UNIT 13: PRE AND PRIMARY PROCESSING – SOME BASIC CONCEPTS

Structure

13.1 INTRODUCTION

In the earlier three units, we learnt about the principles and methods of food processing. Certain issues related to production, harvesting and handling of food prior to processing needs to be considered. For instance, how is the raw material (i.e., the food) to be prepared for processing? What are the aspects to be considered while post-harvest handling of fresh foods? What are the primary processing methods used for foods? In this unit, we will focus on these aspects. Production, harvesting, handling and preparation of raw material for processing will be highlighted. All food grains need some kind of processing, say, primary, secondary and tertiary-for bringing them to a palatable state. We will learn about these processing techniques in this unit.

Objectives

After studying this unit, you will be able to:

- know the production and post-harvest handling of fresh produce
- understand why is the preparation of raw materials essential

- describe the concepts of primary and secondary processing of cereals, pulses and oilseeds and
- discuss the concepts of minimally processed fresh foods.

13.2 PRODUCTION, HARVESTING AND HANDLING OF FRESH FOODS

India has made a lot of progress in agriculture since independence in terms of growth in output, yield and area under many crops. It has gone through a green revolution, a white revolution, a yellow revolution and a blue revolution. Today, India is the world's second largest producer of food next to China and has the potential of being the biggest with the food and agricultural sector. India is the largest producer of milk, cashewnuts, coconuts and tea in the world, the second largest producer of wheat, sugar and fish and the third largest producer of tobacco and rice, the second largest producer of fruits and vegetables after Brazil and China respectively.

The present production of fruits and vegetables in India is 47 and 80 million tones respectively. Among fruits, 63% of world production of mangoes, 14% of banana, 8% of pineapple and among vegetables, 12.4% of onion, 6% of potato, 7% of tomato, 13% of cauliflower and 6% of cabbage are produced in India. The per capita availability of food grains has risen in the country from 350 gm in 1951 to about 500 gm per day now despite the increase in population from 350 millions to 1000 millions.

The quality and condition of produce sent to the market and its subsequent selling price are directly affected by the care taken during harvesting and field handling. The objectives of the grower hence should be:

- to harvest a good quality crop in good condition
- to keep the harvested produce in good condition until it is consumed or sold and
- to dispose off the crop to a buyer or through a market as soon as possible after harvest.

To meet these objectives, success in harvesting and marketing must depend on planning from the earliest stages of production.

How to determine whether a crop is ready for harvest or not? What are the factors to be kept in mind that would help to get an optimal yield? What are the environmental conditions best suited for harvesting? Which harvesting techniques should be employed to minimize the extent of wastage? Finally, what post-harvest technologies should be employed to get maximal output as well as reduce the risk of spoilage? In the following sub-sections, we will study about all these aspects.

Let us begin first with the concept of *harvest maturity*, what do we mean by it and what role does it play in the harvesting of crops?

- *When is fresh produce to harvest?*

Optimum quality of fruits and vegetables is obtained only when they are harvested at the optimal stage of maturity. A critical time for growers of fruit and vegetables is the period of decision on when to harvest a crop. Normally, any type of fresh produce is ready for harvest when it has developed to the ideal condition for consumption. This condition is usually referred to as harvest maturity. Harvest maturity refers to *the time when the "fruit" is ready to harvest.*

- *How is harvest maturity identified?*

Before harvesting, the first thing to be looked into is the identification of harvest maturity. We have already seen what the term actually means; let us see how can we identify it. Picking should be done as per maturity indices, which are different for each variety of fruit and vegetable. Most growers decide when to harvest by looking and sampling.

Some of the judgments are based on:

- Number of days from setting
- Sight-colour, size and shape
- Touch-texture, hardness or softness
- Smell-odour or aroma

- Taste-sweetness, sourness, bitterness
- Resonance-sound when tapped.
- Minimum juice content (citrus)
- Break in rind colour (citrus, mango, papaya, pineapple)
- Sugar-acid ratio (citrus, grapes, pineapple)

Experience is the best guide for this kind of assessment. Harvest maturity can be readily observed in some crops: bulb onions, when their green tops collapse and potatoes, when the green tops die off. While other crops can be more difficult: avocados remain unripe off the tree even after maturity.

- *When are conditions right for harvesting a crop?*

When the crop is ready for harvest, will depend largely on weather conditions and the state of the market. When the decision to harvest has been made, the best time of the day must be considered. The aim is to dispatch the produce to market in the best possible condition, that is, as cool as possible, properly packed and free from damage. The basic rules to observe are:

- harvest during the coolest part of the day : early morning or late afternoon;
- do not harvest produce when it is wet from dew or rain. Wet produce will overheat if not well ventilated and it will be more likely to decay. Some produce may be subject to more damage when wet, e.g. oil spotting and rind breakdown in some citrus fruits;
- protect harvested produce in the field by putting it under open-sided shade when transport is not immediately available. Produce left exposed to direct sunlight will get very hot. For example, potatoes left exposed to tropical sunlight for four hours can reach temperatures of almost 50° C.

Produce for the local markets can be harvested early in the morning to avoid higher level of field heat. For more distant markets it may be an advantage-if a suitable transport can be arranged to harvest in the late afternoon and transport to market at night or early the next morning.

- *Harvesting techniques*

Many different harvesting techniques are used depending on the place of sale, the type of crop and the stage of maturity of the crop to be harvested.

In the developing countries, most produce for internal rural and urban markets is harvested by hand where as sophisticated harvesting machinery will be limited for the most part to agro-industrial production of cash crops for processing or export or both. In most circumstances, hand harvesting, picking and catching methods cause less damage than mechanized techniques. Hand-harvesting is usual where fruit or other produce is at various stages of maturity within the crop, that is, where there is need for repeated visits to harvest the crop over a period of time e.g. roots and tuber crops, fruits and vegetables. Machine harvesting is usually viable only when an entire crop is harvested at one time. Machine harvesting may improve quality over manual harvesting.

