# UNIT 4 FOOD GRAINTS, PULSES AND OIL SEEDS

**Structure**



## 4.0 OBJECTIVES

After reading this unit, you should be able to:

- explain importance of cereals pulses and oil seeds in our day-to-day requirement and to national economy;
- state the important properties and primary processing methods to make them edible and their storage; and
- describe value added products and Utilization of by products of cereals, pulses and oilseeds.

## 4.1 INTRODUCTION

Food grains play a major role in the Indian economy as they meet our food and fiber requirements. Food grains are the basic need of day-to-day requirement of human life. With the increase in population and awareness, every human being need right quality of foodstuff at the right time. It is also our duty that the cost of the foodstuff to meet the basic need should be affordable to every one. Agricultural produce are seasonal, weather dependent thus their storage for whole year and some times more than a year is required. During the storage, the quality of the foodstuff should not deteriorate. Most of the agricultural produce (cereals, pulses and oil seeds) is not consumed as they are produced. These produce need to be processed. The processing should be economically viable and the loss of energy and nutrition should be the least. Therefore, knowledge of appropriate machines and process is must.

Food processing industries have enormous significance in the national development through linkage between two main pillars of economy namely industry and agriculture. Growth of food processing industry means raising agricultural yield and creating rural employment. It leads to rise in the economic standard of large number of people through out the country.

## 4.2 PRODUCTION AND IMPORTANCE

Agricultural production in India has travelled a long way in the post independent era from scarcity to surplus. After green revolution the country has become not only self-sufficient but also surplus in food grain production. Now the country is producing about 200 million tonnes of food grains (90 million tonnes of paddy, 75 million tonnes of wheat and other coarse grains) 15 million tonnes of pulses and 23 million tonnes of oil seeds. In spite of such huge production, our population have per capita availability is less than the dietary requirement given by Indian Council of Medical Research. Therefore, nation has to import edible oil from other countries.

Post harvest technology of food grains have also had a paradigm shift in the last 50 years. At the time of independence most of post harvest operations were carried out by small scale processing units. These units were operated by human or animal power. There recovery was less and losses were high. Now many modern processing units comprising primary to tertiary processing are working. These units not only process the material but also process the byproducts into value added products.

## 4.3 STRUCTURE AND COMPOSITION

Wheat is a single seeded fruit consisting germ and endosperm enclosed by epidermis and seed coat. Paddy, pulses and other crops consist an outer husk cover in addition to above parts. The husk consists of silica acts as a barrier to moisture migration, insect infestation and fungal damage.

The germ is the principal part of the seed. It is rich in fat and is heat sensitive. The endosperm is full of starch granules and works as reservoir of food for developing embryo.

The chemical composition of the seed is widely dependent upon the environment in which crop is produced, the variety, soil and fertilizer application. In general, cereals are rich in carbohydrate; pulses are in protein and oilseeds in fats and lipids. The proximate composition of important cereals, pulses and oilseeds are given in Table 4.1. In general outer layers (pericarp) contains cellulose, endosperm is rich in carbohydrate and small amount of proteins, germ contains the highest amount of fat, protein, enzyme and small amount of sugars.

Protein present in the cereals gets denatured above 50$^{o}$C. Thus, their water absorbing and swelling capacity decreases. It affects the quality of dough. The starch is insoluble in cold water. Its quality is not affected even if the temperature is raised to 60$^{o}$C. However, at temperature higher than 70$^{o}$C geletinization of starch takes place. It leads to deterioration in the colour. Fats are heat resistant up to an extent. However, at higher temperature (above 70$^{o}$C) partial decomposition starts and increases the acid numbers. Vitamins present in the germ are destroyed with the heat treatment.

## 4.4 POST HARVEST LOSSES

With the green revolution and support of farmers the country has increased its food grains production to four fold between 1950's and 1970's. Though the rate of increase in production has declined after 1980's but still it is more than our country's requirement. It is also estimated that about 8 to 12% of the produce is lost in various post harvest handling and storage practices. The loss amounts to be Rs. 20,000/- crores annually.

The traditional processing of dal and oilseeds results in poor recovery. In most of the pulse mills in India has the dal recovery of 65 to 70 % against maximum possible recovery of 81 to 84 %. Similarly oil remains in the residual oil cake which is about 10 to 15 % of total available oil in the oilseed.

The maximum loss of food grain occurs during storage. As you know, in India major portion of food grains (more than 75%) is stored in large number of small capacity rural godowns. These godowns have free access to insect-pest, rodents and also affect the quality of the grains by the change of environment. It is estimated that in some of the godowns the losses are as high as 30 % in humid region if grains are stored for 8-10 months.

**Check Your Progress Exercise 1**

**Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Name two main pillars of Indian economy.

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2. "Whole world is looking towards India as a big market". Give reasons?

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3. List the factors, which affects the chemical composition of the grains?

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4. What happen to the solubility of starch when temperature increases?

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5. Post harvest losses in the pulses are mainly during ………………………...

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**Table 4.1: Average composition of food grains, pulses and oil seeds**

| Commodity | Moisture (%) | Calories (Cal/ 100g) | Protein (%) | Fat (%) | Fiber (%) | Ash (%) | Mineral (%) | Thia-mine (mg/ 110g) | Ribo-flavin (mg/ 100g) | Niacin (mg/ 100g) |
|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 12.5 | 330 | 12.3 | 1.8 | 2.3 | 1.7 | 1.5 | 0.52 | 0.12 | 4.3 |
| Paddy | 12.0 | 360 | 7.5 | 0.9 | 0.9 | 1.2 | 0.7 | 0.34 | 0.05 | 4.7 |
| Corn | 13.8 | 348 | 8.9 | 3.6 | 2.7 | 1.2 | 1.5 | 0.37 | 0.12 | 2.2 |
| Bajra | 12.4 | 360 | 9.5 | 5.0 | 1.2 | 2.5 | 2.7 | 0.73 | 0.38 | 2.3 |
| Ragi | 13.1 | 332 | 7.1 | 1.3 | 3.3 | 2.7 | 2.0 | 0.42 | 0.12 | 1.1 |
| Bengalgram | 9.8 | 361 | 17.1 | 5.3 | 3.9 | - | 2.7 | 0.45 | 0.21 | 2.6 |
| Blackgram | 10.9 | 350 | 24.0 | 1.4 | - | - | 3.4 | 0.45 | 0.22 | 2.0 |
| Cowpea | 12.0 | 327 | 24.6 | 0.7 | 3.8 | - | 3.2 | 0.50 | 0.21 | 1.5 |
| Greengram | 10.4 | 350 | 24.0 | 1.3 | - | - | 3.6 | 0..46 | 0.21 | 2.0 |
| Soyabean | 8.1 | 432 | 43.2 | 19.5 | 3.7 | - | 4.6 | 0.73 | 0.32 | 2.4 |
| Mustard | 7.9 | 549 | 26.7 | 40.1 | 4.1 | - | 1.9 | 0.90 | 0.13 | 14.1 |

**Source:** NIN, ICMR, Hyderabad 1999

## 4.5 PHYSICAL AND THERMAL PROPERTIES

The knowledge of properties of grains such as size, shape, surface area, different densities, colour, frictional properties, thermal properties, diffusivity, equilibrium moisture content etc. are important for designing the various post harvest handling, storage, separation and drying systems. Some of the properties are discussed hereunder in this unit.

