

## **Subject- Technology of Cereals, Pulses and Oilseeds.**

### Wheat

Wheat is the one of the important cereal crop of the World, with an estimated annual production of 540 - 580 million metric tonnes. Wheat belongs to the genus *Triticum* of the grass family Gramineae. Common wheat (*Triticum aestivum*) and durum wheat (*Triticum durum*) are the two major wheat groups grown for food use now. Wheat is the most valuable of all food grains and is widely used in all its stages, from whole to finely milled and sifted. In the bakery, wheat flour is the most important ingredient, which provides bulk and structure to most bakery products, including breads, cakes, cookies, and pastries. Wheat is classified into two groups: hard and soft. Hard wheat is higher in protein compared to soft wheat. It yields stronger flour, which forms more elastic dough, and is better for bread making when strong elastic dough is essential for high leavened volume. Soft wheat is lower in protein, which forms weaker dough or batter, and is better for cake making.

### Wheat Processing

#### Storage

Quality of wheat is to be preserved while moving from field to storage and subsequently to the processing mill. If not properly stored; insects, moisture damage, molds or other conditions may cause losses. Moisture content must be less than 20% before harvesting, and wheat is then carefully dried to moisture below 12.5%, a level which is regarded as safe for storage. The desired moisture content is achieved in kiln or in modern driers taking care of the temperature of grain does not exceed 50°C.

#### Milling

The objective of wheat milling is to grind cleaned and tempered wheat by separating the outer husk from the internal endosperm. Early processing of wheat was accomplished by means of hand grinding, grinding stones, or a mortar and pestle. Later on wheat was milled between two circular millstones, one fixed and the other mobile and rotating. Recent technology of wheat milling involves metal cylinders or rollers for milling purposes.

#### Cleaning

Wheat received at mill may contain certain impurities entering from field, during storage and transportation, or accidentally. Frequently encountered impurities include: straws, chaff, sticks, weed seeds, other cereal grains, shrunken and broken kernels, infected kernels, mud, dust, stones, metal objects, etc. Wheat cleaning operation makes use of certain characteristics of impurities which are different from those of wheat e.g. size (length and width), shape, terminal velocity in the air currents, specific gravity, magnetic and electrostatic properties, colour, surface roughness, etc. The grain is initially passed through a series of screens of selected apertures that removes

matter either smaller or larger in size than the wheat kernel. Gross foreign material is removed over a set of sieves (rubble separator). In gravity separator, impurities which are similar to wheat in size but different in specific gravity are separated out. Wheat grains are then moved on tilted screen, through which adjusted air currents are drawn. Heavier materials such as stones are separated and remain closer to screen, while lighter impurities and wheat floats down the screen. After gravity separation, series of rotating discs separators remove impurities that are similar in diameter but different in shape from the wheat. This rotating discs with indentations pick-up only those wheat kernels that fit into the pockets and allow other grains such as oats, barley to pass through. Dry scouring of wheat kernel removes any dirt adhering to it. In the scorer wheat kernel is bounced against a wall, which may be of a perforated sheet metal, a steel wire woven screen or any emery surface. Magnetic separators separate foreign materials such as nails, pieces of metal that could damage equipments or generate spark, which could cause a dust explosion. In final cleaning operation, wheat is washed by water. Wheat is immersed in water (0.5 – 1.0 lit per kg) and then conveyed by means of a worm to a centrifugal machine called whizzer, where it is vigorously agitated and spun dried. Washing of wheat removes crease dust.

#### Conditioning / Tempering

Conditioning of wheat is carried out primarily to improve the physical state of grain for milling. In conditioning moisture content of wheat kernel is adjusted. This includes heating and cooling of the grain for definite period of time, in order to obtain the desired moisture content and distribution. At this adjusted moisture level of wheat before milling, wheat endosperm becomes mellow and bran becomes tough. Bran that absorbs proper amount of moisture becomes elastic and will not splinter during grinding to contaminate the flour with fine particles, and thus flour becomes whiter in colour. The endosperm becomes mellower and more friable, thereby reducing the amount of power required to grind it. Several methods are employed to condition the wheat. Heating the wheat, application of warm water, application of live steam, or just intensive mixing of wheat and water are some of the methods used to increase the amount and rate of water penetration into kernel. Three factors affect the rate and level of water penetration into the kernel: temperature, amount of water (% moisture content) and time. The ideal water and wheat temperature for tempering condition is 25°C. Higher temperature will increase the rate of penetration into the kernel. Temperature above 50°C will change endosperm starch and protein characteristics.

