UNIT 2 FOOD FROM PLANT SOURCES

Structure

2.0 OBJECTIVES

After reading this Unit, we shall be able to:

- list out foods from plant sources;
- describe the of cereals, legumes, oilseeds, and horticultural crops; and
- explain post harvest processing mainly: primary, secondary and tertiary processing of plant sourced foods.

2.1 INTRODUCTION

We have learnt that food substances are primarily composed of carbohydrates, fats, proteins, minerals, vitamins and water/moisture. It is consumed by the animal or human being for nutrition and satiety. Food may be sourced from plants, animals and other categories such as fungus. Man uses plant products that correspond to many different parts of the plant and many different stages in plant development as a source of food. There are around 2,000 plant species that are cultivated for food, and many have several distinct cultivars. The plant-sourced foods can be grouped as seeds, roots, leaves, stems, flowers and fruits. Among these, seeds are the most important source of food because they are enriched with all the nutrients and energy necessary for the plant's initial growth. Seeds also account for bulk of the foods consumed by human beings. These include cereals (e.g. rice, wheat, maize, and millets), legumes (e.g. beans, peas, and lentils), nuts and oilseeds. Apart from seeds, other plant parts like roots, leaves, stems, flowers and fruits are also eaten as food.

On the basis of keeping quality and suitability for storage, plant products can be grouped into durables and perishables. Cereals, pulses and oilseeds are mainly durables whereas fruits and vegetables are perishables. Perishables are high in moisture content and prone to spoilage after their harvest. Whereas cereals are low in moisture and could be stored for longer periods. The plant

products first stored and transported by man were all durables. It is only relatively recently that man has been able to keep and transport the more perishable products. Keeping quality of perishables varies from few hours to some weeks. The main difference between durables and perishables are summarized in Table 2.1.

Table 2.1: Difference between durables and perishables

Durables	Perishables
Designed for preservation	Not designed for preservation
Low moisture content, usually 10-15%	High moisture content, usually 50-90%
Small unit size	Large unit size, typically 5g to 6 kg
Often symmetrical in shape	Often asymmetrical in shape
Hard texture	Soft texture
Stable- inherent storage life of years	Perishable- natural storage life of a few days to month depending on type
Losses mainly caused by external factors, e.g. mould, insects and rodents	Losses caused by external factors, mainly moulds and bacteria, and internal factors, e.g. respiration, sprouting, ripening, etc.

2.2 FOOD GRAINS

The grain seeds that are used primarily for food are referred to as food grains. These include rice, wheat, corn (maize), coarse grains (sorghum and millet) and legumes/pulses (beans, dried peas, and lentils). The grain seeds that have high oil content and processed for oil extraction are called oilseeds. The grains are compact and dry. They can be easily handled, transported and stored. They also have good storage stability. All the grain seeds used as food are important in meeting the basic nutritional requirement. The grains have high carbohydrates content, sufficient protein, fats, vitamins and minerals.

Based on their main growing season in India, food grains are usually grouped as Kharif (rainy season) crops or Rabi (winter season) crops. Kharif crops are grown during summer and rains during April-August, and harvested by October whereas Rabi crops are generally sown between October to February and harvested by May. Rice, maize, millets, groundnut and soyabean are important Kharif crops whereas wheat, barley and a variety of oil seeds are Rabi crops. The total food grain production in India in the year 2005-2006 was 208.3 million tonnes, out of which cereals accounted for 195.2 million tonnes. The total food grain production in 2007-08 was 227.32 million tonnes (mt). The production values for major cereals included: rice-95.68 mt, wheat-76.78 mt and maize-18.54 mt. The production of food grains is seasonal and weather sensitive.

2.3 CEREALS

Food grain crops that belong to the grass family (Graminae) form a major part of the food grains basket. They yield seed grains usable as food by humans and

livestock. The common cereals are: rice, wheat, barley, oats, maize (corn), sorghum, rye, and certain millets. Jowar and Bajra are important millet crops grown in India. There are several reasons why cereals are so important on the human diet. They can be grown in a variety of areas, some even in adverse soil and climatic conditions. They can be easily cultivated and give reasonably assured high yields compared to most other crops. Cereal grains are grown in greater quantities and provide more energy worldwide than any other type of crops. Because of their big contribution to the dietary and nutritional requirements, these are known as 'staple foods'. In some developing nations, grains constitute practically almost the entire diet of poor people.

2.3.1 Structure and Composition of Cereals

A) Structure

The structure of all cereals is similar, yet each one has its distinguishing features. The cereal grain is a one-seeded indehiscent fruit or caryopsis. The basic structure involves three parts--the bran (a layered protective outer coat), endosperm (the large starchy part, containing some protein) and the germ (the embryonic part of the plant) (Fig. 2.1).