- *Post-harvest handling of fresh produce*

Fruits and vegetables because of their high moisture content are extremely susceptible to deteriorate, especially under tropical conditions. It is estimated that about 20-30% of the fruits and vegetables produced in India annually (worth Rs. 3000-4000 crores) is lost due to inadequate post-harvest management. These losses result in poor returns to the growers and increase the cost of raw material, which ultimately affects the consumer. Therefore, proper handling of fresh produce after harvesting plays a great role for reducing the losses. Cereals and pulses are relatively stable during transportation and storage due to their low moisture content and hence, less care is usually taken during post-harvest handling except bringing down the moisture content to safe level (usually 12 to 14%) by drying.

At all stages of harvesting and handling of harvested commodities, methods should aim at avoiding damage and loss to the produce. The main steps to be followed during post-harvest handling of harvested food commodities or produce are discussed below.

- *Field processing:* Certain processing techniques at the field itself could help to reduce the chances of spoilage of the fresh produce, specially during transportation. Fruits and vegetables are sorted and graded in the field itself. Also

shelling and depodding of peas, beans and lentils can be done in the field. Pre-cooling of the commodity in the field will help in improving the quality and reduce heat build up during transport.

- *Post-harvest treatments:* Certain post-harvest treatments to fruits and vegetables can bring down spoilage significantly. A wide range of chemicals used to control post-harvest diseases include chlorine, sulphur dioxide, dichloran etc. Extension of storage life of fresh produce could be obtained by treatment with skin coatings like wax coating of fresh fruits and vegetables. Treatment of fruits with ethylene or ethylene-releasing chemicals such as ethrel or calcium carbide helps in the induction of early and uniform ripening.

- *Packing and Transportation:* What steps should be taken to minimize the risk of spoilage and wastage of the harvested produce during packing and transportation? What factors need to be considered while transporting these to over long distances? What packing materials should be used? Let us see and try to understand all these aspects.

  Harvested produce should be collected in a suitable container and well packed, and then transported quickly to the destination, without exposing it to the potentially adverse effects of sun, rain or wind. The packing of produce directly into marketing packages in the field at harvest reduces the damage caused by multiple handling and is used increasingly by commercial growers. Most developing countries use traditional baskets, sacks and trays to carry produce to markets. These are usually of low-cost, made from readily available materials such as dried grass, palm leaves or bamboo. They serve the purpose for fresh produce carried over short distances, but they have many disadvantages in big loads carried long distances.

  Farm roads should be kept in good condition for transporting the fresh produce without damage. Containers must be loaded on vehicles carefully and stacked in

such a way that they do not shift or collapse, damaging their contents. Vehicles need good shock absorbers and low-pressure tyres and must move with care. At the destination, the produce has to be transferred immediately to the proper storage area depending on the chill characteristics of the product. For long destination, fresh produce may be transported by air or by rail wagon.

Let us now study about how to prepare the raw materials for various processing techniques in the following section.

13.3 PREPARATION OF RAW MATERIALS FOR PROCESSING

All the incoming raw materials, including packaging materials, should be evaluated and monitored to prevent potential contamination of the food product manufactured. Incoming materials must be received into an area, which is separated from processing areas. The raw materials are then processed as soon as possible in order to avoid deterioration. Healthy and sound commodities without any infection are selected for processing. Preliminary preparation of raw materials includes cleaning, peeling, cutting, trimming and grating, sieving, soaking, processing, coating, blanching, marinating, sprouting, fermenting, grinding, drying and filtering.

- *Cleaning:* Cleaning is applicable to vegetables, fruits and many other food products. One of the aspect of cleaning is soaking or washing and is applicable to fruits, vegetables, cereals, pulses and non-vegetarian foods. Washing fruits render them free from dirt, twigs, stalks, sand, soil, insects, pesticides and fertilizer residues. Soaking helps to loosen the adhered soils particularly on root crops. Washing cereals or *dhals* help to remove husk, mud and any other unwanted matter. Hard vegetables are scrubbed under cold running water.
- *Sorting:* The purpose of sorting is to separate the ripe fruits from the underripe or overripe fruits. At the same time, parts of damaged fruits will be removed. Some fruits are cut in two to check the inside.
- *Peeling and stringing:* These methods involve the removal of non-edible or fibrous portion of fruits or vegetables. It may be done (a) by hand ;(b) with steam

or boiling water ;(c) with lye or alkalis (NaOH, KOH) ; and (d) by mechanical means. Peeling facilitates the operation of cutting the raw material into pieces or into slices before processing.

- *Cutting and grating:* Dividing the food into smaller pieces is cutting. This helps in easy cooking. Various terms used under this are cut, chop, mince, dice and slice.
- *Blanching:* Blanching is plunging food commonly fruits and vegetables into boiling liquid and immersing in cold water. This destroys the enzymes present in food which otherwise causes browning and off-flavor hence, used as pre-preparation for preservation. Generally tomatoes, potatoes, almonds, carrots and beans are blanched.
- *Sieving:* Sieving is done to remove coarse fibres and insects and also in preparing cakes for blending of flour with baking powder.
- *Grinding:* The term implies to *reduce to powder by friction, as in a mill, or with the teeth; to crush into small fragment*. This includes both wet and dry grinding. Wet grinding includes the grinding *idli* batter and preparations of *chutneys*. Dry grinding is grinding spices for masala powders and wheat and other cereal grains to flour.
- *Processing:* Processing includes all the things to get food ready for cooking and serving. The various processes included under this are: mixing, blending, binding, beating, whipping, folding, mashing, rolling and stuffing.
- *Marinating:* Marinating is nothing but soaking a food in a *marinade,* which is a seasoned liquid, usually containing an acid, such as vinegar, lemon juice, or wine to add flavour or to tenderize it or both. Vegetables, fruits and meats are marinated with many flavour combinations like oil, flavour and acid. Oil helps to hold natural juices of meat. Acid is used to tenderize by breaking down connective tissue. Vegetables like brinjals, onions, radish, bittergourd, potatoes and chillies are normally marinated.
- *Sprouting or Germination:* It is defined as the process whereby the seeds sprout and begin to grow. All kinds of grams like green gram, bengal gram, peas and cereals like ragi and wheat are generally sprouted. Sprouted pulses are used in making salads and curries.

