17. PULSES

Pulses are the edible fruits or seeds of pod-bearing plants belonging to the family of *Leguminosae* and are widely grown throughout the world. They have a high protein content ranging from 20-40 per cent and this makes them important in human food from the point of view of nutrition. There is widespread protein-calorie malnutrition in developing countries and pulses can play an important role in bridging the protein gap. India depends greatly on pulses to meet its demand for proteins. Because of religious sentiments, meat is not used by a good section of the people and also there is not enough meat even for those who use it. Pulses are the "poor man's meat". The per capita availability of pulses has declined from 64g per day (1951-56) to less than 40g per day as against the FAO/WHO's recommendation of 80g of protein per day. If we take into account the total protein nutrition derived from other protein sources such as food grains, milk and milk products, fish, etc., then 55g per capita/day requirement of pulses may be the realistic target.

An alternate name for pulses is "legumes", which is common in many parts of the world. In India, the term "gram" is commonly used for dry legume seeds with husk, while split decorticated grains are called "dhal".

17.1 Pulse Crop

There are over 13,000 species of plants belonging to the family of *Leguminosae* and some are cultivated as crop plants whose seeds are edible. Over the years, wild varieties of legumes have been domesticated. In this process, ancient Indian and Chinese civilizations seem to have played an important part in the domestication of Bengal gram (*Cicer arietinum*) and soyabean (*Glycine max*), respectively. Some pulses are also used as cattle feed and as green manure.

The world production of pulses in 1997-98 was 56.9 million tonnes. India is the second largest producer of pulses in the world, coming next only to China, with a production of 14.2 million tonnes cultivated in an area of 24.4 million hectares with an average yield of 6.02 quintals per hectare. The total area under pulses has remained virtually stagnant (22-24 million hectares) as also the production (12-14 million tonnes) over the last four decades. It is of interest to note the yield of pulses recorded in countries like China (15.79), Yemen (12.40) and Egypt (30.22) in quintals per hectares. There has to be a marked increase in the production of pulses in India either by increased area of cultivation or by a technological breakthrough resulting in increased yields per hectare, to meet the anticipated requirement of 20 million tonnes by 2000 AD.

The most important pulse crop in India is groundnut or peanut (*Arachis hypogaea*) which can be put to a wide range of uses. With its high oil content, groundnut goes to a great part into oil production and it is considered in Chap. 18 under oils and fats.

Leaving aside groundnut, of the legumes which are used just as pulse, the most important pulse crop in India is Bengal gram or Chana, which is grown in an area of nearly two-fifth of that under pulse cultivation and accounts for about 50 per cent of the total production of pulses. Next in importance is red gram (*Cajanus cajan*) accounting for about 11 per cent of the pulses. Some of the major pulses produced in India and their percentage of total production of pulses is given in Table 17.1.

Table 17.1 Major pulse crops of India

Common name	Botanical name	Percentage of total production
1 Bengal gram or chick-pea (chana)	*Cicer arietinum*	51
2 Red gram or tur (arhar or pigeon pea)	*Cajanus cajan*	11.2
3 Black gram or urad	*Phaseolus mungo* Roxb.	3.9
4 Greengram or mung	*Phaseolus aureus* Roxb.	2.5
5 Moth or tepary bean	*Phaseolus aconitifolius*	2.6
6 Lentil or masur	*Lens esculenta*	2.9
7 Horsegram or kulthi	*Dolichos biflorus*	3.0
8 Peas	*Pisum sativum*	9.8
9 Khesari dhal	*Lathyrus sativus*	7.6
10 Others	—	5.5

Source: Kachroo, P., *Pulse Crops of India*, Indian Council of Agriculture Research, New Delhi 1970.

Among the others in the table, some important ones are: cow pea (*Vigna unguiculata*), cluster bean or guar (*Cyarnopis tetragonolaba*), Indian bean or field bean (*Dolichos lablab*), French bean or kidney bean (*Phaseolus vulgaris*) and soyabean (*Glycine max*).

17.2 Composition

The chemical composition of edible pulse seeds depends upon the species. In general, their protein content is high and is commonly more than twice marked increase in the production of pulses in India either by increased area of cultivation or by a technological breakthrough resulting in increased yields per hectare, to meet the anticipated requirement of 20 million tonnes by 2000 AD.

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17.2 Composition

The chemical composition of edible pulse seeds depends upon the species. In general, their protein content is high and is commonly more than twice that of cereal grains, usually constituting about 20 per cent of the dry weight of seeds. The protein content of some legumes like soyabean is as high as 40 per cent. The nutritional value of legumes is not just confined to their usefulness as a source of vegetable protein. They are rich in carbohydrate and some species like groundnut and soyabean are rich in oil. Pulse seeds are also sources of other nutritionally important materials, such as vitamins and minerals. However, their importance lies in their actual and potential value as a source of plant protein in human nutrition. The chemical composition of some legumes of common usage in India is given in Table 17.2.