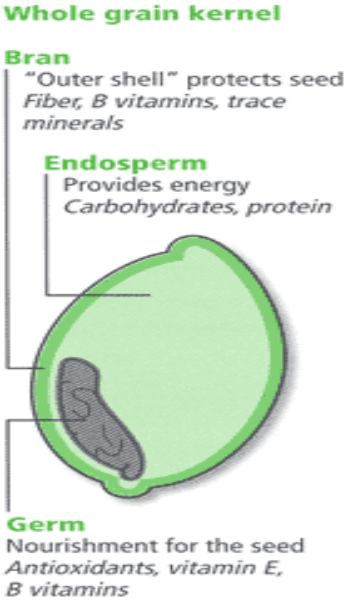

Fig. 2.1: Structure of cereal grain

The grains also have a husk cover which surrounds the entire bran. The husk or hull is the external, fibrous part of the grain that protects the grain during its formation and is totally indigestible. The bran consists of several layers, the fruit coat (pericrap) and seed coat (testa). The germ or embryo is the part of the grain from which a new plant develops. The endosperm or starchy part constitutes between 80 per cent and 90 per cent of the grain. It is the food store of the grain providing nourishment for the germinating plant. It is the most important part of the grain for the consumer and miller since it is from this part that the flour is obtained.

Important food substances like carbohydrates, protein, fat, vitamins and mineral matter and water/moisture are found in cereals. However, they occur in different quantities in the different grains. Some contain large quantities of protein while others practically have none. Certain ones have considerable fat content while others have it only in lesser quantities. A characteristic of all

cereals, however, is that they contain a large amount of carbohydrate and a small amount of water/moisture.

The largest proportion of carbohydrate lies in the center, gradually declining toward the outside of the grain. The protein lies near the outer portion. Fat is found in small amounts scattered through the entire grain, but most of it is found in the germ, which is a tiny portion of the grain from which the new plant sprouts. The mineral matter of cereals is found chiefly just inside the bran, or outer covering. So, when this covering is removed in the processed food preparation or processing, a certain amount of mineral matter is generally lost.

During milling, the bran and germ are removed because bran is ingestible and the high oil containing germ is susceptible to rancidity. However this process also removes much of the B vitamins, iron, and dietary fiber. The resulting grains after milling are known as refined/polished grain. White flour and white rice are examples of refined grains. Some refined grains are enriched. This means certain B vitamins (thiamin, riboflavin, niacin, folic acid) and iron are added back after processing. Fiber is not added back to most enriched grains. Whole grains, on the contrary contain the entire grain kernel -- the bran, germ, and endosperm. Examples include whole-wheat flour, bulgur, oatmeal, rye bread, whole cornmeal and brown rice.

B) Composition

Cereal grains contain carbohydrates, fats, proteins and mineral matter.

Carbohydrates: We have already learnt in the Unit 1 the physiological functions of carbohydrates in human body. Carbohydrate in the form of starch is the major food substance found in cereals. Rice with 75 per cent starch content is the highest starch containing cereal while oats having less than 50 per cent starch has the least starch content. Distributed throughout the grain in tiny granules, starch is more easily digested than either protein or fat. However, starch in its natural form is insoluble, tasteless and unsuitable for human consumption. To make it digestible and acceptable it must be cooked or processed.

Fats: The fat content provides the heat-and energy-producing qualities in cereals. Of the important cereals used as food, oats and corn contain the more amount of fat. The oil of corn, because of its lack of flavor, is frequently used in the manufacture of salad oil, cooking oil, and pastry fat. The fat that occurs in cereals becomes rancid if it is not carefully stored. In the making of white flour, the germ of the wheat is removed. And since most of the fat is taken out along with the germ, white flour keeps much better than the flour from which the germ is not abstracted in the milling process.

Proteins: Cereals are essentially a carbohydrate food, but some also yield a good proportion of protein. Cereal proteins are however deficient in lysine and methionine. This is in contrast to the food from animals sources that yield mainly protein, with the exception of milk which yields carbohydrates also. The grain that contains the most protein is wheat and it occurs as gluten, a substance that is responsible for the gumminess and elasticity of the wheat flour when it is mixed with water. The rubbery consistency of bread dough is also because of gluten. Cereals that contain no gluten do not make good bread. Rye is only next to wheat in protein content. Rice contains the least. The protein sourced from cereals is relatively cheap compared to that from other food sources.

Minerals: Cereals also contain a variety of minerals required for the human body. Much of the mineral matter lies directly under the coarse outside covering; some of it is lost when this covering is removed in the milling. For this reason, the grains that remain whole and the cereal products that contain the entire grain are much more valuable for nutritions reasons. In the diet/dish if sufficient mineral content is sourced from vegetables, fruits, and milk, it is perhaps unnecessary to insist on whole cereals. But if the diet is at all limited in variety, it is advisable to select the whole grain.

Cereals contain very little water/moisture in their composition. This is a distinct advantage, for it makes their nutritive value proportionately high and improves their keeping quality. This low proportion of water/moisture allows them to be stored easily without much chances of spoilage.