- *Fermentation:* Fermentation is the process of breaking down of complex matter into simpler ones with the aid of enzymes and bacteria. This can be under aerobic or anaerobic conditions. Fermented foods are often more nutritious than their unfermented counterparts.
- *Drying:* Drying or dehydrating is removal of moisture from food products. Removal of moisture helps to prolong the shelf life of the food.
- *Filtering:* This process is generally done to remove dirt, unwanted particles or to remove moisture from foodstuff. Foodstuffs filtered are coffee, tea, rice, soups, fruit juices and tamarind water.

POINTS TO REMEMBER

1. India is the world's second largest producer of food next to China, and has the potential of being the biggest with the food and agricultural sector.

2. Optimum quality of fruits and vegetables is obtained only when they are harvested at optimal stage of maturity. Harvest maturity refers to the time when the "fruit" is ready to harvest.

3. Maturity indices of fruits and vegetables are determined based on the number of days from setting, sight-colour, size and shape, touch-texture, hardness or softness, Smell-odour or aroma, taste-sweetness, sourness, bitterness

4. When the decision to harvest has been made, the best time of day is during the coolest part of the day: early morning or late afternoon
5. Hand-harvesting is usual where fruit or other produce is at various stages of maturity within the crop, where as machine-harvesting is usually viable only when an entire crop is harvested at one time.
6. It is estimated that about 20-30% of the fruits and vegetables produced in India annually (worth about Rs. 3000-4000 crores) is lost due to inadequate post-harvest management.

7. Fruits and vegetables, because of their high moisture content, are extremely susceptible to deterioration and hence, intense care is taken. Whereas, cereals and pulses are relatively stable during transportation and storage due to their low moisture content and hence, less care is usually taken during post-harvest handling.
8. Pre-cooling of the commodities in the field will help in improving the quality and reduce heat build up during transport.
9. To control post-harvest diseases of fruits and vegetables, chlorine, sulphur dioxide, dichloran are used. To help in the induction of early and uniform ripening of fruits, ethylene or ethylene-releasing chemicals such as ethrel or calcium carbide are used.
10. The packing of produce directly into marketing packages in the field at harvest reduces the damage caused by multiple handling and is used increasingly by commercial growers.
11. Preliminary preparation of raw materials includes cleaning, peeling, cutting, trimming and grating, sieving, soaking, processing, coating, blanching, marinating, sprouting, fermenting, grinding, drying and filtering.

Check Your Progress Exercise 1

1. Fill up the blanks:

(a) India is the largest producer of (i) ……in the world, the second largest producer of (ii)……. and the third largest producer of (iii) ……., the second largest producer of (iv)……

(b) The objective of the grower should be:

……

……

(c) Hand harvesting, picking and catching methods cause……. than …….

(d) ……of the commodity in the field will help in improving the quality and …….. heat build up during transport.

(e) The raw materials are processed as soon as possible after harvest in order to avoid …….

(f) ……is a process of heat treatment given to vegetables followed by cooling prior to dehydration or freezing or canning.

(g) …… is the process of breaking down of complex matter into simpler ones with the aid of enzymes and bacteria.

2. How is harvest maturity identified?

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3. When are conditions right for harvesting a crop for local and distance markets?

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4. List the main steps involved during post-harvest handling fresh produce.

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5. What are the preliminary steps involved during preparation of raw materials?

13.4 PRIMARY PROCESSING OF CEREALS, PULSES AND OILSEEDS

Both cereals and pulses are nutritionally important, since both together constitute the staple foods for the population. They are also a relatively cheap source of energy, protein and important vitamins and minerals. All food grains need some kind of processing for bringing them to a palatable state and for their efficient and economic utilization. This is due to the fact that grains contain an outer protective cover of fibrous husk/bran layer.

Cereal grains like rice and maize also contain oil rich bran/germ, which are of high economic value, but are undesirable for the purpose of storage. Separation of these parts from the grains is generally referred to as *primary processing* and is a prerequisite to make them more palatable and safe for storage. The process of preparing certain products like flour, semolina, flakes and popped grains is referred to as *secondary processing*. *Tertiary processing* further processes these to provide variety in product making and to meet the growing demands for ready-to-eat or ready-to- use products.

Let us now have a look at the different levels of processing in a variety of food commodities. We shall begin with cereals-one of the crops that forms a part of the staple diet.

13.4.1 Cereals

Cereals or grains are the seeds of grasses and include the many species of wheat, rice, maize or corn, jowar, barley, ragi, bajra, rye and oats. Cereals account for the largest share, about one-fifth of the consumption expenditure in India. They are mainly consumed in the form of products obtained from primary processing, such as rice from paddy and *atta* or flour from wheat. Rice, wheat, maize and sorghum are the four major cereals, which are grown and consumed in the country. As per FAO figures for the year 2003, India produces around 102 million MT of rice against world's production of 590 million MT.

The ease with which the grains can be produced and stored, together with the relatively low cost and nutritional contribution has resulted in the widespread use of cereal foods.

Processing of Cereals

Owing to the low moisture content, cereals and pulses are relatively stable during storage; and processing is not so much for preservation. However, processing is of primary importance for bringing them to a palatable state, adding a variety to the diet and in improving their nutritive value. They are generally milled to remove the outer husk and

the resulting product is consumed after cooking and is used in various food preparations. Cereal processing goes through three stages:

(a) Harvesting: It includes threshing, winnowing and preparation for storage of the cereal grain.

(b) Primary processing: It involves further treatment of the grain such as cleaning, dehulling (decorticating), pounding and milling; and

(c) Secondary processing: It involves transforming the primary processed material into food, i.e., cooking, blending, baking or fermenting and roasting, which makes the grain suitable for human consumption.