In addition to nutritional factors, pulses contain several heat-stable and heat-labile antinutritional and/or toxic factors. These include enzyme inhibitors, toxic substances, factors inciting clinical disorders, factors which interfere with digestion and flatulence-causing substances. These factors are to be reduced or eliminated to make pulse seeds more acceptable as a source of inexpensive nutritional proteins and maximize their utilization as human food.

17.2.1 Pulse Proteins Pulse proteins are chiefly globulins but albumins are also present in a few species. Their nutritional importance depends not only on the quantity of protein but also on its quality which in turn depends upon the amino acid composition. Pulse proteins are deficient in sulphur-containing amino acids, particularly in methionine, and in tryptophan. It is only in the case of soyabean that the tryptophan level is equal to the FAO provisional pattern. All the pulses contain sufficient amounts of leucine and phenylalanine. Lysine and threonine contents are low only in groundnuts. Overall, the most satisfying pulse protein from the standpoint of the FAO provisional pattern is that of soyabean.

There are a number of factors which reduce the nutritional value of pulse proteins. A majority of pulse proteins have high molecular weights and are very compact molecules, and this reduces the digestibility of the native protein. Some proteins are found complexed with carbohydrates and the carbohydrate moiety has a negative influence on the digestibility of native protein. Proteins also form complexes with phytin and polyphenols present in pulses contributing to their low digestibility.

17.2.2 Carbohydrates Food pulses contain about 55–60 per cent of total carbohydrates including starch, soluble sugars, fibre and unavailable carbohydrates. Starch accounts for the major proportion of carbohydrates in legumes. The unavailable sugars in pulses include substantial levels of oligosaccharides of the raffinose family of sugars (raffinose, stachyose and verbiscose), which are notoriously known for the flatulence production in man and animals. These sugars escape digestion, when they are ingested, due to the lack of α-galactosidase activity in the mammalian mucosa. Consequently, the oligosaccharides are not absorbed into the blood and are digested by the microflora of the lower intestinal tract resulting in the production of large amounts of carbon dioxide and hydrogen and a small amount of methane. Some of the methods used in processing pulses, such as germination, soaking, cooking and autoclaving, reduce considerable amounts of oligosaccharides. Fermentation also reduces oligosaccharides as has been observed during the fermentation of black gram and rice.

17.2.3 Lipids Lipids form about 1.5 per cent of the dry matter in pulses except in groundnut, soyabean and winged beans. Most of the pulse lipids contain high amounts of polyunsaturated acids. These undergo oxidative rancidity during storage resulting in a number of undesirable changes, such as loss of protein solubility, off-flavour development, and loss of nutritive quality.

17.2.4 Minerals Pulses are important sources of calcium, magnesium, zinc, iron, potassium and phosphorus. A major portion (80 per cent) of phosphorus in many pulses is present as phytate phosphorus. Phytin complexes with proteins and minerals and renders them biologically unavailable to human beings and animals. Processing methods, such as cooking, soaking, germination, fermentation, etc., can reduce or eliminate appreciable amounts of phytin.

17.2.5 Vitamins Pulses contain small amounts of carotene, the provitamin A. Many pulses contain 50 to 300 international units of vitamin A per 100 g. Fresh pulses like peas may have a vitamin A activity considerably in excess of this figure.

The thiamine content of pulses is approximately equal to, or exceeds that of, whole cereals, the average value of the vitamin being 0.4 to 0.5 mg per 100 g of pulses. Pulses are also fairly rich in niacin (about 2.0 mg/100 g). They are poor in riboflavin and dry legumes are almost devoid of ascorbic acid.

17.3 Processing

Processing of pluses is of primary importance in improving their nutritive value. The processing methods used are soaking, germination, decortication, cooking and fermentation.

17.3.1 Soaking Soaking in water is the first step in most methods of preparing pulses for consumption. As indicated above, soaking reduces the oligosaccharides of the raffinose family. Soaking also reduces the amount of phytic acid in pulses.

17.3.2 Germination Germination improves the nutritive value of food pulses. The ascorbic acid content of pulses increases manifold after 48 hours germination. Germinated and sprouted pulses have been used to prevent and cure scurvy since the 18th century. The riboflavin, niacin, choline and biotin contents of all pulses increase during germination. The folic acid content, however, greatly decreases and the pantothenic acid value remains practically unaltered. Germination also brings about changes in the carbohydrates of the pulses, some of the starch being converted into sugars. The sprouts may be used either as a salad or a vegetable. The germination process reduces and/or eliminates most of the antinutritional and toxic factors in several pulses. Also, preparations obtained from sprouted pulses, such as those of horse gram, green gram and Bengal gram, by methods similar to those used in cooking dry seeds, are more delicious.

