity, the descent should be done on a sturdy platform that is at least one foot above ground level. The go down's ceiling needs to be high enough above the stacks of mustard seeds to maintain the lowest temperature inside the go down. It is important to provide enough space between stacks in storage to allow for adequate air circulation.

Conditions for storing seeds safely

Cleaning of godowns: Godowns must be thoroughly cleaned before being stored to ensure that no grains remain that could cause an infestation or contaminate fresh stock. The godown's walls should be painted with coal tar up to a height of 1.5 meters in addition to being whitewashed. Furthermore, attention must be given to sealing the gaps and fissures in the gutters, as this can harbour a crawling infestation.

Cleaning and drying of oilseeds: To prevent dust, dirt, and moisture from causing the oilseeds' quality to deteriorate, the oilseeds should be thoroughly cleaned and dried before being stored.

Separate storage of old and new stock: Old and new stock should be stored separately in order to prevent crawling infestations and to preserve the hygienic state of the go down.

Cleaning of bags: When storing oilseeds, new, dry gunny bags should always be used. The old gunny bags, however, can be sun-dried for at least three to four days prior to use.

Vehicle cleaning: Phenyl should be used to clean oil seed-transporting vehicles.

Use of dunnage: Oil seed bags shouldn't be kept straight on the go down's floor. To preserve them, set up bamboo mats or wooden crates covered with polythene sheets. If not, moisture from the floor may seep into the bottom layer of the stack's oil seed bags, damaging them.

Aeration of godown: In order to keep the godown's stock at a high quality, it is imperative that regular aeration be provided. As a result, adequate aeration should be provided in clear weather, but rainy days should be avoided.

Routine examination of the inventory: Every two weeks, or every fifteen days, there must be routine inspections of the stocks to ensure their health and cleanliness.

10.7. Transportation

Three common modes of transportation are used to move mustard and rapeseeds: pathways, roads, and railroads. The following precautions need to be taken when being transported:

- The oil seed packets need to be handled and transported carefully to ensure that they are well shielded from the sun, rain, or other sources of extreme heat, an unpleasant smell, and any kind of cross-contamination.
- Enough insulation and aeration should be properly arranged during transportation to lower the temperature.
- It is best to limit stacking height to six or ten tiers.

- Laborers should avoid using hooks excessively when handling and lifting bags during transportation as this could result in spillage losses.

10.8. Value addition and applications

Seed : The essential oil 9 allyl-iso-thiocyanate) found in the seed is used as a condiment. Mustard seeds have been highly prized medicinal as well as culinary spice being in use since earlier times. It has the highest concentration of health-promoting mono- and polyunsaturated fatty acids and the lowest concentration of saturated fats.

Mustard oil : The oil is used to fry and flavour vegetables as well as to make pickles. Oil has many therapeutic uses, including treating rheumatism, lumbago, and arthritis. Because of its low level of saturated fatty acids (8%), high mono saturated fatty acid 70%) and alpha linolenic acid (10%) it is recognized as a healthy cooking medium.The risk of a heart attack is decreased by alpha linolenic acid because it lessens blood platelets' propensity to adhere and aggregate.

Mustard oil cake: Biopesticides and animal feed are made from mustard cake.

11. Black Gram

Effective post-harvest management practises are crucial to preventing losses of this nature, as losses in the black gram post-harvest chains can result in weight loss, quality loss, or financial losses. Harvesting on time guarantees the best possible green quality and customer acceptance.

Time and care of harvesting

- When 70–80% of the pods have reached maturity, the majority of the pods have turned black, and the grain moisture content is between 14 and 18%, harvest the crop.
- To obtain a true-to-type variety, keep the harvested crop apart from other varieties.
- Pods that are overly mature may break.
- Lower yields, a larger percentage of immature seeds, poorer grain quality, and an increased risk of disease attack during storage are all consequences of immaturity.
- To avoid breaking losses, harvesting should ideally be done early in the morning.
- Hand harvesting involves carefully pulling out the entire plant or chopping a few centimetres above the ground with a sickle.
- Placed the harvested crop in the threshing floor and allowed it to sun dry for a period of 7 to 10 days before threshing. To ensure effective threshing, all harvested stems should be kept in one direction.

Winnowing and threshing

- Before threshing, dry the pods to a moisture content of 13–15%.
- To prevent contamination, threshing ought to take place on pucca flooring rather than kutcha flooring.
- Either a mechanical or manual thresher can be used for threshing.
- Clean the threshing yards using pesticides that are advised, such as Malathion (50%EC).
- Make use of rodent- and moisture-free threshing yards.
- Store the tarpaulin/polyethylene sheet ready to cover the crop in the threshing yards in order to protect it from unexpected downpours.
- The separated seeds should undergo either mechanical or manual winnowing after threshing.
- In mechanics, black gram can be cleaned after threshing using winnowing pedal or power-operated air screen cleaners.

Drying

- Drying can be accomplished using a mechanical dryer or the sun.
- Sundry the grains between plastic sheets and a spotless concrete floor, tarpaulins, bamboo mats for 3-4 days to bring their moisture content 10-12%.
- Black Gram should not be dried on bare ground as this will contaminate the grains with dirt or soil and promote the growth of mould or fungus.

Grading

- Before being sold, products are graded to help farmers get a better price for their produce.
- Grading enables consumers to purchase produce of a consistent calibre.
- It makes it easier for customers to compare the costs of various produce qualities available on the market.
- Buyers make price offers based on the visual inspection of the entire item, taking into account quality factors such as grain size, colour, moisture content, refraction, and admixture of other varieties.