The total post harvest system of cereal processing is given in the following flow chart:

Harvesting

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Pre-drying in field

↓

Threshing

↓

Winnowing

↓

Drying

↓

Storage

(Sacks, bags, bulk)

↓

Primary Processing

(Cleaning, grading, hulling, pounding, milling)

↓

Secondary Processing

(Cooking, blending, fermentation)

↓

Packaging & Marketing

(a) Let us now take a look at the major steps involved in the post-harvest system of cereals.

(i) Threshing: The process of threshing separates the kernels from the stalks or panicles on which they grow. Threshing may take place in the field, or at the homestead or village; it may be carried out manually with the aid of animals or with machinery. A simple method consists of beating the cereal heads against a wall or the ground; animals or humans can also trample the panicles on a hard surface or animals can draw a machine or sledge over the grain. Maize grains must be separated from the cob after the husk has been removed.

(ii) Grading: Grading consists of separating the sound kernels from chaff and impurities, and may be achieved by sieving or winnowing.

(iii) *Sieving:* Impurities are separated on the basis of their differences in size from the kernels. Hand sieves are usually used singly. The simpler machines will have two sieves: one with oversized holes (which retain large impurities and let the grain kernel pass through) and the other one with undersized holes (which retain the kernels but allow smaller impurities to pass through).

(iv) *Winnowing:* In this process, the impurities are separated on the principle that their density differs from that of the grain kernels. The operation depends on air movement to remove the lighter fractions. The simplest method is to drop a basket of kernels and impurities in a thin stream onto a clean surface through a slight natural breeze. This is a slow and laborious process but it is still widely practiced. Winnowing machines operate on the same principle but a fan creates air movement.

(b) Primary processing of wheat: Wheat is consumed mostly in the form of flour obtained by milling the grain. Wheat can be broadly classified into three groups from the milling and baking point of view: (a) Hard wheat, (b) Durum wheat, and (c) Soft wheat. Flour made from hard wheat is used for bread-making, while flour from soft wheat is used for biscuits, cakes and breakfast foods. Semolina is prepared from hard wheat and durum wheat.

Wheat milling: The milling of wheat consists of the separation of bran and germ from endosperm and reduction of endosperm to fine flour. There are three distinct methods of milling wheat: stone milling, roller milling, and fragmentation milling. Irrespective of the method of milling, all wheat grains will go through two main stages before being milled:

1. ***Cleaning:*** Cleaning of the grain is the main step before milling. The objective is to remove grains of other cereals, seeds from a variety of field weeds, straw, dust and mud from fields, stones, live and dead insects, small rodents and their excreta and small pieces of metal.

The processing stage of cleaning is usually broken down into four separate operations:

(a) Screening: The grain is passed through several sieving operations to remove items both larger and smaller than it. It is then passed along a conveyor belt, where any pieces of metal are removed magnetically and dust, rodent hairs etc. are removed by the use of current air.

(b) Sorting: At this stage, all non-wheat grains such as barley and oats are removed by passing through a range of separators which remove all foreign grains by virtue of their size.

(c) *Scrubbing:* The grain is passed through scanners which remove any mud or dirt and the beard and bee wing from each grain (the bee wing is the epidermis or outer layer of the bran coatings).

(d) *Washing:* This operation cleans the grains by removing any fine dust and hairs, and also any stones, which have not been removed previously. After washing the grain is centrifuged to remove excess surface water.

2. Conditioning: The grain is conditioned to desired moisture content by the addition of water. The purpose of conditioning is to make the bran and germ pliable, thus preventing them from getting powdered. This may be done by moistening the grain and allowed for 24-72 hrs, depending on the air temperature. The cleaned and conditioned wheat is then ready to be milled by one of the following methods:

(i) Stone-milling: The traditional procedure for milling wheat in India has been the stone grinding (chakki) to obtain whole meal flour (atta). In the stone mill, two circular stones are used, each with its surface corrugated radially, with the distance between the stones being smaller towards the outer edge of the stones. In the operation, the cleaned and conditioned grain enters from the above into an aperture in the center of the top stone. The bottom stone is stationery at all times whilst the top one revolves, grinding the grain more finely as it is pushed to the outside of the stones. The resulting flour is then sieved before being bagged. The method results in 90-95% extraction rate flour, which retains almost all the nutrients of the grain, while simultaneously eliminating the part of the grain which is most indigestible, like cellulose and phytic acid, which binds and carries away the minerals.

(ii) Roller-milling: The roller-milling is a much more complete method than stone-milling and involves a large amount of specialized equipment. It is concerned with the milling of white flour, where bran and germ are separated from endosperm and flour of any extraction rate can be produced. The process can be broken down into two clear stages:

- *Breaking:* The cleaned and conditioned grain is passed through a series of break rolls. These are the grooved rollers, which operate in pairs, rotating in the opposite direction to each other, the top one rotating two and a half times faster

than the lower roller. It is usual for the mill to have five sets of break rolls, with each set being more finely set than the previous set of break rolls. Each of the above are passed through purifiers, where by means of air currents any minute particles of bran are removed to ensure purity of the white flour end-product.

- *Reduction:* The purpose of this stage is to reduce the endosperm to fine flour and to extract the germ. The reduction stage is less complicated than the breaking stage. It consists of a series of reduction rollers, which are smooth and each pair is set more finely than the previous set. After passing through each set of reduction roller, the product is sieved; the coarse particles go to the next set of rollers for finer reduction. The process is repeated until all the semolina, which was fed into the reduction rollers, is reduced to fine white flour, germ and a small amount of branny by-product. The germ is extracted early in the reduction stage, where it is easily sifted off because being of a tough and oily nature, it is flattened on the rolls with little fragmentation taking place.

(iii) Fragmentation-milling (Air classification): This is a relatively new method of milling, by which it is possible to control the protein quality and quantity in the production of a particular flour. This is a refinement of roller-milling in that after producing the white flour, it is then processed a further step and is separated by means of air classification into particles of three broad ranges, lesser the size, higher the protein content.