- Physical properties
- Thermal properties

### 4.5.1 Physical Properties

Accurate measurement of size and shape of the individual grain are important engineering data. These data helps in designing of machines for the post harvest handling and processing. The size and shape of the grain helps in designing cleaner, grader and if grains are to be passed between two rollers for shelling, milling or crushing. The terminal velocity of the grain helps in designing pneumatic conveyor, winnower etc. The geometry of the grain provides the surface area, which helps in moisture migration (absorption or drying). In general three major axis are measured and denoted as dimension a, b and c of the grain. **The sphericity** is defined as the ratio of geometric mean of 3-major axis to the largest axis dimension. It represents degree of closeness of the grain with the sphere.

$$\text{Size of the grain} = (a \times b \times c)^{1/3}$$

$$\text{Sphericity of the grain} = (a\ b\ c\ )^{1/3} / a$$

Where, a: is the largest dimension of the grain.
b: is the medium dimension perpendicular to the largest dimension of the grain.
c: is the smallest dimension perpendicular to above two of the grain.

Some dimensions and sphericity of the grains is given in **Table 4.2**

**Table 4.2: Major dimensions and sphericity of the grains**

| **Grains** | **Longest dimension (a) (mm)** | **Medium dimension (b) (mm)** | **Smallest dimension (c) (mm)** | **Sphericity** $\frac{(abc)^{1/3}}{a}$ |
|---|---|---|---|---|
| Rice, IR-8 | 8.68 | 3.02 | 1.97 | 0.427 |
| Wheat, PB593 | 6.43 | 3.55 | 3.09 | 0.652 |
| Maize, Ganga 5 | 8.92 | 8.33 | 6.89 | 0.901 |
| Bengal gram | 8.56 | 6.25 | 5.96 | 0.801 |
| Black gram | 4.87 | 3.90 | 3.37 | 0.762 |
| Green gram | 3.86 | 3.18 | 3.11 | 0.865 |
| Pea,VRS-6115 | 6.89 | 6.43 | 6.04 | 0.945 |
| Pigeon pea | 6.56 | 5.30 | 4.63 | 0.895 |
| Groundnut kernel | 14.45 | 8.74 | 7.50 | 0.685 |
| Soya bean | 7.02 | 6.29 | 5.05 | 0.874 |

**Source:** Engineering Properties of Food Materials (1980) CIAE, Publication /80/15

The bulk density, specific gravity and porosity plays an important role for designing the storage structures, specific gravity separator, pneumatic conveyor and other handling equipments. The bulk density is defined as the weight of grains per unit volume. The specific gravity is defined as the ratio of true density (mass of the grains per unit solid volume) to the density of water. The true density of the grains is calculated by fluid displacement method using **pycnometer.** The density of the grains varies with the variety and moisture content. The porosity is calculated from the true and bulk density of the grains. The porosity is affected by degree of compaction. Some properties of the grains are given in Table 3.

Angle of repose and frictional properties of grains plays an important role in designing hoppers, discharge chutes, elevators, dryers, storage bins and other equipments for grain flow and handling. The frictional coefficient depends upon the shape of the grain, surface characteristics and moisture content of the grains. **The angle of repose** of the grains is the angle between the base and the slope of the cone formed, when grains are freely dropped on the horizontal plane. The frictional properties and angle of repose of some grains are given in Table 4.3.

**Table 4.3: Some physical and mechanical properties of the grains**

| Grains | Moisture content (%, wb) | Bulk Density (Kg/m$^3$) | True Density (Kg/m$^3$) | Porosity | Angle of repose (Degree) | Friction coefficient on sheet metal |
|---|---|---|---|---|---|---|
| Wheat | 8-14 | 790-700 | 1390-1400 | 40 | 26-28 | 0.40 |
| Rice | 9-11 | 610-580 | 1200-1240 | 54 | 27-30 | 0.48 |
| Corn | 10 | 820 | 1393 | 41 | 26-28 | 0.23 |
| Soya bean | 10-11 | 680 | 1180 | 42 | 24-25 | 0.34 |
| Pigeon pea | 9-10 | 815 | 1330 | 39 | 19 | 0.29 |
| Gram | 8-9 | 815 | 1340 | 39 | 17 | 0.35 |

**Source:** Engg. properties of Food material (1980) CIAR Publication /80/15

### 4.5.2 Thermal Properties

Cereals, pulses and oilseeds are harvested at higher moisture content in order to reduce shattering losses and safety against untimely rains or weather. These grains are to be dried to safe moisture level for marketing, processing or storage. For that heating, drying and cooking may be involved. Therefore, thermal properties namely, conductivity, diffusivity etc are required to be known for designing the dryers, cookers etc. Thermal properties of some grains are given in Table 4.4.

**Table 4.4: Thermal properties of grains**

| Grains | Moisture content (%, db) | Specific heat (KJ / Kg K) | Thermal conductivity (W / m K) | Thermal Diffusivity ($10^{-7}$ $m^2$ /s) |
|---|---|---|---|---|
| Wheat | 10-20 | 1.09 | 0.139 | 0.91 |
| Rice | 10-20 | 1.33 | 0.087 | 1.00 |
| Corn | 10-20 | 1.20 | 0.165 | 0.89 |
| Pigeon pea | 8-22 | 1.50 | 0.153 | 0.94 |
| Soyabean | 8-10 | 2.01 | 0.116 | 0.54 |
| Bengal gram | 10-20 | | | 17.1 |
| Mustard | 8-12 | 2.56 | 0.175 | 0.73 |
| Sorghum | 8-12 | 1.69 | 0.124 | 0.85 |

**Source:** Engg. properties of Food materials (1980) CIAE Publication /80/15

## 4.6 WATER ACTIVITY

Water activity is an important characteristic of food grains. It influences odour, flavour, texture, colour, enzymatic activity and microbial load on the food product. Therefore, for safe keeping the food grains its knowledge and relationship with the atmosphere is must.

Water activity is a ratio of partial vapour pressure in a food product over the equilibrium vapour pressure of the product at the same temperature. In general for safe storage of food grains water activity should be below 0.6. However, to avoid lipid oxidation (which leads to rancidity in fats) water activity should be below 0.3. The most congenial atmosphere for growing the bacteria is when water activity is above 0.8 and for yeast and molds above 0.7.

**Check Your Progress Exercise 2**

**Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Why do we require to measure the size of the grains?

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2. Name two machines in whose designing terminal velocity is used?

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3. Define angle of repose of the grains.

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4. Name the instrument used for measurement of true density of the grains.

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5. List the characteristics of the grain influenced by the water activity of the storage.

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6. For safe storage of oil seeds, what is the water activity recommended.

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## 4.7 CLEANING AND GRADING

Cleaning is the first unit operations in any grain-processing unit. As the name explains, the purpose is to remove unwanted materials like chaff, stone, dust, and metallic pieces. In general, it is done with the set of sieves arranged one above other. The top sieve will have openings just equal to the size of the grains. The impurities bigger than the grain size are rolled above the screen and discarded. The grains and smaller impurities pass through the first sieve; fall on the second sieve, which have the openings smaller than the grain size. Here dust and smaller impurities pass through the sieve and collected separately. Clean grains roll over the screen and are collected. In general a fan is also attached with the cleaner. The fan blows/sucks the sufficient air to throw/carry away the finer impurities of the grains. Usually fan blows the air beneath the sieve. Thus, it helps in cleaning the screen to avoid choking of sieves. An oscillating screen cleaner with aspirator is shown in Figure 4.1.