2.3.2 Post Harvest Processing

Cereals undergo a number of processing stages between harvest and consumption. This chain of processes is often referred to as the total post-harvest system. Each type of cereal requires a specific post-harvest treatment. However, there are certain general principles that apply to most of them. The post-harvest processing systems can be split into four distinct areas. The first involves the preparation of harvested grain for storage. This is further followed by primary, secondary and tertiary processing. Soon after harvesting, grains are subjected to threshing and winnowing. Threshing involves the removal of grains from the rest of the plant whereas winnowing is the separation of the grains from the chaff or straw and is traditionally carried out by lifting and tossing the threshed material. In the process, the lighter chaff and straw get blown to one side while the heavier seeds fall down vertically.

Now the grains are ready for drying and subsequent storage. The most cost-effective method is to spread out in the sun to dry. In humid climates it may be necessary to use an artificial dryer. Cereal grains should be dried to 10-14% moisture before storage. Grains are often stored along with some permitted insecticides and must be stored in rodent-proof containers.

A) Primary Processing

Primary processing basically involves several different processes designed to clean, sort and remove the inedible fractions from the grains. It includes operations like grading, hulling, milling, pounding, grinding, tempering, parboiling, soaking and drying. After cleaning, the grains are graded according to the size. Several grains have an unpalatable husk or shell that needs to be removed by a decorticator. This is known as hulling. After hulling, the grains are milled.

Milling or pounding is the process of conversion of grain to flour. If the grain is too dry and hard, it is difficult to break down and requires more energy to convert it into flour. If the grain is too moist, the material sticks to the mill. Most grains can be ground in a hammer mill. The milled grain is filtered out through a perforated plate/sieve that runs around the edge of the mill chamber. The size of the holes in the perforated plate determines the fineness of grinding of the particles. Grain for human consumption is ground to a 1mm particle size while animal feed is ground to a 3mm particle size. Parboiling is another kind of primary processing that is followed only in rice. Parboiling involves soaking and heating the rice which pre-cooks the grains, loosens the hull, sterilizes and preserves the rice. At the village level, parboiling is carried out in large pans

over an open fire. The products from primary processing are still not consumable and require secondary processing.

B) Secondary Processing

The third stage called secondary processing transforms the grains into edible products. Secondary processing of cereals (or 'adding value' to cereals) is the utilization of the primary products (whole grains, flakes or flour) to make more interesting products and add variety to the diet. They were developed specifically to manage the agricultural surplus and ensure stability of the food markets in developed countries. Secondary processing of cereals includes the following processes: flaking, roasting/puffing, frying, baking, fermentation, and extrusion. These foods require minimum preparation, typically just heating, and are packaged for a long shelf life with little loss of flavour and nutrients over time. Puffed rice also known as '*murmure*' is made by heating rice in sand-filled ovens. Puffed rice is used in snack foods and breakfast cereals, and is also a popular street food in some parts. Flaked rice, popularly known as '*poha*' is made by a process in which whole rice is cleaned, conditioned to a suitable moisture and lightly rolled between smooth rolls to fracture the outer layer. Moisture can then penetrate the grain more readily, thus help in cooking.

C) Tertiary Processing

During primary and secondary processing of cereals lot of waste and bio-products are generated. These can be utilized by converting into useful products. By-products such as broken grains and flours are often used as animal feed. Rice-hulls are sometimes used as fuel and their ashes as fertilizer. Rice bran wax is used as wax coating for fruits and vegetables. Rice bran is used for recovering oil. Defatted bran is utilized as important ingredient for cattle and poultry feed. Rice is also used industrially in the production of alcohol, beer, starch, oil and other byproducts

2.3.3 Foods from Cereals

Four general groups of foods are prepared from the cereal grains. (1) Whole-grain products include rolled oats, brown rice, popcorn, shredded and puffed grains, and breakfast foods. (2) Milled grain products, made by removing the bran and usually the germ (or embryo of the seed), include polished rice, farina, wheat flour, cornmeal, corn grits, pearled barley, semolina (for macaroni products), prepared breakfast cereals, and soup, gravy, and other thickenings. (3) Baked products, made from flour or meal, include breads, pastries, pancakes, cookies, and cakes (4). Beverages such as beer and whiskey, made from fermented grain products (distilled or un-distilled) and from boiled, roasted grains (5) other miscellaneous products such as starch, malt, distilled spirit, livestock feed, and wheat straw.

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) Define foods.

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2) What are staple foods?

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3) What is difference between Kharif and Rabi crops?

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4) Differentiate between whole grains and refined grains.

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5) If the bran or outer covering of a food grain is removed which is the nutrient that suffers most?

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6) Cereals are not hard to digest. Explain why?

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7) Name the amino-acids deficient in cereals.

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8) What is primary and secondary processing in cereals?