Primary processing of Rice

Rice is the staple food for the majority of the world's population and is cooked in boiling water and eaten mostly with cooked pulses, vegetables, fish or meat. It is also used in many food preparations like idli and dosa. Rice with the husk is called *paddy*. Primary processing of rice consists of cleaning, grading, dehusking (shelling) and milling (polishing). Dehusking and polishing are traditionally accomplished by hand pounding, using pestle and mortar. In modern rice milling, the two main steps involved are dehusking and polishing.

(i) Cleaning and grading: The paddy as received will contain foreign matter such as stones, clay particles, straw, chaff and dirt. These have to be separated in a paddy cleaner.

(ii) Dehusking (shelling): After cleaning, the outer husk is first removed by shelling process exposing the grain covered by a brown bran layer. It is sold in this condition as brown rice. The shelling is carried out normally using two different types of shellers:

(a) Disc sheller: It consists of two discs. The inside surface of the discs is covered with a mixture of emery and hard cement. The clearance between the discs is adjusted close to the length of the paddy grain to be shelled. One plate is stationary, while the second plate revolves. The husk is removed by aspiration.

(b) Roller type Sheller: It consists of two horizontally set rubber rollers rotating in opposite directions, the differential rotation between the two being kept at about 200 per min. Dehusking is effected by the grain hitting the rotating rollers. The resulting brown rice contains the pericarp and germ almost intact. The breakage of rice is minimum with this machine.

(iii) Rice milling (polishing): The brown rice obtained by shelling can be milled (polished) further in a stage known as "pearling" using either a cone-type polisher or a horizontal-type polisher to remove the coarse outer layers of bran and germ, leaving a white grain. Sometimes, the polished rice is further treated with mineral substances such as talc or sugar to give the grain a bright shining surface.

Subsequently, a simple machine like huller came into existence. Hullers achieve both dehusking and polishing in one step. It is estimated that there are over 1, 30,000 hullers in operation throughout the country. They are largely located in the rural areas. More than 30% of paddy produced is processed in hullers.

(iv) Parboiled rice: Parboiling is an ancient process of India. More than 50% of paddy produced in the country is parboiled. Parboiling means *partial boiling and cooking of rice in a limited water environment.* For this reason, prior to milling, the paddy is fully soaked in water and then the drained paddy is cooked by steaming or by dry heat. The process

gelatinizes the starch in the grain aiding the retention of much of the natural vitamin and mineral content. Surprisingly, parboiled rice takes longer to cook, but has the advantage of taking up more water during cooking and therefore increasing the yield.

(v) By-products of rice: The important by-products obtained in rice milling are rice bran oil, bran or polishing (good source of protein and fat), husk (fuel, insulating material, paper making, production of furfural).

(vi) Rice products: Of the 100 million tones of paddy, about 10% is converted to various products like flaked rice (*Aval, Chewda* or beaten rice), expanded rice (*Puri, Murmura*) and popped rice (*Aralu, Kheel*). The other rice products are instant rice (quick cooking rice), rice flour, rice starch etc.

Processing of minor cereals

Maize, jowar, bajra, ragi and other small millets are important minor cereals of our country. They are also termed as *coarse grains*. They are widely consumed without much refinement by the poorer sections of the population, particularly in the rural areas. Judicious refining of these grains can upgrade their appearance and eating quality by removal of the unpalatable rough bran layers without affecting their nutritive quality.

Traditional milling of these grains is done by pounding in a mortar and pestle to remove the outer bran. Dry and slightly wet (soaked in water to soften the bran) and tempered grains are used. After pounding, the bran is removed by winnowing and the endosperm is ground in the same unit or small mechanical hammer/plate mills. Pounding is a very laborious and time-consuming operation and also the quality of the product is often not very good because of high moisture content of the flour and mixing of ground bran. In the mid sixties, it has been observed that when 3-5% water was mixed with the grains and tempered for 5-15 minutes, the outer bran layers were sufficiently toughened and could be abraded off (without powdering) in simple abrasive rice polishers (pearlers) without affecting the inner grain portion, which remained hard. This pearling technique has been

applied successfully to jowar, bajra, varagu and wheat. The pearled grains find wide use for traditional preparations like roti, bhakri, bhath etc.

13.4.2 PULSES

Pulses are the edible fruit or seed of pod-bearing plants and are widely grown throughout the world. They have a high protein content ranging from 20-40%, which makes them important as a major source of proteins in the diets of population dependent mainly on cereals as staple foods around the world. Economically, they provide reasonably good quality protein at a fraction of the cost of animal proteins. In most of the parts of the world, pulses are traditionally consumed either in the whole or in the dehulled split form, as soft-cooked products. Almost all pulses are grown in India. Red gram or *tur* (*arhar* or pigeon pea), Bengal gram or chick-pea (*chana*), Black gram or *urad* and Green gram or *mung* are considered as major pulses depending on their production and consumption while *moth* or tepary bean, lentil, horsegram or kulthi, peas, khesari dhal and others (cow pea, cluster bean or guar, French bean or kidney bean, Indian bean or field bean and soybean) etc. are known as *minor pulses,* since they are grown and consumed only in certain regions. Many of the pulses contain toxic factors, which cause many diseases in human. The toxic factors can be eliminated either by heat processing or by leaching them out in boiling water.

Primary processing of pulses

Dry pulse seeds have a tight and fibrous seed coat (husk or skin) that envelops the cotyledons, which often is indigestible and may have a bitter taste. In grains like cowpea and green gram, the seed coat is thin forming 8-10% of the grain, whereas in Bengal gram and *tur*, they are thick and constitute 10-14% of the grain. Primary processing of pulses involves cleaning, removal of husk or skin and splitting.