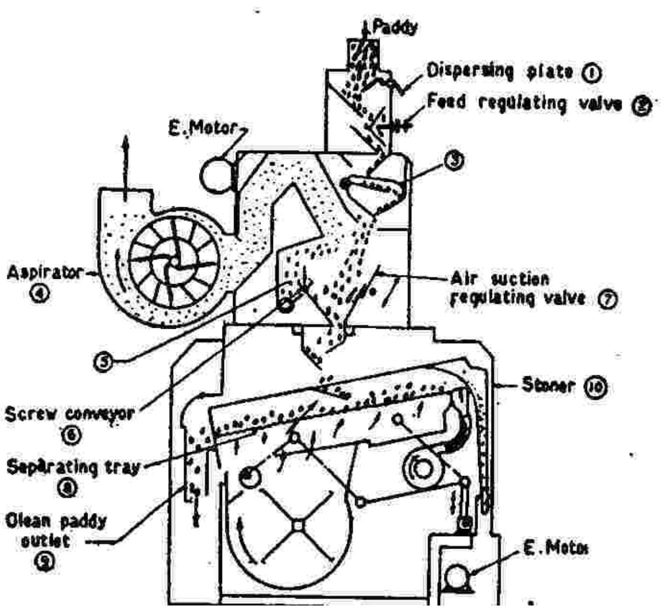


**Figure 4.1: Oscillating screen cleaner with aspirator**

In some cleaners, near the discharge end, a magnet is fitted. This magnet attracts the metallic impurities, which are removed manually at short intervals. Sieves may have round, oblong, rectangular or triangular openings depending on the requirement of the grains (Figure 4.2). In most of the cleaners, sieves are changeable to accommodate large variety of grains for cleaning. The oscillation speed of the sieve, feed rate and impurities composition decides the performance of the cleaner. In the modern cleaner, screen-cleaning brushes are fitted, which clean the screen to overcome problem of choking. Higher airflow of fan may carry away the grains and lower airflow may leave the impurities in the grain. So airflow based on terminal velocity of grains must be used.

Grading of grains is necessary as it aids to the value of the grains and helps in improving the performance and efficiency of processing machines. Grains, which are produced and harvested in the field, vary in their appearance, size, and location in the plant within the farm. If seeds sown are mixture of few varieties, the final produce may differ in the grain characteristics. The grading is defined as separation of the mixture in to separate sections based on their common quality characteristics. Grading is done based on size, wholesomeness of the grain, test weight, varietal purity, oil content, protein content, colour, hardness etc.

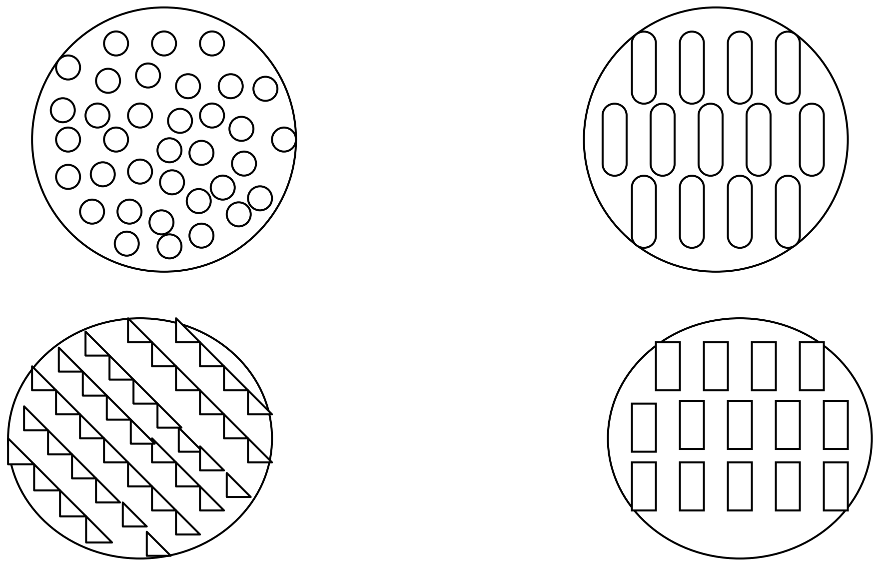

**Figure 4.2: Different types of perforation on the sieve**

## 4.8 PARBOILING CONDITIONING AND DRYING

**Parboiling**

Parboiling is a hydrothermal treatment given to grains specially paddy and wheat in order to make grain harder. In paddy, rice kernel become harder so that it could withstand the milling stresses and result in higher head yield. Parboiling is conducted in three steps namely soaking, steaming and drying. Soaking of paddy in the traditional method is done for 24 to 72 hours at the ambient temperature depending up on weather. In the modern method, soaking is done at 70°C for 3½ hours. The void space between husk and kernel is filled with the water and moisture content of the grain is raised to 30% wet basis. After draining the excess water soaked paddy is steamed for 20-30 minutes. The moisture content of paddy is increased to 35% wet basis. Then paddy is dried to 14% moisture content. Traditional parboiling method has prolonged soaking, which imparts deep colour to the rice, off flavour, and some times in rainy season mold growth on the grains. In the modern parboiling method some of these defects are eliminated. In the process of soaking and steaming rice starch get gelatinized, protein get expanded and occupies the air space with in endosperm. It increases the cohesion and adhesion between starch granules and protein bodies. It also checks the cracks in rice kernel and it become stronger to withstand milling stresses.

During the process of parboiling vitamins of outer layer moves inside starchy endosperm and oil globules moves outside in the bran layer. Thus, after milling parboiled rice has more vitamins than raw rice and its bran has move oil content than raw rice bran. It is also found that due to heat treatment total water uptake, swelling index of parboiled rice is more than raw rice. Energy required in dehusking and loss of solids in the gruel is less in parboiled rice. The total rice turn out of parboiled rice is 70-73% which is 2-8% higher than raw rice and whole rice turn out is 60-65% which 20-30% more than raw rice.

**Conditioning**

Conditioning of grains specially pulses and oilseeds is done in order held or get better dal and oil recovery. Pulses are scratched, smeared with oil and water, dried in order to loosen the husk. Oilseeds are smeared with hot water prior to crushing to improve the oil recovery. Excess of wetting and drying of pulses affects their cooking quality as protein enclosed in the complex form, which changes its behaviour when hydrated and dehydrated.

**Drying**

Drying of grains is an important unit operation as it affects the ultimate quality of the grains. Grains {cereals 12-14%, pulses 10-12% and oil seeds 8-10%} moisture content is considered to be safe for storage.

Traditionally grains are dried in the drying yard with sun's energy. The grains are spread 5-10 cm thick layer and frequently turn to have uniform drying.

The limitations of the sun drying are:

- Weather dependent process
- Require more human energy for turning during drying
- Non-uniform drying
- Slow drying affects the quality of the product and increases the microbial load on the grains.