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2.4 GRAIN LEGUMES

Grain legumes (also called as beans or pulses) are second only to cereals as a source of human and animal food. Legumes or pulses are general names given to plants like beans and peas that are distinguished by having their grains in pods. Beans, lentils, peanuts, peas, and soybeans are some of the common

legumes consumed by humans. The term pulses, as used by the FAO, is reserved for crops harvested solely for the dry grain. This therefore excludes green beans and green peas, which are considered vegetable crops. Legume seeds have twice as much protein as grains. They are also high in iron and B vitamins. Some legumes, such as clover and alfalfa, are used as animal feed. Split pulses are popularly known as *Dals* in India (for example, *chana dal* [Bengal gram], *tuver dal* [red gram], *mung dal* [green gram] and *urad dal* [black gram].

In India, legumes/ pulses are being consumed as part of a primarily cereal-based diet from time immemorial. Legumes/pulses are the main source of protein and are 2-3 times richer in proteins than cereal grains. Pulses are 20 to 25% protein by weight, which is double the protein content of wheat and three times that of rice. For this reason, pulses are sometimes called "poor man's meat".

The food legumes are classified in two categories: the legumes in which energy is stored as starch (e.g. pulses) and the ones in which it is stored as fat or oil (e.g. peanut and soybean). Oilseed legumes are the major contributor to world edible oil supply as well as protein-rich diets and cattle feed. The soy bean in India is exclusively used as a source of oil and the meal as a protein rich animal feed. Inhibitors hold back the popularization of soy bean as a food legume in Indian diets. The trypsin inhibitors present in the soy bean and their removal before consuming is a stumbling block. The trypsin inhibitor does not get destroyed in ordinary cooking. Organoleptic factors such as flavour and odour, and the presence of flatulence factor also have to be tackled. Special processes are available to eliminate or at least reduce these factors to a more acceptable level.

India traditionally has been the largest producer and consumer of pulses (food legumes) in the world, accounting for 25% of the global output. The current production of all pulses/ legumes in India at 91.0 million tonnes is inadequate to meet the huge domestic demand. India is also the world's largest importer of pulses. Canada, Myanmar, Australia and the United States are significant exporters of pulses and significant suppliers to India.

Due to a sea-change in the dietary habits in view of the growing health consciousness and preference for vegetarian proteins, there is an increasing demand for grain legumes in the developed world not only as food but also for feed.

2.4.1 Composition of Legumes

Pulses supply the same amount of calories as cereals i.e. 350 kcal per 100 g (1464.4 kj/100g) dry weight. While pulses are generally high in protein, and the digestibility of that protein is also high, they often are relatively poor in the essential amino acid methionine. Grains (which are themselves deficient in lysine) are commonly consumed along with pulses to form a complete protein. It is not safe to eat raw or undercooked kidney beans and soya beans because of the anti-trypsin factor (or trypsin inhibitor) that prevents the assimilation of the amino acid.

Carbohydrates Content: Legumes usually contain large amounts of carbohydrates ranging from 24 to 68% and starch is the main carbohydrate along with oligosaccharides. Oligosaccharide raffinose is predominant in

legumes. It is known to cause indigestion and flatulence that cause discomfort, abdominal rumbling, cramps, pain and diarrhea. Besides they also contain cellulose and hemicellulose.

Protein Content: The protein content in pulses range from 17 to 30 per cent about twice or thrice of that in cereals. Soybean with a high of 42 per cent protein is the highest protein containing pulse. Proteins from legumes generally have all the essential amino acids, but is deficient in tryptophan, methionine and cysteine. This deficiency can be made up by taking cereals and pulses together.

Fat Content: The fat content of most pulses is low i.e. 1-2 per cent, however some legumes, such as peanuts (with 50 per cent), soybeans (21 per cent) and winged beans (17 per cent) contain considerable fats. Pulses and legumes are also a rich source of dietary fiber.

Minerals and Vitamins: Legumes are a good source of minerals such as calcium, iron, copper, zinc, potassium, magnesium and phosphorous. These are reputed to lower blood cholesterol and help diabetics by reducing post meal rise in blood sugar. They are gradually absorbed in the body, resulting in low rise of blood sugar. Legumes are rich in vitamins especially vitamin B complex and also beta-carotene and niacin. Germinated chickpea and green gram contain plenty of ascorbic acid.

Anti-nutritional Factors: Legumes contain some compounds that have a negative food value. These include protease inhibitors, hemagglutinins, saponins, cyanogenic glucosides, lathyrogens, phytate, raffinose and tannins. Most of these anti-nutritional factors can be neutralized by soaking in water before cooking the pulses. Peanuts, because of their high moisture content at harvest, may support mold growth and development of toxic metabolites of molds such as aflatoxins. Heat processing and cooking can help reduce aflatoxin levels to some extent.