17.3.3 Decortication Dry pulse seeds have a fibrous seed coat (husk or skin) which often is indigestible and may have a bitter taste. In such cases the skin has to be removed. The germ is usually removed during dehusking, and this may result in some loss of thiamine. Husked and split pulses are commonly used in India as dhals. Dhals may not be nutritionally as good as the whole seed, but its keeping qualities, cooking time and digestibility will be better.

A number of methods are available for decortication. A simple method is to soak the seeds for a short time in water; the husk takes up more water than the seeds and may be easily separated by rubbing while still moist. In the alternative, the soaked grains may be dried and the husk removed by pounding and winnowing. Roasting also renders the husk easier to separate. Roasted legumes like those of Bengal gram and peas are widely used in India.

17.3.4 Cooking Cooking destroys the enzyme inhibitors and thus improves the nutritional quality of food pulses. Cooking also improves the palatability. However, pulses should not be overcooked as this reduces the quality of proteins. Longer cooking causes a drop in the nutritive value of pulses as it results in the loss of lysine. Prolonged heating also results in loss of vitamins and consequent loss of nutritional value.

17.3.5 Fermentation The processing of food pulses by fermentation increases their digestibility, palatability and nutritive value. Soyabean is a very valuable pulse whose proteins approach the quality of animal protein. However, it cannot be directly used as food because of the toxic substances present in the pulse. The toxic substances can be eliminated by fermentation. In South-East Asia various fermented products of soyabean (see Sect. 17.8) are produced and consumed on a large scale. It appears to be possible to prepare products from Bengal gram similar to those of fermented soyabean products. The preparation of idli from a blend of fermented black gram and rice has been described in Chap. 16. This fermentation process improves the availability of essential amino acids and, thus, the nutritional quality of protein of the blend. In general, the nutritive value of the legume-based fermented foods has been shown to be higher than their raw counterparts.

17.3.6 Pulse Protein Concentrates Separation of digestible protein from the indigestible portion of pulses is of great nutritional and economic importance. Such protein extracts have been made from soyabean (Subsection 17.8.1) and groundnut cake (Subsection 19.7.1). Such concentrates are free from antinutritional factors and provide nutritionally valuable proteins. Efforts to obtain such protein concentrates and isolates with low or no antinutritional factors will help solve the protein malnutrition problem of developing countries.

17.4 Utilization of Pulses

The fruits and seeds of pulses can be utilized in a variety of ways and the nutritional value may be influenced markedly by the way in which they are used. Their use after they are subjected to some types of processing has been described above and the ways in which the unprocessed pulses are used are the following.

17.4.1 Mature Seeds A great bulk of pulse seeds are consumed in this form. It is convenient to use them this way as it is most economical to store the harvested crop as dry seeds (except the oil-containing legumes) without loss of nutritive value, provided the moisture content of the grains is low and the storage pests are avoided. There are, however, certain pulses, like the moth bean which become very hard on storage and require prolonged soaking and cooking before they are reduced to an acceptable condition for eating. The great majority of the pulses can be used as such after storage by soaking the dried seed followed by cooking in water.

17.4.2 Fresh Seeds Pulses which can be used as dry seeds can also be used as mature or immature fresh seeds. If the pods are tough and fibrous, the seed is separated and cooked in much the same way as dry seeds. Some of them are preferred to be cooked as fresh seeds as the products obtained have better taste and flavour than those of dry seeds.

17.4.3 Immature Pods Pulses which produce pods that remain fleshy for two or three weeks before the fibre becomes hard can be used as green vegetables. This is the common way in which some beans (e.g., *Phaseolus vulgaris*) are used. The nutritional values of immature fruits are different from those of mature seeds; their protein contents are lower but they are relatively rich in vitamins and soluble carbohydrates.

17.5 Toxic Constituents of Pulses

The seeds of pulses include both edible and inedible types. Even amongst the edible legumes toxic principles occur and their elimination is important in order to exploit them for edible purposes. Two thermolabile factors are implicated in toxic effects. The first includes inhibitors of the enzymes trypsin, chymotrypsin and α-amylase and the second includes haemagglutinins, which impede the absorption of the products of digestion in the gut. In addition, legumes also contain a goitrogen, a toxic saponin, cyanogenic glycosides and alkaloids.