Thin layer drying through mechanical dryers with 10-15 cm thickness of the grain layer are the most common dryers used in the grain processing industry. Burning agricultural waste generates the heat, which is passed through heat exchanger. The hot air is blown and mixed with a falling bed of grains to get them dried. The main advantage of these dryers is the uniformity in drying and the drying time is reduced. These dryers are weather independent; require less space and energy.

In general drying air temperature depends on the type of grain, their moisture content and end use. For cereals, to be used for consumption, drying air temperature is to be limited to 70$^{o}$C, whereas for seed purpose it should be 45$^{o}$C. For oil seeds and pulses it should be 50-55$^{o}$C. Rapid drying develops fissures in the grain results in poor milling quality of paddy, affects, storability of wheat.

There are only few dal mills in the country where mechanical dryers are used. In general, sun drying is done for drying pulses in the process of dal milling (specially for pigeonpea the milling process takes 2-4 days longer depending on the weather.). Oil seeds are threshed/decorticated when fully dried. Conditioning is done to get maximum oil recovery. Generally dryers are not used in the oil industry.

## 4.9 GRAIN MILLING AND OIL SEED CRUSHING

Milling of cereals and pulses is a series of processing treatments prior to its conversion into edible form. These treatments vary from grain to grains. Flow chart for milling of paddy, pulses and oil seed given in Figures 4.3, 4.6 and 4.7.

### 4.9.1 Rice (Paddy) Milling

Paddy raw or parboiled is cleaned to remove all the impurities. Cleaned paddy fed in a sheller / dehusker. Traditional dehusker is an Engleberg rice huller. A huller is small mill operated by motor with a capacity 500-750 kg/h. The mill consists a cast iron roller, where shelling and polishing is done simultaneously. Therefore, bran, brokens are mixed with the husk, which is difficult to separate. As the moving part is cast iron roller, it results higher broken pieces during milling. Though, the machine is simple in operation, low in cost but results poor milling yield (total yield 62-64%, Head rice 40-50%).

The other low capacity paddy milling machines are centrifugal sheller and under runner disc sheller. A mini modern rice mill (Fig. 4.4) consists of feed hopper, rubber roll sheller, husk aspirator and a polisher in a single composit unit. The modern paddy sheller is rubber roll sheller. In it two rubber rolls are rotating in opposite directions at different speeds. Difference in surface speeds of rollers develops shearing action and results in removal of husk. Using rubber rollers only husking is done, in the machine. A blower sucks the husk and paddy-rice mixture is fed on a separator. In general, there are two types of paddy separator namely compartment type or deck type separators are used in the rice mills. Both the separators work on the principle of gravity separation. The heavier material rice remains in touch with the surface and moves along with the separator surface and carried against the gravity to upper side and discharged. Paddy being lighter moves with the gravity down and recycle to the sheller for shelling. Paddy rice mixture is recycled back to the separator. Only rice is fed in the polisher, where due to abrasion rice are polished and upper aleurone layers are removed. These layers are rich in oil content (14-26%). Rice bran is collected through cyclone separator and rice is fed in the grader. Whole rice are separated from the brokens parts through a grader. A typical flow diagram of modern rice mill is shown in Figure 4.5.

### 4.9.2 Wheat Milling

Traditionally wheat is milled in an attrition mill, where or (Break rolls) grains are fed in the center, moves radially out, between two emery/stone discs. Grains are compressed and sheared. The clearance between stones/is gradually reduced and whole grain flour is obtained. As the size from whole grains is reduced to fine in one go, there is significant rise in the temperature. It affects the quality of flour.

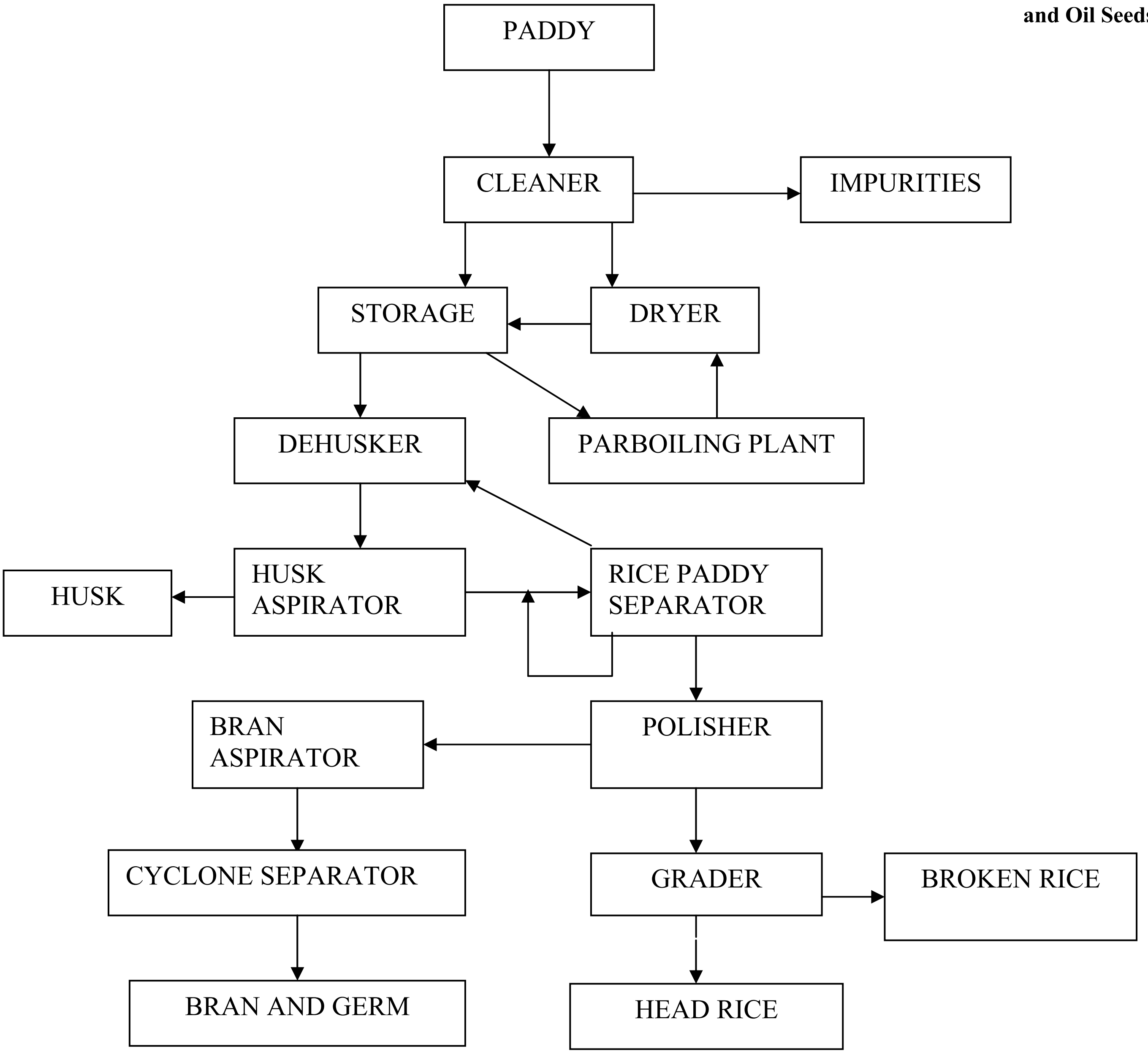


**Figure 4.3: Process Flow Chart of Modern Rice Milling**

Modern wheat mill consists of series of reduction rollers (about 15 to 18) where different fractions, Suji, maida etc are separated. Since size is reduced gradually, rise in temperature doesn't take place and quality of the constitutes is better.