Pulse Milling

Milling of pulses consists of 2 steps: loosening the husk and its removal followed by splitting into dhal. Loosening of the husk referred to as “pre-milling treatment” is normally achieved by wet or dry method, which involves intermittent sun-drying after the

application of oil and water. Dehusking or dehulling or milling and splitting are done in chakkies or power driven machines. Milling is usually done by two methods:

(a) Wet process:

The wet process has been commonly used with pigeon pea or red gram, as the skin in this grain is difficult to be removed. The process consists of the following steps: (i) soaking the grain in water overnight, (ii) smearing the soaked grain with red earth mixed with water and keeping the grain moist as a heap by sprinkling water for 16-24 hours, (iii) drying the grain in sun, and (iv) dehusking the grain using granite or wooden hullers.

(b) Dry process after conditioning skin with water or oil:

(i) Dry process after conditioning skin with water-chickpea, lentils, lathyrus, pea and dried peas.

(ii) Dry process after conditioning skin with oil-pigeon pea or red gram, black gram and green gram

In the first process, the grains are cleaned and after an initial scouring or pitting operation in roller mills, they are sprayed with water 5-10% by weight of the grain and kept in a closed vessel for the water to be fully absorbed by the skin. The material is then dried in the sun. Similarly, in the second process, the cleaned and pitted grains are treated with a vegetable oil (0.2 to 0.5%). The grains are dried in the sun and then conditioned by spraying water (about 4-5%). The conditioned grains are again dried in the sun.

In both the pre-milling treatments, adherence of the husk to the cotyledon weakens and consequently, its removal becomes easy.

The loosened seed coat of the pretreated pulses is then removed in the subsequent operation of milling. For this purpose, different machines are used depending on the types of pulses and scale of operation. Pulse milling is practiced at different levels, viz, (a) home scale, (b) cottage scale, and (c) large scale level and machines like pestle and mortar, hand-driven chakki are used in home-scale and roller mill in cottage and large-

scale operation. There is much loss due to powdering and /or breakage. This process is dependent on climatic conditions, laborious and does not give more than 70% of dehusked and split grains although higher yields are possible.

Pulse products:

The important processed pulse products are puffed chickpea and pea, *besan*, papads, pulse-based weaning foods, quick cooking *dhals*, and canned dry peas

13.4.3 Oilseeds

Like pulses, oilseeds and nuts are rich in protein and in addition, they contain a high level of fat. At present, India accounts for 9.6% of world's total output of oilseeds. The major oilseeds produced in the country include groundnut, rapeseed/mustard, castor seeds, sesamum, nigerseed, linseed, safflower, sunflower and soybean. However, groundnut, rapeseed/mustard and soybean accounts for a major chunk of the output.

Primary processing of oilseeds

Oilseeds are the major sources of edible oil. Edible oilseed meals (cakes) obtained from oilseeds are often highly nutritious and can be used for either animal or human food. The residual oilcake has been used for the preparation of protein foods for feeding the infants and preschool children in developing countries.

There are four main steps involved in the preparation of oil and edible meal from oilseeds:

1. Preparation of the raw material
2. Oil Extraction
3. Clarification
4. Packaging and storage

Let us discuss these one by one.

1. Raw material preparation: This involves cleaning and dehusking. Some raw oilseeds have a fibrous husk or seed coat, and this must be removed prior to processing. The

removal is known as *decortications* and a range of decorticating machines are available which are suitable for small-scale production. The separation of the husks or seed coat from the oil-bearing material after decortications is achieved by gently throwing the seeds into the air and letting the air blow away the husks. This method is called as *winnowing* and requires skill and experience. Some of the oilseeds require grinding or flaking. Traditional hand-pounding methods using a pestle and mortar or more sophisticated roller mills, may be employed to grind groundnuts into coarse flour. Flakers are used for sunflower seeds, and hammer mills are applicable for palm kernels. Subsequently, some of the grounded oilseeds such as groundnuts and sunflower are conditioned with addition of 10% water followed by heating to 90° C in order to rupture the oil-bearing cells. The heating is traditionally carried out over open fires, although seed scorchers, which are basically pans fitted with stirrers, are now available to mix the seeds better.

2. Oil extraction: Extraction of oil from the prepared oilseeds can be done by one of the following methods: (i) traditional method: *ghani*, (ii) Improved methods: (a) mechanical pressing (hydraulic pressing), (b) screw pressing (expeller pressing), (c) prepress solvent extraction, and (d) direct solvent extraction. Let us study about these methods:

(i) *Ghani:* It originated in India, but their use is now more widespread. A ghani consists of a wooden mortar and pestle. The mortar is fixed to the ground, and the pestle is located in the mortar, where the raw material is crushed by friction and pressure. An animal is required to move the pestle and as this continues the oil is pressed out, runs through a hole at the bottom of the mortar, and the residue (cake) is then scooped out. Ghanis are limited in that two animals are required, since any one animal will tire after 3-4 hours. Motorized ghanis are becoming increasingly popular and are fast replacing animal-powered equipment. Mustard oil, groundnut oil and sesame oil are traditionally produced by this method.

*(a) Hydraulic pressing**:*** Prepared raw materials to be crushed are placed in heavy perforated or slotted metal cages (12 to 16 Nos.) and a metal plunger is used to press out the oil. The maximum pressure applied is

2000 psi for a period of 20-50 minutes. The oil content of the press cake may vary from 5 to 8% depending on the raw material.

(b) *Expeller pressing (screw pressing):* The raw material is continuously fed to the expeller, which grinds, crushes, and presses out the oil as it passes through the machine. Oil flows through the perforations in the casing and is collected underneath. The residue, or oilcake, is pushed out of the end of the unit Most small expellers are power-driven. The oil content of the press cake after second pressing may vary from 5 to 8%.

(c) *Prepress solvent extraction:* In this process, the oil from the raw material is expressed in a screw press by single pressing and then the residual oil from the press cake is solvent-extracted by using food grade hexane followed by desolventization of the material. The protein quality in the meal obtained by this method is not adversely affected.

(d) *Direct solvent extraction:* This process is used for the oilseeds having low fat content e.g., soybean. The process consists of the following steps: (i) cooking of the material in steam and flaking, (ii) solvent extraction of the flakes using food grade hexane, and (iii) desolventizing the meal.