The inhibitor of trypsin is a protein found in a number of pulses. The inhibitor suppresses the release of amino acids and thus does not make for the normal growth of animals fed with such pulses. The trypsin inhibitor may stimulate the production of extra trypsin by pancreas and ultimately bring about its loss of activity. Haemagglutinins are also proteins and they combine with products of digestion and thus impair the efficiency of absorption of the digested products. Cyanogenic glycosides cause cyanide poisoning. On hydrolysis of the glycoside by the enzyme, ß-glucosidase, hydrogen cyanide is liberated. However, a cyanide content in the range of 10–20 mg per 100 g of pulse is considered safe. Many legumes except lima bean (*Phaseolus lunatus*) contain cyanide within this limit.

Saponins are a group of natural products possessing the property of producing lather or foam when shaken with water. These are glycosides of high molecular weight. Saponins have been reported in soyabean, sword bean (*Canavalia gladiata*) and jack bean (*Canavalia ensiformis*). Toxic saponins cause nausea and vomiting. These toxins can be eliminated by soaking prior to cooking. Alkaloids are known to occur in the seeds of many legumes but they are relatively innocuous.

Some compounds found in pulse seeds appear to fix iodine inducing a state of iodine deficiency in the thyroid, eventually producing goitre. It is also possible that goitre is the result of blockade of iodine uptake by the thyroid in the presence of such compounds.

Two toxic substances in legumes produce serious pathological conditions. They are the factors in khesari dhal which causes lathyrism and the haemolytic factor in *Vicia faba* associated with the disease favism.

17.5.1 Lathyrism Lathyrism is a paralytic disease affecting the lower limbs. The incidence of the disease is higher in males than females and recovery from the condition does not usually occur. The disease has been known since early times and there is reference to it in early Indian medical writings.

Serious outbreaks of lathyrism have occurred in this country quite a few times. The disease has been associated with consumption of khesari dhal and is commonly noticed in poor families who continuously eat considerable quantities of the dhal. Even when other crops fail, this legume thrives and thus in times of scarcity the poor people are forced to eat this dhal. However, lathyrism develops only when the consumption of dhal is high (300 g daily) and the diet does not contain adequate quantities of cereals and is used for a long time (6 months or more).

In lathyrism, the toxic substance interferes with the formation of normal collagen fibres in the connective tissue. The disease can be prevented by ensuring a reasonable balance between khesari dhal and other food materials and its replacement by other pulses where practicable.

17.5.2 Favism Favism is haemolytic anaemia. The disease is almost entirely confined to persons living in the Mediterranean basin or of Mediterranean origin. In severe cases of favism, death may occur within 24–48 hours of the onset of the attack. Children are more liable to succumb than adults. If the victim survives the acute stage, recovery usually takes about four weeks.

Favism is brought about by eating broad beans or by inhaling the pollen of the flower. The victim suffers from an inherited biochemical abnormality which affects the metabolism of glutathione in red blood cells and is the result of decreased activity of the enzyme glucose-6-phosphate dehydrogenase. In persons with this abnormality the red cells are more prone to injury and destruction by certain drugs, such as sulphonamide, and this raises complications in the treatment of infectious diseases.

17.5.3 Elimination of Toxic Factors It has already been indicated that soaking, heating and fermentation can reduce or eliminate most of the toxic factors of the pulses. Correct application of heat in cooking pulses can eliminate most toxic factors without impairment of nutritional value. Cooking also contributes towards pulse digestibility. Heat causes the denaturation of the proteins responsible for trypsin inhibition, haemagglutination and the enzyme responsible for the hydrolysis of cyanogenic glycosides. The mode of application of heat is important. Autoclaving and soaking followed by heating are effective. Another way of eliminating toxic factors is by fermentation, which yields products more digestible and of higher nutritive value than the raw pulses.

17.6 Pulses in Human Nutrition

Protein malnutrition is common in the third world countries. Pulse protein can serve a useful purpose in alleviating this situation. The animal proteins which are nutritionally the best are available only in small quantities in poor countries and there are limitations to their supply at the present levels even in rich countries. The average daily per capita consumption of animal protein in India is 6 g which is less than one-tenth of what it is in developed countries. Therefore, vegetable proteins, and in particular pulse proteins, have an important place in meeting the protein requirements of the world.

Though compared to animal protein, pulse foods have low nutritional value, it is possible to make pulses more acceptable as a source of inexpensive nutritious protein and maximize their utilization as human food. By the processing and blending of proteins from different sources, it should be possible to produce high quality protein from plant sources with an amino acid profile as close as possible to that of good animal proteins. Such a formula can be prepared from a suitable combination of pulses, rice and oil seeds. Necessary technology has to be developed to harness the tremendous potential of pulses in human nutrition.