2.4.2 Processing Pulses

In India most of the pulses are consumed in dehusked and split form. Thus processing of pulses assumes a lot of importance. Pulses processing industry helps in processing the raw grain legumes/ pulses into edible form. Processing activity is undertaken at 3 different levels namely primary, secondary and tertiary. Primary processing involves cleaning, grading and packaging of pulses. Under secondary processing activities such as dehusking, splitting, polishing, tumeric/ spices/ salt coating and powdering and packaging are done. After dehusking and splitting pulses becomes Dals. Tertiary processing mostly involves activities such as preparation of roasted, fried dals for snack foods and confectionary. Primarily, Dals are consumed after cooking however they are utilized for making other value added products such as papads, baris and besan (fine flour) which is used for making sweets, snacks, and mixed with wheat flour to make chapattis (flat bread), Dals are widely used in south Indian foods such as Dosa , vada and idli. Savoury products such as Aloo Bhujia, Bikaneri Sev, Moong Dal, are prepared from dals.

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) Classify the legumes on the basis of type of stored energy.

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2) What are the limitations in use of soybean as a food legume?

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3) Describe different types of carbohydrates found in pulses.

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4) Name anti-nutritional factors present in pulses.

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5) Name two essential amino acids lacking in legumes.

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2.5 OILSEEDS: CHARACTERISTICS

The crops cultivated for production of oils are known as oilseed crops. Oilseeds rank next to the food grains in importance in the Indian diet. According to the nature of the yielded oil, these are classified as edible oilseeds and non-edible oilseeds. The rapeseed, mustard, sesame, sunflower, niger, safflower, coconut, soybean and groundnut are the most important edible oilseeds crops grown in India. Castor and linseed are two most important non-edible oil crops. Fats and oils are important energy source for animals and plants, and accounts for $2^1/_4$ times the calories found in an equal dry weight of protein or carbohydrate. They are smooth, greasy substances that are insoluble in water.

Fats have other substances associated with it, such as fat-soluble vitamins A, D, E and K in natural foods; the sterols, cholesterol in animal fats and ergosterol in vegetable fats. A typical fat molecule consists of glycerol combined with three fatty acids. There are about 20 different common fatty acids that are connected to glycerol in natural fats. These fatty acids differ in length and in number of hydrogen atoms they contain. The chemical variations in fats lead to different functional, nutritional and keeping-quality properties.

The difference in melting point arises because of this variation. The longer the fatty acids chain, the harder the fats, and shorter the chain, softer the fats.

Vegetable oils are fats of plant origin and remain in liquid form at room temperature, whereas fats of animal origin remain solid at that temperature level. There are some exceptions, however. For instance, coconut oil is solid at room temperatures in colder months because it has a melting point of 24-27^{o}C. On the other hand, fish fats or oils are liquids at room temperature. Generally, the reason that some fats are solids and others are liquids at room temperature has to do with the percentage of saturated or unsaturated fatty acids in the fat.

Unsaturated fatty acids with four or more carbon atoms that can accept hydrogen are more reactive than saturated fatty acids and are especially capable of combining with oxygen present in the atmosphere. This is the case when a carbon saturated with hydrogen is present between two carbons, each of which could accept hydrogen or free electron -CH=CH-CH_2-CH=CH-. When the unsaturated fatty acids in fats become oxidized, the fat generally becomes rancid or has an off-flavour. Oils, therefore, should be stored at ambient temperature in sealed, preferably dark-coloured containers to prevent oxidation. Re-used oils need to be strained to remove impurities that could lead to oxidation and associated rancidity. Oils that have been used frequently for deep frying should be discarded. Vegetable oils are often a rich source of unsaturated fatty acids, although some saturates are also present. Vegetable oils usually contain natural antioxidants such as vitamin E, which helps the oils resist rancidity (which occurs when oxidation takes place). Sometimes a blend of oils is used in a product to take advantage of the desirable characteristics of the different types of oils.

Some important properties of fats are:

1) All fats and oils have unique flavours and odours. Some are more suited for particular purposes than others, *e.g.* olive oil for salad dressing (for flavour) and mustard oil for frying.

2) Fat has shortening power; that is, it interlaces between protein and starch structures and makes them tear apart easily, and allows them to stretch long. In this way, fat tenderizes meat as well as baked goods.

3) Fat is a lubricant in foods; that it makes swallowing of carbohydrates easier while eating.

4) Fats gradually soften on heating, that is they do not have a sharp melting point. This property is called plasticity, and gives each fat its unique character. Some fats have been formulated so that their melting points are low and they can be spread straight from the fridge, *e.g.* soft margarine, ‘spreadable butter’.

5) Fats can be heated substantially above the boiling point of water, so they can brown the surfaces of foods.

6) Fats form emulsions with water and air. Fat globules may be suspended in a large amount of water as in milk or cream, or droplets of water may be suspended in a large amount of fat as in butter. Air may be trapped as an emulsion in fat as in butter, cream, icing or in whipped butter.

7) Fats and oils are used in confectioneries and cakes to give these products opacity, flavor and desirable texture. Addition of fat to sugar confectionery also helps to prolong eating quality.