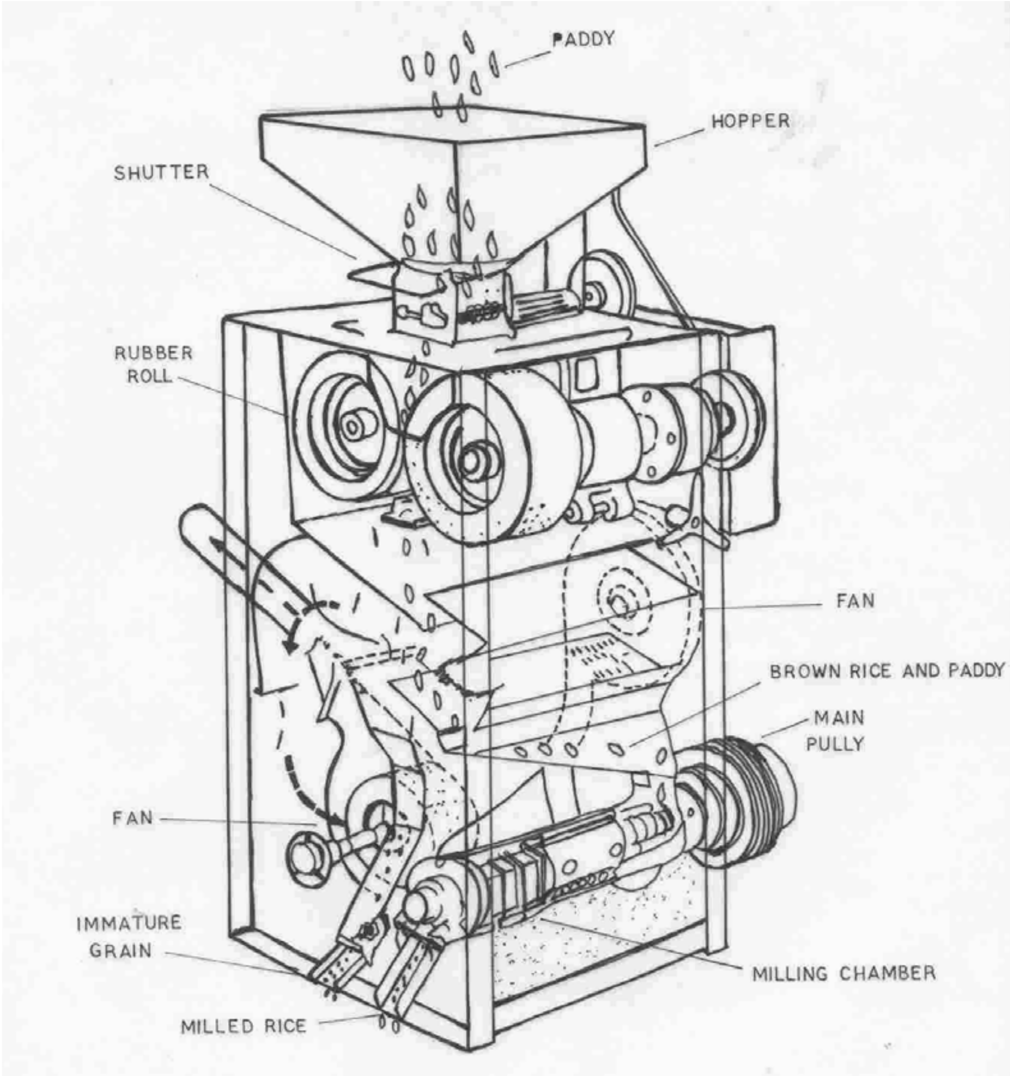


**Figure 4.4: Mini modern rice (paddy) mill**

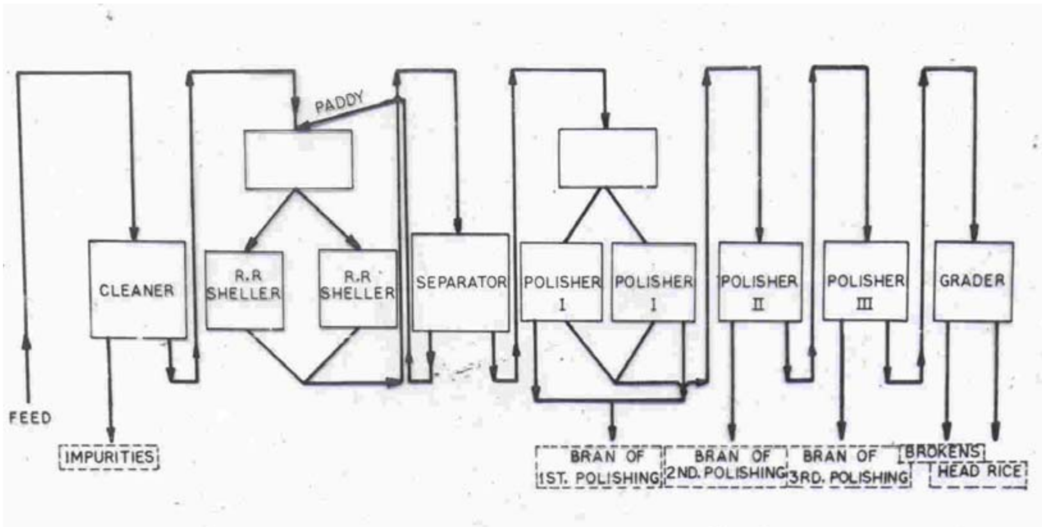


**Figure 4.5: Typical Flow Diagram of Modern Rice (Paddy) Mill**

### 4.9.3 Corn Milling

Corn can be milled by dry milling or wet milling. In dry milling moisture is raised to 24-25% and germ is separated by Beall degermer. Rest grain is dried and milled. In wet milling, corn is soaked in water (50$^{o}$C) for 1-2 days. Germ is separated for oil extraction and rest is centrifuge to make starch, dextrin, sugar syrup etc. The water used for soaking is also drained and concentrated to 35-55% solids to be used for pharmaceuticals.

### 4.9.4 Pulse Milling

Pulses are rich source of protein. They are traditionally milled dry. Except pigeon pea, milling of pulses is easy as binding between husk and cotyledon is poor. For pigeon pea it is most difficult.