17.7 Some Important Pulses

Pulses form an important item of diet all over India, being a good source of protein especially in the vegetarian diet. The nutritional quality of a diet mainly based on cereal improves with a proper intake of pulses. The nutritional status of a pulse depends upon the protein content, its biological value, digestibility, essential amino acid composition, and the vitamin and mineral content. Based on these qualities, Bengal gram and black gram have been assigned a higher order of nutritive merit; green gram, lentil and soyabean being the next best. Then follow red gram and horse gram; the rest being comparatively inferior, mainly being low in their biological value rather than their protein content.

17.7.1 Bengal Gram *(Cicer arietinum)* Other names of this pulse are gram, chana and chickpea. This is the most important pulse crop of India, ranking fourth among the grain crops in area and production. In 1981, it was cultivated in an area of 6.7 million hectares with a production of 4.6 million tonnes. The yield per unit area is 8.32 quintals per hectare and this has remained constant for over 30 years. There is a need to increase the production of this pulse and other pulses by developing appropriate agricultural technology. The crop is also grown in the Mediterranean region and a few other countries.

The Bengal gram seeds vary in size and are beaked, round, semi-round, wrinkled or semi-wrinkled in shape. The seed-coat is either brown, light brown, yellow, orange, black, white or green. The cotyledons are yellow or pale yellow.

The immature grain is eaten raw or boiled as a vegetable, spiced and cooked. When ripe, the grain is consumed in the form of whole grain, dhal and basin (gram flour). The whole grain is also consumed after cooking and mixing with salt or sugar or spices. Gram flour is used as one of the chief ingredients, along with ghee and sugar, in the preparation of many forms of Indian confectionery, such as Mysore-pak. Savory items like bajias are also made out of it.

In Gujarat, *Khaman* a fermented product prepared from coarsely ground Bengal gram dhal and salt, and cooked like dhokla, is very popular.

The proteins of the gram are deficient in tryptophan and sulphur-containing amino acids. The proteins are more digestible and better assimilated than those in other pulses. On the whole, Bengal gram protein is the best pulse protein owing to its high net-protein-utilization value.

17.7.2 Red Gram *(Cajanus cajan)* Red gram is also known as pigeon pea, because its seeds are the favourite food of wild pigeons. It is a highly esteemed food in India, especially in the south and figures in the daily food of a considerable number of people. Its tender green pods constitute a favourite vegetable in some parts. It is largely eaten in the form of split pulse as dhal. It is consumed in various ways but most often in South India it is cooked with spices and vegetables, and consumed as sambar.

Red gram is now cultivated in different parts of the world. It is a native of Africa and is being cultivated in India from a very long time. Numerous types of red gram are known which vary in colour, size and shape of pods and seeds. Some 86 different types are grown in India. These types are grouped under two distinct varieties: arhar (*C. cajan* var. *bicolor*) mostly grown in North India and tur (*C. cajan var. flavus)* grown in the South. The total red gram production in the country in 1998 was 2.88 million tonnes cultivated in an area of about 3.82 million heactares, the yield being 7.63 quintals per hectare.

The seeds differ in size, shape and colour of the seedcoat. Based on size, they are distinguished as large, medium and small. The seeds may be round, oval or kidney shaped. The colour of the seed may be white, light brown, dark brown and pinkish black.

The seeds of red gram are split into dhal before marketing. Both dry and wet methods are used in making dhal. In the dry method, the seeds are dried in the sun for 3–4 days and then split in a mill. The seeds are sometimes smeared with a small quantity of vegetable oil to soften the seed coat and facilitate the milling. In the wet method, the seeds are first soaked in water for 6–10 hours. They are then mixed with red earth, heaped and left overnight. Then the seeds are dried in the sun, sieved and winnowed to remove the earth, and finally split into dhal in a pestle-and-mortar (chakki). This split dhal is cleaned by winnowing and treated with some oil to preserve its quality.

17.7.3 Black gram (*Phaseolus mungo* Roxb.) Black gram or urd belongs to the genus *Phaseolus*, which comprises 230 species of which 20 are cultivated for their edible pods or seeds. Based on origin, the species are divided into two groups, the Asiatic and the American. The American pulses are generally accepted as being members of the genus *Phaseolus*, while the Asiatic pulses are assigned either to the genus *Vigna* or *Adzukia*. Pulses other than black gram belonging to this genus which are important in India are green gram and moth.

Black gram has been reported to have orginated in India. It is the most highly prized of all pulses of the genus *Phaseolus*. It is cultivated in all parts of the country in an area of 3.15 million hectares producing about 1.49 tonnes, the yield being 4.73 quintals per hectare.