Packaging

- The packaging material that is used needs to be safe, sound, free of insect and fungal infestation, and it shouldn't give the product any unfavourable flavours or odours.
- Jute bags, HDPE/PP bags, polythene impregnated jute bags, poly pouches, and cloth bags are among the packaging materials used to package black grams.
- It needs to include information on price, weight, date of packing, variety, and quality. It should be easy to handle and allowed by the FSSAI guidelines.
- The pulsed must have a net weight that complies with FSSAI regulations.
- Every package needs to have the same sample designation and pulses at the same time. It also needs to be tightly sealed and closed.

Marking and labelling

- The following information should be prominently and permanently marked on the package:
- The commodity's name
- Variety
- Classification of grades
- Code, lot, or batch number
- Nation of origin
- The packer's name and address
- Best before that date
- Date of Packing
- If fumigated, the pesticide name, the fumigation date, and the potential fumigation time

Storage

Grain storage in India , the following are some tips Hapur offers for storing pulses:

1. Store the tarpaulin/polyethylene sheet ready to cover the crop in the threshing yards in order to protect it from unexpected downpours.
2. Get the grain ready for storage.

- Before storing, clean, cool, and dry the pulses to a moisture content of about 11% to 12%.

- Fill the insect free pulses in to the structure to check their multiplication and fumigate the pulses within a week with fumigants as recommended to control the insect pests.

3. Preparing the premises and storage buildings

- Make sure the storage structures are thoroughly cleaned, and if necessary, fill in any cracks and crevices with cement, mud, or cow dung.
- Take the household item out of the storage building.
- Wash the storage building white.
- Make use of polyethylene sheets to create an airtight storage structure.
- Use cement, concrete, and broken glass pieces to seal all of the rodent burrows.
- Make sure that rainwater entering the building from any source does not enter.
- When storing bags, use dunnage (crates, bamboo mating, and sandwiched polyethylene sheet).
- Arrange the bags so that there is enough room between them and the walls for periodic inspections.
- If grain is kept in old gunny sacks, make sure they are completely dry before fumigating with EDB at the prescribed dosages under polyethylene covers.
- Use scientific storage structures such as puccaa kothi, metal bins, R. C. C. ring bins, and R. B. bins, or upgrade your current storage structures in accordance with IGBI's recommendations.
- Buildings should not be left open for extended periods of time or opened frequently, especially during the rainy season, to prevent moisture intrusion and cross-infestation.

Hermetic storage: a safe, environmentally friendly way to store

- The quality of black grain is more likely to deteriorate due to insect infestation and microorganisms.
- The hermetic method is a secure storage technique that doesn't require the use of chemical pesticides and is good for long-term storage. It suppresses micro floral activity and quickly eliminates insect development by creating an airtight environment.

11.1. Transportation

Black Gram Transportation uses a variety of transportation methods. These are the most widely used forms of transportation.

- **By Road**: The most common mode of transportation for moving black grams from the production site to the final consumer is road transportation. Various forms of road transportation are employed throughout the nation, including: Head load, pack animals, bullock carts, tractor trolleys, and trucks are the first five.
- **By Trains**: Compared to road, train travel is more affordable and ranks among the most significant modes of transportation. Larger quantities and longer distances are better suited for it.

11.2. Control of Grain Pest in Storage

Insects, rodents, and moulds are the primary pest categories affecting black gram storage grains. The Pulse Beetle, Khapra Beetle, Dried Bean Weevil, Rice Moth, and Confused Floor Beetle are the main pest insects that affect storage.

- Apply efficient preventive chemicals, like Malathion 50% EC, at recommended dosages to walls, alleyways, flour, and grain bag surfaces to manage the infestation of crawling insects.
- When storing dry black gram seeds, they should be well combined with 3 g/kg of black peeper seed powder to prevent bruchid infestation.

- A tiny amount of mineral or vegetable oil added to grains helps keep insects away. You can use vegetable oils made from rice bran, sesame, palm, neem, cotton seed, mustard, rape, soy, and ground nuts.
- The recommended fumigants, such as aluminium phosphide (phosphine), are used at recommended doses to eradicate the insects.
- Use traps, fumigate rat burrows and holes found inside the go down and surrounding areas by filling them with aluminium phosphate tablets, and seal the holes with mud mixture to keep rodents out.
- Reduce physical damage to the grain during harvesting and storage, dry the grain to a safe moisture content before storing it, and make sure the storage environment is clean, dry, and insect-proof to prevent the growth of mould, a fungal pathogen.
- Before using, harvesting and threshing equipment needs to be thoroughly cleaned.

11.3. Grading

- Prior to sale, wash and grade the black gram seeds to producer's level.
- Weevilled/damaged grains, moisture content, immature and shrivelled grains, foreign matter, and other quality factors are taken into consideration when grading black grams.

12. Conclusion:

Farmers receive fair prices from food processing industry and post-harvest management, which also creates job opportunities and offers convenience to consumers. Therein lies the solution to our primary issues of appropriate agricultural growth, agricultural diversification, food insecurity, and covert unemployment in the agricultural sector and rural areas. It also aids in India's rural development. Thus, the food processing industry and post-harvest management now views this area of the Indian economy as its dawning. Farmers receive competitive prices from food processing industry and post-harvest management, which also creates jobs and convenience for consumers. That is the solution to our main issues with proper agricultural development, agriculture diversification, food insecurity, and unemployment in rural and agricultural areas that is concealed. It is also beneficial for India's rural development and economic growth.

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