3. Clarification of oil: Crude oil contains a suspension of fine pulp and fibre from the plant material. It also contains smaller quantities of water, resins, colors and bacteria, which makes it darker in colour. These contaminants are removed by clarifying the oil, either by allowing the oil to stand undisturbed for a few days and then removing the upper layer, or by using a clarifier. If further clarification is needed, the oil may be filtered through a plastic funnel, which has been fitted with a fine filter cloth. Finally, the oil is heated to boil off the traces of water and destroy any bacteria. For those raw materials, which are processed wet (such as coconut), heating is applied prior to clarification in order to break the emulsion. When these impurities are removed, the shelf-life of the oil can be extended from a few days to several months, provided it is stored properly.

4. Packaging and storage of oil: Rancidity can cause the oil to deteriorate and develop off-flavors during storage. Using clean, dry containers, which exclude light and heat, and prevent contact with metals such as iron or copper, may prevent this. Sealed glass or plastic bottles are adequate packaging materials. The containers should be properly dried after cleaning to remove all traces of water. If the oil is packaged adequately and kept away from heat and sunlight, the shelf-life can be expected to be 6-12 months.

13.4.4 Minimally processed fresh foods

Today's consumers are increasingly demanding convenient, ready-to-use and ready-to-eat foods with a fresh like quality, and containing only natural ingredients. The concept of minimal processing theoretically involves the care of foods throughout the entire post-harvest system - from the farm-gate all the way to the consumer, while also meeting the demands of the consumer for convenience and fresh. This minimal processing approach is also called as *hurdle technology*, simply because a series of hurdles is placed in the way of the micro-organisms growth and survival; e.g. combinations of weak acid treatments with modified atmosphere packaging or mild heating with reduced water activity, or alternative doses of mild heating and chilling.

Minimally processed foods include conventional products such as prepared vegetables and salads, prepared fruits, prepared meat items, heat-and-eat meals and new generation foods such as fresh pasta and pasta sauces. If these products are heat processed, the heat treatment is much less than that required of the canned foods. Chilled ready-to-eat or ready-to-heat foods are a very rapidly growing segment of the market. Some of the best examples of this are the fresh and sliced apples and potatoes packaged under the modified atmosphere packaging that have a shelf-life of three weeks. These products are prepared under very rigorous hygienic conditions, packed under vacuum and cooked at fairly low temperatures.

The advantages of minimally processed foods are many:

- Maintains freshness and quality;

- Renders fruits and vegetables in convenient and ready-to-cook form;
- Extends the shelf-life;
- Bulk reduction for better storage, easy transportation and packaging;
- Boosts export of vegetable in minimally processed form;
- Renders 60% value addition; and
- Low technology, without involvement of sophisticated machinery.

Increased product safety is also much in demand by the producers and distributors. The fresh-like products are highly perishable and actions that increase safety are important. Minimally processed products readily deteriorate in quality than the original raw material due to the alteration of tissue integrity during processing of these products. Therefore, minimally processed foods must be held continuously at refrigerated temperatures and guarded from temperature abuse in distribution and retailing.

POINTS TO REMEMBER

1. *Major cereals:* Rice, Wheat, and Sorghum; *Minor cereals:* Maize, Jowar, Bajra, Ragi and other small millets.

2. *Major pulses:* Black gram or urad, peas, Green gram or mung, Bengal gram and Soybean. *Minor pulses:* Moth or tepary bean, lentil, horsegram or kulthi, khesari dhal, cow pea, cluster bean or guar, French bean or kidney bean.

3. The important oilseeds are groundnut, rapeseed/mustard, castor seeds, sesamum, nigerseed, linseed, safflower, sunflower and soybean.

4. All foodgrains need some kind of processing for bringing them to a palatable state, and for their efficient and economic utilization.

5. Processing of cereals consists of three stages: harvesting, primary processing and secondary processing.

6. The milling of wheat consists of: separation of bran and germ from endosperm and reduction of endosperm to fine flour. It involves three stages: cleaning, conditioning and milling.

7. Primary processing of rice (paddy) consist of cleaning, grading, dehusking (shelling) and milling (polishing).

8. The important by-products obtained in rice milling are rice bran oil, bran or polishing (good source of protein and fat), husk (fuel, insulating material, paper making, production of furfural).

9. Primary processing of pulses involves cleaning, removal of husk or skin and splitting.

10. Using clean, dry containers, which exclude light and heat, and preventing contact with metals such as iron or copper, can eliminate rancidity in oil during storage.

11. Minimally processed foods are convenient, ready-to-use and ready-to-eat foods with a fresh like quality, and containing only natural ingredients e.g. prepared fruits, vegetables, salads, meat items, heat-and-eat meals, fresh pasta and pasta sauces.

Check Your Progress Exercise 2

1. Mention the different methods of wheat milling.

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2. List the important rice products.

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3. Mention one advantage of parboiling of rice.

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4. Write the purposes of conditioning of wheat prior to milling.

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5. What are the important processed pulse products?

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6. What are the steps involved in pulse milling?

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7. List the main steps involved in the preparation of oil from oilseeds.

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8. List the methods of oil extraction.

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9. What are the impacts of minimally processed foods?

13.5 LET US SUM UP

In this unit, we studied about issues related to production, harvesting and handling of food prior to processing.

Availability of raw materials is another important consideration for processing. We learnt about the present scenario of production of agricultural produce like cereals, pulses, fruits

and vegetables, milk, sugar, fish etc. in India. We also discussed the importance of right type of harvesting procedures in order to maintain the quality as well as to minimize the wastage of fresh produce during post-harvest handling including transportation.

In another section, we learnt about the various steps involved during preliminary preparation of raw materials prior to processing or to produce finished products. The important steps are cleaning, washing, sorting, grading, peeling, trimming, blanching, etc. Though the cereals, pulses and oilseeds are relatively shelf-stable commodities due to low moisture content, they need to be processed to bring them to a palatable state and in improving their nutritive value. In this regards, we have studied the various primary-processing steps involved in cereals and pulses milling and in oil extraction.