It has a mucilaginous material (see Subsection 16.3.1) which makes it a valuable ingredient in idli preparation. The chief proteins present in black gram are albumins and globulins (55–56 per cent). It also has prolamines and glutelins (24–25 per cent).

Germination of the black gram reduces the phytin content and increases the vitamin content. By the action of proteolytic enzymes, protein degradation products are formed

Black gram flour is the chief constituent of the highly popular wafer-biscuit known as papad. Black gram dhal is an important ingredient in the preparation of idli and dosa. It forms the main base of some fried savory and sweet preparations, such as vada and jahangir, which enjoy popularity on account of their special sensory and textural attributes. Like mung and moth, urd dhals are fried in fat, salted and eaten as snack.

17.7.4 Green gram (*Phaseolus aureus*) Green gram or mung is being cultivated in India for over 2,000 years. Currently about 1.31 million tonnes are produced from a cultivated area of about 3.08 million hectares. The yield of seeds is low being 4.73 quintals per hectare.

The seeds are used as whole seed or dhal. The protein content of the pulse is high and is easily digested. The proteins are deficient in methionine, cysteine and tryptophan.

Green gram, whole or split, is used in a variety of ways in the Indian homes. Dry seeds or sprouted whole seeds are used in the preparation of curry and a number of savoury dishes. Sweet dishes also are made from green gram. Split and dehusked green gram, soaked for some time, is used in the preparation of salads or fried in a little fat and salted, and is used as a snack.

17.7.5 Moth Bean *(Phaseolus aconitifolius)* Moth bean or terapy bean is a native of India and it grows wild in the country. The seeds are small, up to 0.5 mm long, 2 to 3 mm wide, yellow or brown in colour or mottled black, somewhat uniform in shape with rounded or truncated ends. The yield of the grain is low. The grain is used either whole or split as a dhal. The whole grain, after frying, is mixed with other savoury dishes to make "dhalmoth".

17.7.6 Lentil (*Lens esculenta*) Lentil or masur has been known in India as an article of food from the most ancient times. It is cultivated mostly in the North. In 1998, it was grown in an area of about 1.34 million hectares and with a production of nearly about 0.88 million tonnes. The yield is about 660 kg per hectare.

Germination of the pulse increases its biological value. In nutrition, lentil occupies a place second only to Bengal gram and black gram.

Lentil is mostly used as dhal in the preparation of soups flavoured with spices. Young pods are eaten as vegetables. Lentil meal mixed with barley or other cereal flour and common salt is marketed as invalid food in some countries. The whole seed is used in preparing a salted fried preparation.

17.7.7 Horse Gram *(Dolichos biflorus)* Horse gram or kulthi is grown largely in South India. The seeds are small, flattened, light red, brown-black or mottled.

Horse gram is extensively used in South India as feed for cattle and horses in the same way as Bengal gram is used in North India. The seeds are cooked before feeding. The legume is the poor man's pulse. It is eaten by poor people both boiled and fried. It can be eaten whole or after grinding into a meal, unlike other pulses which are consumed after splitting. Germinated seeds and seedlings are also used in cooking.

17.7.8 Field Bean *(Dolichos lablab)* *Dolichos lablab* is of Asian origin and there are two varieties: one is an annual, commonly cultivated as a garden crop; and the other, perennial in varying degrees, cultivated as a field crop. The two varieties have been designated *D. lablab* var *typicus* and *D. lablab* var *lignosus* (field bean). They are of varying colours ranging from white to green or purple. The seeds are white, yellow, brownish purple or black.

Field bean is popular as a vegetable. The pods in most cases retain their tenderness until they attain full size; therefore, the seeds alone can be utilized. *Lablab* var *lignosus* is valued more for the seeds than the pods. Green pods are gathered at all stages of development and tender seeds eaten fried or cooked, and salted in the same manner as green pea. Ripe and dried seeds are consumed as split pulse, while seeds are sometimes soaked in water overnight and when germination starts, they are sun dried and stored for future use.

17.7.9 Pea *(Pisum sativum)* There are two kinds of peas—the field pea and the garden pea. The field peas are small, round and tender, while the garden peas are large and smooth or wrinkled. The field pea is grown as a dry pulse, whereas the garden pea, in addition, can be harvested immature and the immature seeds cooked as vegetables.

Several varieties of garden peas and field peas are grown in India. In 1998, the area under peas was 0.73 million hectares with a production of over 720 thousand tonnes. The average yield of green pods is 9.5 quintals per hectare.