8) Some vegetable oils are richer in fatty acids that are extremely good for health e.g. omega-6 fatty acids (*e.g.* sunflower and corn oils) and omega-3 fatty acids (*e.g.* rapeseed oil and soya oil). Other oils are rich in monounsaturated fatty acids (*e.g.* olive oil, rape seed oil, groundnut oil).

2.5.1 Processing of Oilseeds

Processing of oilseeds may vary with raw material however some general steps are common to all. The first step involves, preparation of the raw material; removal of fine impurities, husks or seed coats from the seeds and separating the seeds from the chaff. The seeds are then cracked to expose the "meats" of the raw material. Oil is then extracted mechanically with an oil press, an expeller. Presses range from small, hand-driven models that an individual can build to power-driven commercial presses. Expellers have a rotating screw inside a horizontal cylinder that is capped at one end. The screw forces the seeds or nuts through the cylinder, gradually increasing the pressure. The material is heated by friction and/or electric heaters. The oil escapes from the cylinder through small holes or slots, and the press cake emerges from the end of the cylinder. Oils can also be extracted with solvents, but solvent extraction is a complex operation and not suitable for small scale processor. After extraction oils are clarified to remove contaminants, such as fine pulp, water, and resins. Sealed glass or plastic bottles are adequate. Colored containers in a dark box help to increase shelf life. Seed cake is a valuable by-product of pressing and makes a good chicken, pig, or cattle feed. Oil finds wide uses as food, skin care products, aromatherapies, biodiesel fuels, and industrial lubricants.

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) Name two edible and two non-edible oilseeds crops.

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2) Name two vegetable oils rich in omega-6 fatty acids.

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3) Name two vegetable oils rich in monounsaturated fatty acids.

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4) Differentiate between animal and vegetable fats.

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5) What is rancidity? How can it be overcome?

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6) What is shortening?

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2.6 HORTICULTURAL CROPS: STRUCTURE AND COMPOSITION

A range of crops including fruits, vegetables, flowers, ornamental plants, plantation crops is grouped as **Horticultural crops**. These crops play an important role in the national economy and are important drivers of growth. The total annual production of horticultural crops in the country is around 149 million tonnes. Fruits and vegetables are the principal horticultural crops. The two together provide the base for nutritional and healthy foods, but also generate a considerable cash income for growers. India is the second largest producer of fruits (45.5 million tonnes) and vegetables (90.8 million tonnes), accounting for 10.23 per cent and 14.45 per cent respectively of the world production.

Plantation crops are perennial crops, planted on large-scale or in estates. Its objective is meant for large-scale production of a single cash crop. This often involves large landowners, raising crops of high value and great economic importance. These crops usually require a sequence of post harvest processing before they can be utilized. Tea, coffee, rubber, coconut, arecanut, cashewnut, black pepper, and cardamom are some of the important plantation crops. India is the largest producer of areca nut, cashew nut and tea and second largest producer of coconut and cardamom in world.

Fruits and Vegetables

Botanically, fruits are the mature ovaries containing the seeds of the plants whereas vegetables are derived from various plant parts such as root, leaves, stems, buds and so on. Fruits and vegetables make up a significant part of the diets of most cultures. Fruits include soft fruits (raspberry, blackberry, redcurrant, strawberry and bilberry), citrus fruits (orange, lime, lemon, kumquat and grapefruit), stone fruits, (plum, apricot, peach, lychee, cherry and mango), fleshy fruits (apple, papaya, pineapple, pear and banana) and vine fruits (grape, water melon and cantaloupe). Vegetables include root vegetables (carrots, sweet potatoes), leaf vegetables (such as spinach and lettuce), stem vegetables (such as bamboo shoots and asparagus), and inflorescence vegetables (such as globe artichokes and broccoli). Some fruits, such as tomato, pumpkin and eggplant, are also eaten as vegetables. Many herbs and spices have proved to be highly-flavored vegetables.

An important distinction between fruits and vegetables is based on their usage: those plant items that are generally eaten with the main course of meal are often considered to be vegetables; those commonly eaten alone as a dessert are considered as fruits. Fruits are generally acidic and sugary whereas vegetables are low in acids and sugar.

Vegetables are rich in vitamin A, ascorbic acid, protein (legumes) and fiber. Carrots, sweet potatoes, green leafy vegetables and tomato are best sources of Vitamin A. Among vegetables, Hot chili peppers, turnip greens and spinach are also good sources. Sweet peppers, hot chilies, broccoli, brussel sprouts and cauliflower and bittergourd are prominent sources of vitamin C. Vitamin B is found in green peas, lima beans, turnip greens, spinach and sweet potato. Potato is an important source of potassium for people in many countries. Lima beans, soybeans and spinach are good sources of iron. Calcium is present in moderate amounts in turnip greens, soybeans, garlic, parsley and chinese cabbage. Fruits and vegetables are equally good sources of dietary fiber. We already have seen the importance of dietary fiber in previous Unit. Scientific studies have consistently shown that consumption of diets rich in dietary fiber can help reduce the risk of cardiovascular diseases, diverticulosis and colon cancer. A more obvious effect of dietary fiber is their laxative action, which helps relieving of constipation by increasing the water-holding capacity of foods.