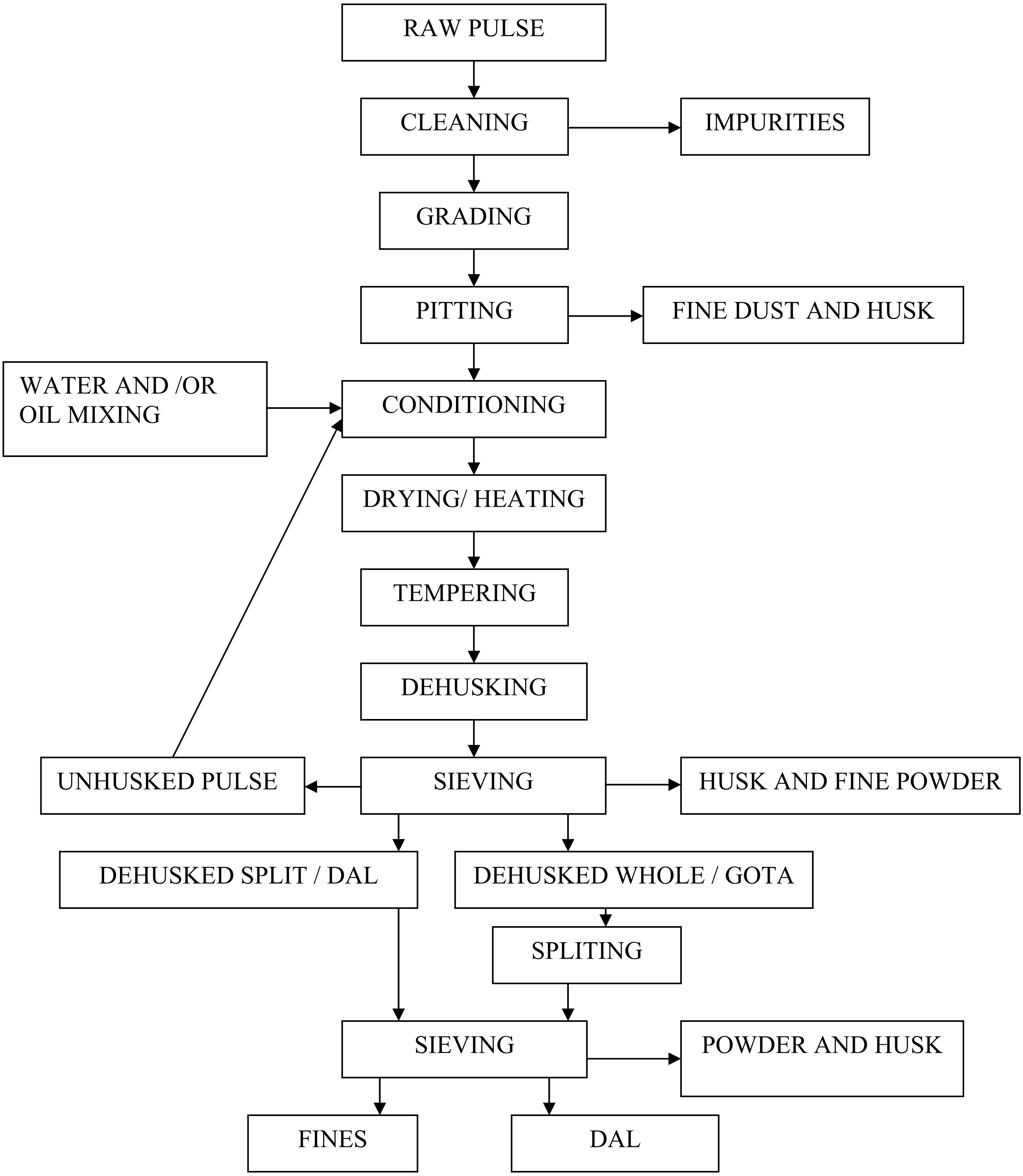


**Figure 4.6: Process flow chart of improved pulse milling**

Traditional milling of pigeon pea includes cleaning, scratching, treating with oil, and wetting, mixing with red earth, conditioning, scratching and splitting. In general, it yields 65-70% of dal recovery against potential of 81-84%. In modern pigeon pea milling, which includes cleaning, preconditioning, dehusking separating and splitting. It provides 72-78% dal recovery. The preconditioning includes addition of moisture, oil and drying in LSU dryer. In the modern method dal can be prepared in 1-2 days from pulses whereas in the traditional process it takes 5-10 days. A process flow chart of improved pulse milling as shown in Figure 4.6.

### 4.9.5 Oil Seed Crushing

Oil seeds like groundnut, castor etc are decorticated in manual or motorized decorticator. Clean seeds are crushed either in ghani operated by bullocks or mechanical power or in screw press oil expeller.

Ghanis are made of wooden taper barrel, where pestle is rotated in it. In general, 6-12 kg oil seeds are fed and hot water 1-5% is added in a batch, which takes 45 minutes to crush. A ghani recovers 60-75% of the total available oil in the oil seeds.

A screw press oil expeller is 6 to 12 bolt expeller having series of worms of different pitches. Due to pressure built up inside the horizontal casing, oil oozes out. The capacity of the expellers are to crush 60 to 120 kg oil seeds/ batch and recovers 80-85% of total available oil in two to three passes. Commercially 8 power ghanis with one mechanical oil expeller are in practice. Firstly, oil seed is crushed in ghanis and residual oil cake is passed through expeller. However, even after that 6-7% oil remains in the residual cake, which is extracted through solvent extraction process. Process flow chart of oil seed processing is given in Figure 4.7.

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**Check Your Progress Exercise 3**

**Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Differentiate cleaning and grading.

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2. State merits and demerits of parboiling of paddy.

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3. Why conditioning of pulses and oilseeds is done during processing?

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4. “Rapid drying of grains is not recommended”. Why?

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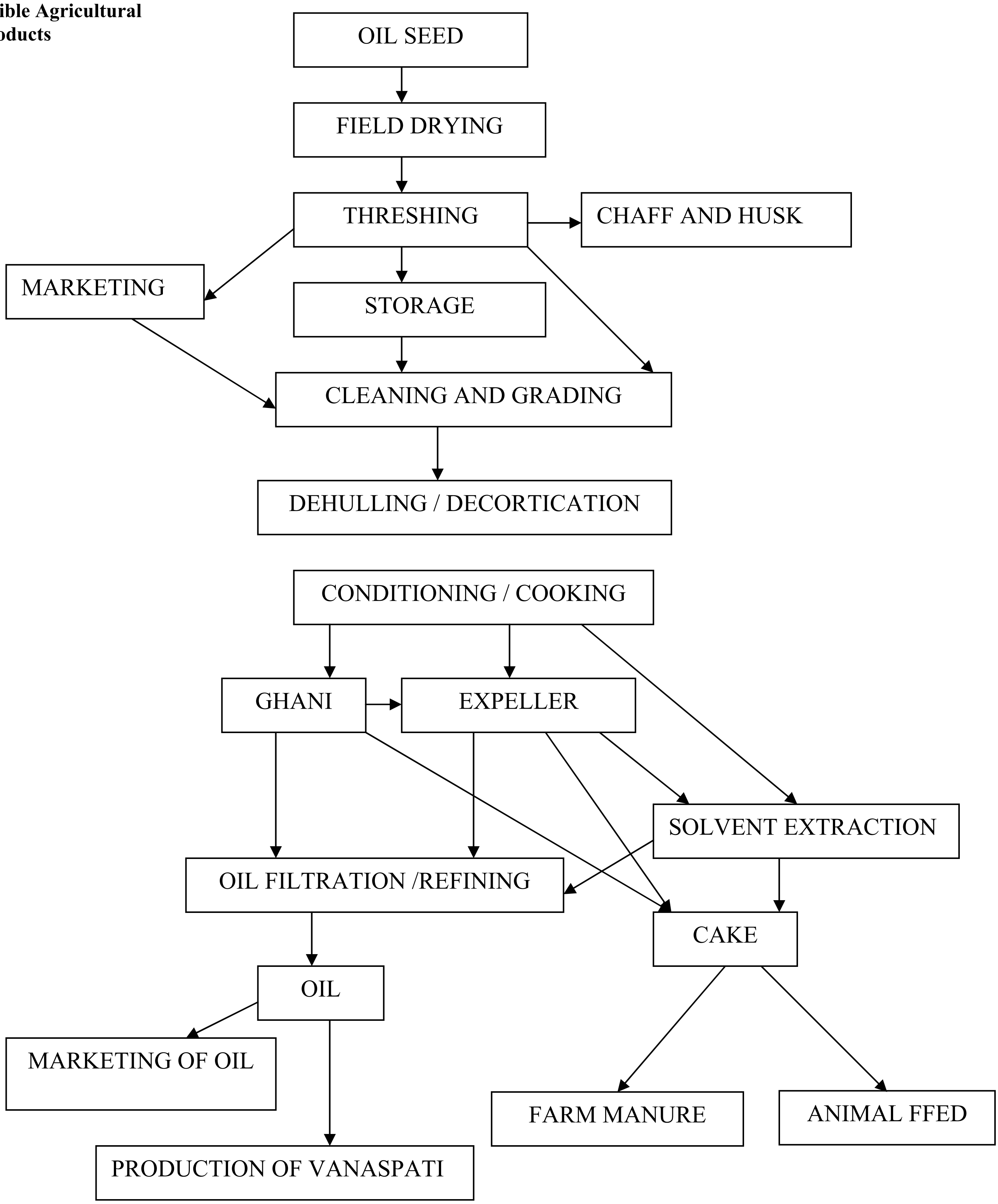