Peas are consumed in India in a variety of ways. The fresh ones are consumed as such or canned, curried and dehydrated. The dry ones of certain green-seeded varieties are also processed for canning. The round smooth-seeded field peas of various colours are used as pulse mostly in the split form. Dry peas are also used for making flour which can be used as a substitute for Bengal gram flour.

The pods of some garden peas lack the parchment tissue on the inner pod walls and these are known as sugar peas. These can be chopped like those of fresh bean or the garden *lablab*, so that the entire pod can be used. However, these are hardly known in India.

17.7.10 Khesari Dhal *(Lathyrus sativus)* Khesari dhal is grown to the greatest extent in India and to a lesser extent in a few other countries of the Eastern and Mediterranean regions. The greatest drawback to its use is the occurrence of the pathological condition of lathyrism (Subsection 17.5.1) amongst people who consume it in large quantities, as has frequently happened in India.

The pulse grows under adverse conditions and is commonly grown in paddy areas. The yield is low and averages about 670 kg per hectare, the total production being 0.49 million tonnes from 0.73 million hectares.

17.7.11 Cluster Bean (*Cyamopsis tetragonoloba*) Cluster bean or guar is indigenous to India and has been grown from early times for vegetable and forage purposes. This is grown in an area of about 1.6 million hectares with a production of 373 thousand tonnes. The yield of green pods varies from 4500–7500 kg per hectare and the average yield of seed is 650–750 kg per hectare.

In India, the young tender pods are used as a favourite vegetable. The pods are also preserved after drying and salting and eaten after frying. The seeds are very mucilaginous and they find a range of uses as a thickener in food products and for sizing textile and paper products.

17.7.12 Cow Pea (*Vigna unguiculata*) Cow pea is one of the commonly used pulses in India, but is not extensively grown. Yet it is one of the pulses used from ancient times. The yield is rather low being about 400–700 kg per hectare. The seeds vary in size, shape and colour.

In India, cow pea is used whole or as dhal. It is also used as flour after husking or with the husk. The pods are used as a vegetable when tender. The seeds may be germinated and the seedlings eaten. Cow pea is considered inferior to blackgram as a food being difficult to digest.

17.7.13 Kidney Bean *(Phaseolus vulgaris)* This bean is known by a great many names, none of which has more than local significance. Names, such as fresh bean, snap bean, salad bean, green bean, apply to varieties used as vegetables; those that are used as pulses are denoted by such names as dry bean and navy bean. The name common bean is used because it is the most ubiquitous bean of consumption.

The bean is grown in different parts of the world. The beans vary in size, shape and colour of pods and seeds. Green pods are harvested before they become fully grown, tough and stringy. Dry beans are harvested when pods are fully ripe. The yield of green pods varies from 2,500 to 3,500 kg per hectare, while the yield of dry beans varies from 1,500 to 2,000 kg per hectare.

The beans are used as a green vegetable or dry pulse, according to the stage at which they are harvested. French bean, the most important variety used as a vegetable, has a fleshy-walled pod with less fibres in the younger stages. The dry bean is an important source of food.

17.7.14 Soyabean *(Glycine max)* Soyabean or soybean is both a useful pulse and an oilseed. It is an important food crop in China, Japan and Korea. It is also cultivated in India and throughout South-East Asia. From China, soyabean went to Europe in 1792 and to the United States in 1804. In the United States, more than 1000 types of soyabean are grown essentially as an oil-seed crop and the country stands first in the world, both in the area under cultivation and production (58 per cent of the world production).

The world production during 1997-98 was 158 million tonnes from 70 million hectares, the yield being 22.4 quintals per hectare. China comes next with about 35 per cent of the world production. All other countries put together produce about 7 per cent of total world production.

In India, soyabean is grown in the Northern hill parts over an area of 6.35 million hectares, the production being 6.1 million tonnes with a yield of 9.6 quintals per hectare.

Different varieties of soyabean with different coloured seeds, varying from white, yellow and brown to black are produced. Their chemical composition depends upon the variety.

Soyabean utilization for food in China, Japan and other countries is high. In China, of the average daily consumption of legumes of 42 g per capita, 18 g are soyabean. In Japan, it was noticed that in an area where the average pulse intake was 70 g daily, 64 g were soyabean in various forms. This is because of the advanced Japanese technology in the processing and manufacture of highly acceptable and palatable soyabean products.

Soyabean, with its high protein content, could be a substitute for expensive meat products, as there is a worldwide shortage of affordable protein. It is estimated that one hectare of land used for grazing purposes will produce enough meat to satisfy one man's protein needs for 190 days; planted in wheat it will provide enough protein for 2,167 days. But that hectare, planted with soyabeans, will yield enough protein for 5,496 days. Soyabean is being used to produce textured vegetable protein (TVP), also known as nutrinuggates, to replace meat (see Sec. 23.1). Cheap soyabean meal feeds are used for growing livestock and poultry. It is reported that soyabean has a hypoglycemic effect, hence can be used for diabetic patients.