2.6.1 Post Harvest Technology

Fruits and vegetables are different from cereals, pulses and oilseeds. Generally they cannot be stored for longer periods and should be used as soon as possible. If stored, they should be kept in a cool, dark place to prevent sprouting, mould growth and rotting. Since they are tender and high in moisture content they are highly perishable. If not handled properly, a high value nutritious product can deteriorate and rot in a matter of days or even hours. Some fruits such as coconut and citrus (with a protective rind) can be handled and shipped reasonably well. Post harvest losses can occur in the field, in packing areas, in storage, during transportation, and in wholesale or retail markets. Therefore, a series of sophisticated technologies have to be applied in post harvest handling of horticultural crops. Fruits and vegetables breathe like humans do, respiring day and night, continuously giving off water as they release energy for growth and metabolism. In respiration, plants use oxygen to break down carbohydrates, proteins, and fats into carbon-dioxide and water. Respiration leads to drying out, wilting and shriveling, less food value and less sweetness. This leads to loss of quality and freshness. Mechanical injuries such as abrasion, puncture and bruising lead to more water loss. Also wounded and punctured areas are more prone to be attacked by bacteria and fungi. Apart from these, there are other factors that lead to loss in quality. These include inefficient crop production, harvesting and handling methods, poor crop processing techniques, inadequate methods of storage and transportation and even poor preparation procedures. Traditional marketing systems often contribute to reduced returns to farmers, by involving several changes of hands. Modern post harvest technologies applied in grading, packaging, pre-cooling, storage, and transportation, minimize losses, and preserve quality.

Another useful approach to minimize post harvest loss of horticultural commodities is to add value to products. Value addition involves change of form of a product, converting raw material into ingredients or processed

products to cater to demands of heterogenous consumers. Value addition offers numerous advantages to the growers and consumers. Value added products have extended shelf life, improved quality, and palatability. Farmers can derive high farm income from their produce by adding value to their products by way of cleaning, trimming, processing, and packaging. Post-harvest value addition includes primary, secondary, and tertiary processing, operations performed on farm produce. Primary processing refers to on-farm handling, cleaning, trimming, sorting, grading, cooling and packaging whereas secondary processing includes processes which modify the form of the product i.e. convert raw product to a processed products. Processed products offer cent percent edible product, are convenient, and have improved eating quality. Jams, jellies, marmalades, sauces, ketchups, cordials, juices, nectars, pickles, candies, preserves, canned, frozen, dried, and fermented products are examples of secondary processed products.

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) Name some important plantation crops?

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2) Analyze the main causes of post harvest losses in fruits and vegetables.

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3) What are important post harvest technologies used to minimize loss of fruits and vegetables?

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4) What does secondary processing of fruits and vegetables refers to?

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2.7 LET US SUM UP

Cereal grains, pulses, oilseeds and horticultural crops are important foods from plant sources. Together cereal grains, pulses, oilseeds and horticultural crops provide us much needed carbohydrates, proteins, fats and vitamins and minerals for human nutrition. Pulses are 2-3 times richer in protein than cereals. A combination of cereals and pulses also complements the diet in respect of amino-acids lacking in respective diets. Cereals grains are compact and dry and can be easily handled transported and stored or long periods in comparison to horticultural crops. The shelf life of horticultural crops is limited because of their moisture content and respiration activities. Secondary processing adds value to cereals and transforms grain to edible products such as breakfast cereals, puffed, flaked, fried and extruded products. Horticultural crops require a range of modern post harvest technologies applied in grading, packaging, precooling, packaging, storage and transportation to minimize losses and preserve quality.

2.8 KEY WORDS

Food : Food is any substance, primarily composed of carbohydrates, fats, water and/or proteins, that can be eaten or drunk by an animal or human being for nutrition or pleasure.

Caryopsis : The cereal grain is one seeded indehiscent fruit called caryopsis. In this the pericarp is completely fused with the seed coat.

Hulling : The process of removing an unpalatable husk or shell around the cereal grain.

Anti-nutritional Factor: Some compounds found in pulses that reduce their biological value.

Milling : The conversion of grain into flour.

Parboiling : A primary treatment given to rice to improve its keeping quality and nutritional value. Parboiling involves soaking and heating the rice which pre-cooks the grains, loosens the hull, sterilizes and preserves the rice.

Gluten : A protein found in wheat.

Puffing : The process of making a puffed ready-to-eat product from rice.

Flaked Rice : A popular breakfast cereal known as '*poha*' from rice. The process involves rolling the conditioned rice to fracture the outer cells.