**Figure 4.7: Process flow chart for oil seed processing**

## 4.10 STORAGE OF GRAINS

Primary function of storage is to prevent food loss during the storage. The loss means any change in the availability, edibility, wholesomeness or quality of the food that prevents it from being consumed by people. Losses may be direct or indirect. A direct loss is disappearance of food by spillage, or consumption by insects, rodents, birds etc. An indirect loss is lowering of quality to the point where people refuse to eat it. All the types of losses could be conveniently categorized into two categories i.e. quantitative and qualitative.

**Causes of deterioration of food grains are**:

A) Environment
   i) Temperature
   ii) Ambient RH
   iii) Gaseous composition $\{O_2:CO_2:N_2\}$

B) External Micro-organisms
   iv) Insect
   v) Pest (birds, rodents)
   vi) Mites, fungi, bacteria, yeasts

C) Biochemical composition of the grain
   vii) Moisture content
   viii) Fat content

**Changes occurring during storage on the grains are:**

A) Wholesomeness/purity
   i) Excreta
   ii) Dockage-impurities
   iii) Damage grains

B) Quality of the grains
   iv) Weight loss
   v) Taste
   vi) Colour
   vii) Odour
   viii) Nutrition
   ix) Fat acidity
   x) Toxicity
   xi) Germination
   xii) Moisture content
   xiii) Post harvest quality: Milling and baking quality

Moisture is the most important factor, if taken care can limit development of bacteria, fungi, mites and insect attack which cause the spoilage of the grain during storage.

Some tips are:

1. Uniformly dried grains below 13% moisture content usually do not have growth of most of the microorganisms and mites.

2. Insect cannot attack the grains having moisture content below 10%.

3. In bulk storage, moisture content of the grain seldom remains uniform. Relative humidity of store, outside environment condition develops air currents. Thus within the bulk storage high and low moisture pockets develop. To check them, periodic inspection at these points is a must.

4. It is desired that relative humidity of the store should be 50-60%. Lower humidity results in over drying of the grains and develop fissures which affects milling, baking, cooking quality of the grains.

5. Higher humidity will increase the moisture content and grains are likely to be attacked by insects-pests and microorganisms.

6. Grains should be stored in dry and cool place. As the moisture content of the grains is directly proportional to the respiration of the grains.

7. The increase in respiration increases the temperature, growth of microorganisms and enzymatic activity of the bulk grain up to certain temperature.

8. Mites do not develop if the storage temperature is below $5^oC$, insects do not grow if the storage temperature is below $15^oC$ and fungi do not develop if the storage temperature is below $0^oC$.

9. Most favourable temperature for insect growth is $25\text{-}30^oC$.

An ideal storage structure should:

- have adequate protection against insect-pest.
- maintain wholesomeness and purity
- be air tight during fumigation and allow air movement during ventilation
- be easy to inspect and clean.

In India, major portion of produce is stored in a large number of small capacity rural godowns. These godowns are neither air tight nor safe from insect-pest and rodent. It is estimated that the losses in such rural godowns is as high as 30 % in humid conditions if stored for 8-10 months. The grains with scientific storage are stored in the bulk either in bag storage or in silos. The bag storage has following advantages:

- ✓ Small lots of a number of crops or varieties can be stored in the same space
- ✓ Infested bags can be easily segregated and fumigated.
- ✓ Each bag can be handled independently

After the green revolution our food grain production has increased many fold. However, the warehouse capacity is limited. Therefore, for short period food grains are stored in CAPS (cover and plinth storage). The maximum safe storage period for CAPS is only 6 months under ideal conditions, but in practice grain is stored in CAPS even up to 2 to 3 years. It is mainly due to poor infrastructure facility for storing food grains in bulk or godowns.

The most modern and safe method of storage of single type food grains is silo. The advantages of storing in silos are:

- ❖ Greater storage capacity per unit volume of space,
- ❖ Loading and unloading is easier and cheaper as mechanical handling devices do it.
- ❖ No cost of purchasing gunny bags and dunnage
- ❖ No danger of rodents as they are metal or RCC bins/silo
- ❖ Insect infestation is considerably less and if required easy to fumigate.

- ❖ Minimal effect of outside environment on food grains and if required easy to turn with the help of mechanical handling devices.

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**Check Your Progress Exercise 4**

**Note:** a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. What are the causes of food grain deteriorations?

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2. List the characteristics of ideal storage structure for food grains.

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3. Compare the bag storage and silo storage methods.

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4. What is the temperature, relative humidity of the environment and moisture content requirement of the grain for safe storage.

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## 4.11 VALUE ADDED PRODUCTS

There is a great scope for diversification and value addition to cereals, pulses and oil seeds. Consumer preferences especially in urban areas for processed, fast foods have gained significantly. Media and television have played a significant role for domestic market. Even developed and other countries are looking towards India as a big market for processed foods. Now–a-days time is the biggest constraint with the urban people. So ready to eat, fast to cook, extruded, puffed, baked snacks are convenient have great potential in the market. Some of the possible products are listed in Table 4.5.

Besides these blended products as functional foods have domestic and export market. Functional foods are modified foods that help to improve health (provide specific health benefit) and prevent diseases when ingested. Some examples are:

- **Energy bars:** Constitute simple sugar to complex, contain about 12 % fat; 8-20 % protein and can be fortified with vitamins and minerals. It is specially made for athletic group.
- **Weight loss bars:** Balance nutrition with control calories intake and fortified with vitamins and minerals.
- **Breakfast bars:** High carbohydrate, low protein and fortified with vitamins and minerals.
- **Nutrition bars:** High protein content (15-27 g per serving) for body builders and fortified with vitamins and minerals.