There is a growing demand for ready to use and ready to eat foods with a fresh like quality in the consumers' market. In this connection, we studied the concept of preparation of minimally processed fresh food like fruits and vegetables, meats etc. Since the fresh like products are highly perishable and actions that increase safety are important.

13.6 GLOSSARY

Acetic acid **:** active ingredient in vinegar; used in food preservation.

Acid foods **:** foods which contain enough acid to result in a pH of 4.5 or lower. Includes all fruits except figs; most tomatoes; fermented and pickled vegetables; relishes; and jams, jellies and marmalades.

Anaerobic fermentation **:** fermentation in the absence of air (secondary fermentation).

Antioxidants **:** scavengers of particles called oxygen-free radicals.

Asepsis **:** keeping out microorganisms from food.

Blanching : process of exposing a food product to either steam or hot water for a short time, before being placed in packages and frozen or dried.

Canning : method of preserving food in air-tight vacuum-containers and heat processing sufficiently to preserve the food.

Clarifier : a chemical used to help clear water by coagulating smaller particles into filterable sizes.

Contaminant : an undesirable substance that is considered to make something impure or dirty.

Curing : a method of food preservation that involves soaking the food in a strong salt solution.

Decortication : removal of the outer covering of an organ or part.

Dehydrating : method of food preservation that involves removing the water from the food.

Emulsifier : A substance that is used to prevent the liquids in an emulsion from separating into layers.

Food additive : a substance added to food that enhance the palatability or preserve the foods.

Food spoilage : a process which occurs due to growth of microorganisms, action of enzymes present in the food, mechanical and insect damage to the food.

Freezer : a reach-in or walk-in food storage unit that maintains a temperature of 0°F (-18° C).

Freezing : a method of food preservation involving low temperatures (-18° C), a change of state of a substance from liquid to solid.

Hermetic seal : an absolutely airtight container seal, which prevents reentry of air or microorganisms into packaged foods.

Marinating : a form of food preparation; it involves leaving the food for a given time while it is coated in a liquid. The process makes the food tastier, easier to chew and digest, and

sometimes it is used as a preparation before other forms of cooking.

Oxidation **:** reaction with the oxygen in the air, causes food to go bad.

Par-boiling **:** partial boiling or cooking of rice in a limited water environment.

Pasteurization **:** a heating process designed to destroy the most heat-resistant pathogenic or disease-causing microorganism in a food product.

Perishable Food **:** a food product that spoils readily without special processing or preservation techniques.

Pickling **:** the practice of adding enough vinegar or lemon juice to a low-acid food to lower its pH to 4.6 or lower.

Pounding **:** repeated heavy blows.

Preservative **:** a substance used to prolong the shelf life of foods or to prevent the spoilage of food.

Rancidity **:** development of any off or disagreeable flavors in oil or fat due to enzymatic or oxidative reactions.

Sprouting **:** the process whereby the seeds or spores sprout and begin to grow.

Staple food **:** a basic but nutritious food that forms the basis of a traditional diet, particularly that of the poor.

Sterilization **:** a process that destroys virtually all microorganisms and their spores.

13.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1.

(a) (i) Milk, cashewnuts, coconuts and tea; (ii) wheat, sugar and fish; (iii) tobacco and rice; (iv) fruits and vegetables.

(b) (i) to harvest a good quality crop in good condition; (ii) to keep the harvested produce in good condition until it is consumed or sold; (iii) to dispose of the crop to a buyer or through a market as soon as possible after harvest.

(c) less damage ; mechanized techniques

(d) Pre-cooling; reduce

(e) Deterioration

(f) Blanching

(g) Fermentation

2. Maturity indices can be determined on the basis of : Number of days from setting, Sight-colour, size and shape, Touch-texture, hardness or softness, Smell-odour or aroma, Taste-sweetness, sourness, bitterness, Resonance-sound when tapped, Minimum juice content, Sugar-acid ratio.

3. The conditions right for harvesting a crop for local markets: harvest in the early morning to avoid higher level of field heat while for the distant markets: harvest in the late afternoon and transport to market at night or early the next morning.

4. Main steps involved during post-harvest handling fresh produce are:
   Field processing: sorting, grading, shelling and depodding, pre-cooling.
   Post-harvest treatments: treatments for controlling disease, for enhancing or delaying ripening, skin coating
   Packing and Transportation: packing in suitable container to prevent damage and from spoilage during transportation.

5. Preliminary steps involved during preparation of raw materials include cleaning, peeling, cutting, trimming and grating, sieving, soaking, processing, coating, blanching, marinating, sprouting, fermenting, grinding, drying and filtering.

Check Your Progress Exercise 2

1. Three methods of wheat milling are stone milling, roller milling and fragmentation milling.

2. The important rice products are flaked rice, expanded rice, popped rice, instant rice, rice flour, rice starch etc.

3. The advantage of parboiling of rice is to retain natural vitamin and mineral content in the rice.

4. The purpose of conditioning of wheat prior to milling are to make the bran and germ pliable, thus preventing them from getting powdered during breaking.

5. Puffed chickpea and pea, *besan*, papads, pulse-based weaning foods, quick cooking *dhals*, and canned dry peas are the important processed pulse products.

6. The important steps involved in pulse milling are - overnight soaking in water, smearing with red earth mixed with water followed by sprinkling water for 16-24 hours, sun dried, dehusking and splitting.

7. The main steps involved in the preparation of oil from oilseeds are: preparation of the raw material, extraction, clarification, packaging and storage.

8. The methods of oil extraction are: (i) traditional method (ghani); (ii) improved methods, such as hydraulic pressing, screw pressing, prepress solvent extraction and direct solvent extraction.

9. Impacts of minimally processed foods are: it maintains freshness and quality; convenient and ready-to-cook form products; extended shelf-life; bulk reduction for better storage, easy transportation and packaging; boosts export potential; about 60% value addition; low technology, without involvement of sophisticated machinery.