Plasticity : A unique property of oils, wherein oils gradually soften on heating, because they do not have a sharp melting point.

2.9 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

Your answer should include following points:

1) Food is any substance, primarily composed of carbohydrates, fats, water and/ or proteins, that can be eaten or drunk by an animal or human being for nutrition or pleasure.

2) Cereals grains are grown in greater quantities and provide more energy worldwide than any other type of crop; they are, therefore, also known as 'staple foods'

3) Crops sown in rainy or summer seasons (April-July) and harvested in winters (October) are kharif crops e.g. rice. Rabi crops are those which are sown in winters (October to February) and harvested in summers are rabi e.g. wheat

4) Whole grains are grains comprising of the entire kernel- the bran, germ and endosperm whereas refined grains donot comprise of the entire grains. During milling, bran and germ are removed. Whole grains are more nutritious than refined grains because minerals largely present in the outer bran are retained.

5) Minerals are lost when the outer covering of a food grain is removed

6) Cereals are not hard to digest because they are rich in carbohydrate starch. Starch is more easily digested than either protein or fat. Furthermore, cooking and processing makes the starch more digestible and acceptable.

7) Lysine is lacking in cereals.

8) Primary processing of cereals is a term given to set of operations involving cleaning, grading, hulling, milling, pounding, grinding, parboiling, soaking and drying. The products from primary processing are not consumable. Secondary processing is advanced processing and transforms grains into edible products. It includes operations like fermentation, baking, puffing, flaking and frying.

Check Your Progress Exercise 2

Your answer should include following points:

1) The food legumes are classified in two categories: the legumes in which energy is stored as starch (e.g. pulses) and which energy is stored as fat or oil (e.g. peanut and soybean).

2) Soybean contains anti-nutritional factors such as trypsin inhibitors which are not destroyed on ordinary cooking. Also there are unacceptable factors such as taste, odor and flatuence factor, which further limits its acceptance.

3) The major carbohydrates found in legumes are starch, raffinose, cellulose and hemicellulose.

4) Pulses contain protease inhibitors, hemagglutinins, saponins, cyanogenic glucosides, lathyrogens, phytate, raffinose, tannins and aflatoxin.

5) Methionine and tryptophan are essential amino acids lacking in legumes

Check Your Progress Exercise 3

Your answer should include following points:

1) The rapeseed, mustard, sesame, sunflower, niger, safflower, coconut, soybean and groundnut are the most important edible oilseeds crops of India whereas castor and linseed are two most important non-edible oil crops.

2) Sunflower and corn oils are rich in omega 6 fatty acids

3) Olive oil and groundnut oil are rich in monounsaturated fatty acids

4) Vegetable oils are mainly of plant origin and are liquid at room temperature whereas fats are mainly of animal origin and are usually solids. Vegetable oils have more unsaturated fatty acids whereas animal fats have more saturated fatty acids.

5) When the unsaturated fatty acids in fats oils become oxidized, the fat undergoes rancid and has an off-flavour. Fats and Oils, therefore, should be stored at ambient temperature in sealed, preferably dark-colored containers to prevent rancidity.

6) Fats interfaces between protein and starch structures and makes them tear apart easily and short rather than allow them to stretch long. In this way, fat tenderizes meat as well as baked goods. This is property of fat is known as shortening.

Check Your Progress Exercise 4

Your answer should include following points:

1) Plantation crops are perennial crops, planted on large-scale or estate, meant for large-scale production of a single cash crop. Most of these involve a large landowner, raising crops with high value and great economic importance rather than for subsistence. These crops usually require a sequence of post harvest processing before they can be utilized. Tea, coffee, rubber, coconut, areca nut, cashew nut, black pepper, and cardamom are some of the important plantation crops.

2) The main causes of post harvest losses in fruits and vegetables include inefficient crop production, harvesting and handling methods, poor crop processing techniques, inadequate methods of storage and transportation and even poor food preparation procedures.

3) Modern post harvest technologies applied in grading, packaging, pre-cooling, storage, and transportation, which minimize losses, preserve quality.

4) Secondary processing refers to value added products such as Jams, jellies, sauces, ketchups, cordials, juices, nectars, pickles, canned, frozen, dried baked and fermented products.

2.10 SOME USEFUL BOOKS

Ron Wills, Barry Mc Glasson, Doug Graham, Daryl Joyce. (1998) *Introduction to the Physiology and Handling of Fruits, Vegetables and Ornamentals*. 4th Edition, CAB International Wallington Oxon. U.K.

Norman N. Potter and Joseph H Hotchkiss (1997) *Food Science*. 5th Edition, Chapman & Hall Publishing Inc, New York, USA.

John T.R Nickerson and Louis J. Rensivalli (1995) *Elementary Food Science.* AVI Publishing Company, Westport, Connecticut, USA

Peter Golob, Graham Farrell and John E Orchard (2002) *Crop Post Harvest: Science and Technology*. Blackwell Publishing, U.K.