Containing essential vitamins and amino acids for heart patient, diabetic patient, obey people etc.

**Table 4.5: Value added products from cereals, pulses and oilseeds**

| Grains | Existing products | Newer products |
|---|---|---|
| Paddy | Raw and parboiled rice; puffed and flaked rice and rice flour | Quick cooking rice; pasta products; rice based snacks and rice bran oil |
| Wheat | Flour; maida; suji; dalia; and noodles | Durum wheat; puffed product and extruded products |
| Corn | Flour; flakes; popcorn; starch; dextrose and dextrin | Corn oil and degermed corn flour corn chips |
| Pulses | Dal; Powder; roasted grains; animal feed (husk) | Mixed flour; blended products; fortified products; instant dal and dal analog |
| Millets | Flour and puffed | Blended products and baked products |
| Oil seeds | Oil and cake for feed and fertilizer | Edible deoiled cake as flour; protein isolate from soy flour and blended flour |

## 4.12 BY-PRODUCT UTILIZATION

In the present day competition an industry has to use every source of earning from the product and by-products. Moreover, unutilized by-products are an effluent to the industry. As per the environmental regulation these effluents had to be safely disposed off so that they do not pollute the environment or surroundings.

In general grains, pulses and oil seed milling units have solid by products. Some of these by-products if properly processed and used can become more profitable than the main product. A list of some by-products of cereals, pulses and oil seed milling and their possible value added products or utilization is given in Table 4.6.

**Table 4.6: By-products and their utilization in the vale added products**

| Grain | By-product | Utilization |
|---|---|---|
| Paddy | Husk | Fuel: Heating value 3000-3500kcal/kg.<br>Insulating, packaging and building material.<br>Husk ash mixed with hydrated lime produces cement like material.<br>Husk as an abrasive.<br>Producing activated carbon, sodium silicate for soap industry.<br>Pure silicon can be produced from rice husk.<br>Silicon carbide and silicon nitride can also be produced. |
| Rice | Rice bran | Rice bran oil as edible oil.<br>Defatted bran as cattle feed.<br>Defatted bran as fertilizer.<br>Defatted bran contains vitamins like B complex, $B_1$, $B_6$, amino acids, phosphoric acid compounds etc. for medicinal and dietetics use.<br>Defatted bran for bakery purposes.<br>Crude rice bran oil is used in industries, for soap, cosmetics, plasticisers, emulsifiers, protective coating, synthetic fibre etc. |
| Rice | Broken rice | Pasta products, rice flour, production of starch, and alcohol. |
| Soya bean | Defatted soya cake | Defatted soya flour for soya nuggets, soya laddu, soya granules and blended flour, soy isolates & concentrates. |

## 4.13 LET US SUM UP

Food grains play an important role in the national economy and a day-to-day requirement of human being. Post harvest handling, storage and processing of food grains is an important operation, which can create large amount of employment at all the sectors. Moreover, it has scope to reduce the post harvest losses, which amounts to be Rs. 20,000/- crore annually. Indigenously designed food processing machines based on the properties of the grains has another employment avenue. Traditional processing technologies and machines are consuming more energy, producing poor quality turnout and results in high losses. Therefore, improved machines and technologies can solve some of these problems. However, their capacity of processing is high. There is a need to develop proper storage techniques to reduce the loss of quality and quantity of the grains during storage. Food grains can be used to produce many value added convenience products to meet special requirements. Utilization of the by-products can make food-processing industry more viable.

## 4.14 KEY WORDS

**Sphericity** : It is the ratio of the geometric mean of 3-major axis with the largest axis dimension of the grain.

**Angle of repose** : It is the angle between the base and slope of the cone formed, when grains are freely dropped on the horizontal plane.

**Cleaning** : Removal of impurities from the grains.

**Grading** : Separation of the grains based on their value.

**Parboiling** : It is hydrothermal treatment given to cereals in order to improve their milling quality.

**Silo** : Modern bulk storage structure where single type of grains can be stored for longer duration.

**Functional foods** : Modified food that help to improve health and prevent diseases when ingested.

## 4.15 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

**Check Your Progress Exercise 1**

1. Industry and agriculture are two pillars of Indian economy.
2. “Whole world is looking towards India as a big market” because of large population (more than 1 billion) and unorganized food processing sector.
3. The chemical composition of the grains depend upon the crop, variety, environment in which crop is grown, type of soil, water and fertilizer applications while raising the crop.
4. The solubility of starch increases with the increase in the temperature.
5. Post harvest losses in the pulses are mainly during milling. Theoretical expected dal yield is 81-84% but actual recovery is 68-72%.

**Check Your Progress Exercise 2**

1. The size of the grains helps in designing the cleaner, grader and some other processing machines.

2. Winnowing and pneumatic conveying are two machines, in which terminal velocity is used for designing.

3. **The angle of repose** of the grains is the angle between the base and the slope of the cone formed, when grains are freely dropped on the horizontal plane.

4. Pycnometer is used for measuring the true density.

5. Water activity influences odour, flavour, texture, colour, enzymatic activity and microbial load of the grain.

6. For safe storage of oil seed the water activity of the store should be below 0.3.

**Check Your Progress Exercise 3**

1. Cleaning is to be done in the beginning of the processing, where grading is done either in between or at the end to improve the economic value, performance of processing, or storage as the case may be.

2. In parboiling the grain become harder and can withstand the milling stress. Therefore, milling improves the yield. The process of parboiling involves partly fermentation so that the parboiled rice develops off flavour and dark colour.

3. Conditioning of pulses help in loosening the husk. So milling becomes easier. Conditioning of oil seed improves oil recovery.

4. Rapid drying develops fissures on the grain. Thus during milling it breaks and its storability is poor.

**Check Your Progress Exercise 4**

1. The causes of food grain deteriorations are:

   (A) Environment: Temperature, Ambient RH, Gaseous composition $\{O_2:CO_2:N_2\}$

   (B) External Micro-organisms: Insect, Pest (birds, rodents), Mites, fungi, bacteria, yeasts

   (C) Biochemical composition of the grain: Moisture content, Fat content

2. Characteristics of ideal storage structures are:

   - Adequate protection against insect-pest.
   - Maintain wholesomeness and purity.
   - Sufficient air tight during fumigation and air tight during ventilation.
   - Ease in inspection and cleaning.

3. The comparison of bag storage and silo storage system:

| Bag storage | Silo storage |
|---|---|
| Small lots of a number of crops or varieties can be stored in the same space | Only one commodity can be stored. However, Greater storage capacity per unit volume of space is available |
| Infested bags can be easily segregated and fumigated | Insect infestation is considerably less and if required easy to fumigate. No danger of rodents as they are metal or RCC bins/silo |
| Each bag can be handled independently | Loading and unloading is easier and cheaper as mechanical handling devices do it. |

4. Ideal storage temperature below is 15$^{o}$ C, Relative humidity 50-60% and moisture content of the grain between 10-13% for safe keeping of the grains.

## 4.16 SOME USEFUL BOOKS


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