17.8 Processed Soyabean Products

As food, soyabean may be flaked, ground or powdered, and made into a sauce, oil or meal. Some of the processed food products of soyabean are discussed below.

17.8.1 Extracted Soyabean Proteins Two readily digestible proteins are separated from the indigestible portion of soyabean. They are soyabean curd and soyabean milk. These products are commonly prepared and used in China and Japan. Technology for processing these products from soyabean has also been developed in this country.

Soyabean curd: A curd called "Tofu" is obtained by grinding soaked beans into an emulsion followed by cooking and straining. The curd is precipitated from the milky fluid by the addition of calcium sulphate, allowed to settle, then separated, washed and dried. The final product which has a white colour and a soft delicate structure is cut into slices or slabs. The protein content of the preparation varies from 6 to 17 per cent depending on the moisture content. The fresh curd does not keep well; drying and refrigeration prolong storage life. In China and Japan, the curd is widely used as a food for young children. Soyabean curd may be fermented to produce cheese-like products.

Soyabean milk: Soyabean milk is prepared by grinding soaked beans in a stream of water to obtain an emulsion. The emulsion is cooked for 20 min. when margarine, sugar, salt, lime and malt are added. The cooked product is then homogenized or emulsified and it may be used fresh or spray-dried. When the milk is prepared to conform to a satisfactory formula, it is very good for infant feeding, particularly for those who are allergic to cow milk, and also is a boon for persons who, because of an enzyme deficiency, are unable to digest cow milk. Since it contains less sodium than cow milk soyabean milk is better for persons with high blood pressure.

Proteins are also extracted from soyabean in other ways. The seeds are defatted by mechanical processes and the oil remaining in the pressed cake is extracted by solvents. The material is then heated under controlled conditions to eliminate the bitter principles and enzymes interfering with digestion or causing rancidity. The product thus obtained is very rich in protein and nutritionally valuable.

17.8.2 Fermented Products of Soyabean Some fermented products of soyabean are soya sauce, soyabean paste, tempe and natto. Their methods of preparation are given below:

Soya sauce: Soya sauce is prepared in a variety of forms and is produced from a long and complex fermentation with various fungi and bacteria. Soyabeans are cooked for 4 to 6 hours and cooled. They are then mixed with an equal quantity of roasted ground wheat and the mixture, under suitable conditions, is seeded with *Aspergillus oryzae*. After the initial fermentation, salt is added and the product is matured for 6 months to 3 years when further fermentation occurs. When "ripening" is complete, the product is strained. Soya sauce thus obtained contains 67 per cent moisture and 5 to 6 per cent protein.

Soyabean paste (miso): Soyabean paste is mostly a Japanese product. The fermenting agent, as in soya sauce, is *Aspergillus oryzae*. The ingredients are cooked soyabean and steamed rice or barley, and the mixture is fermented from 2 weeks to years. Miso may be white or dark. White miso is produced by the fermentation of a mixture containing a high proportion of rice or barley and the fermentation is complete in two weeks. Dark miso results from a mixture with a high proportion of bean and fermentation takes longer. The rate of fermentation is controlled by the addition of salt. The product contains 10 per cent protein and has a paste-like consistency. It is used in the preparation of soups or served with rice and other foods as dressings or a side dish.

Tempe: Tempe is an Indonesian product. The fermenting agent is the fungus *Rhizopus oryzae*. The fungus is added to cooked and mashed soyabean, and is allowed to incubate for 24 hours during which time the mold penetrates the mash. Then the ferment is exposed to air and the tempe is ready for consumption. The fermented product contains 25 per cent or about half of the original protein content of the beans. The other half of the protein is broken down to amino acids which are readily assimilable. Tempe has a strong smell but it is a highly nutritious product.

Natto: Natto is a Japanese product similar to Tempe. The fermenting agent is *Bacillus subtilis*. The cooked soft beans are inoculated with the bacterium and the fermentation is complete in 20 hours. The finished product is grey in colour, has a mushy flavour and rather poor keeping qualities. It is eaten with rice.

Hamanatto: Hamanatto is a Korean product. The fermentation in this case is brought about by a fungus. Soaked and steamed beans are impregnated with the mold and when the fungus covers the bean, it is dried in the sun. The dry preparation is treated with salt water and allowed to ferment for another 3 to 12 months. It is again sun dried, and then is ready for consumption.