#### Milling / Separation of flour

Objective of wheat milling is to separate the branny cover and germ of the wheat kernel from the endosperm. Wheat flour milling is a process that consists of controlled breaking, reduction and separation. Wheat flour milling involves three basic processes: (i) Grinding: Fragmenting the grain or its parts (ii) Sieving: Classifying mixtures of particles based on its particle size (iii) Purifying: Separating bran from endosperm particles based on their terminal velocity, by means of air currents.

Grinding of the wheat occurs between two cast rolls (break rolls) that rotates against each other. These rollers are fluted and they are not in contact with each other. The

upper roller rotates two and a half times for each rotation of the lower one. Hence, the grain is engaged between fluted serrations of the rolls and broken or cut by the faster roll as it is held back by the slower roll. This initial stage in milling process is referred as 'breaks'. The breaks are used in the grinding steps to separate the bran, germ and endosperm from each other. The grist coming out from the rolls is sifted through a plansifter. The plansifter is a machine consisting of a vertical nest of horizontal sieves, the whole assembly gyrating in a horizontal plane. A single plansifter consist of four or five different mesh sizes may yield five or six fractions of different particle size. The series of break rolls and sieves converts the grain into semolina, which is small granule made up of endosperm. The outer husk is collected separately as bran. The semolina is separated into three grades: fine, medium, coarse in an operation called 'gradual reduction system'. Here the rolls are smooth and one rotates only one and a quarter times for each rotation of the other. These three streams are then put through purifiers. Purifier consists of a long, narrow, sieve set. The sieves become coarser progressively in size of mesh from head to tail. The sieve section is connected to a fan and the air is drawn up through each sieve section to draw off branny particles. The number of parts of flour by weight produced per 100 parts of wheat milled is known as the flour yield, or percentage extraction rate. The wheat grain contains 82% of white starchy endosperm, but it is never possible to separate it out fully from the bran.

## Wheat Quality

Flour produced at every grinding machine is different in terms of proportion of endosperm, germ and bran contained in it. Thus, each 'machine' flour is distinct in terms of baking quality, colour, granularity and the ash content. This difference in the composition of flour can lead to non-uniform quality in baked products. Thus to improve the quality of bakery products numerous chemical and biological compounds are added to the wheat flour during processing. They are usually added in very minute quantities to get the desired effects. These additives must be GRAS (Generally Recognised As Safe) and should be permitted under food laws of the country of use. Wheat flour is major ingredient in manufacture of baked goods. But each type of bakery product requires a specific type of flour or combination of flour with certain improvers to get desired quality of end product. These additives are known as flour improvers, as they improve the technical quality of flour. The examples of flour improver are: bleaching agents, maturing agents, surfactants, enzymes, reducing agents, vitamins and minerals, antimicrobial agents, etc.

## Types of Wheat Flour

Wheat flour is used in manufacture of numerous baked products. Other than baked products wheat flour is used in making other food products such as meat pie, sausages,

chapattis, soups, etc. Biscuit dough should be stiff enough to permit rolling and flattening, while bread dough must be plastic mass that can be moulded and shaped. Wafer batter is a liquid suspension, which is able to flow through a pipe. So for each application flour with specific properties is necessary. Flour from different stages in the mill are not identical in physical appearance, chemical analysis or baking properties. If all the streams of flour are mixed to one composite, then the resultant flour is known as 'straight-grade flour'. It is also possible to blend the streams in definite proportions/ratios to produce the flour which is called 'split milling' or 'divide milling'. Flour streams head end middlings, primary sizing and in some cases that of second and third breaks originate from the centre of wheat kernel. The blend of these flour streams is called 'patent flour'.

### Criteria of Wheat Flour Quality

Flour quality is a subjective concept that relates to the final product usage. For different baked goods wheat flour with specific characteristics is required as discussed earlier in types of wheat flour. Quality parameters such as colour, protein, granulation distribution, gluten quantity and quality, and starch damage play important role in deciding the suitability of flour for the baker.

**Table 5.1 Types of wheat flour and their characteristics**

Sr. No.	Type of wheat flour	Specific characteristics
1	Bread flour	<input type="checkbox"/> Flour with high level of good quality protein <input type="checkbox"/> Protein content: 10.8 – 11.3% (Mechanical process), 11.8 – 12.3% (Fermentation process)
2	Biscuit flour	<input type="checkbox"/> Milled from weak wheat of low protein content <input type="checkbox"/> Protein content: 8 – 9.5%
3	Household flour	<input type="checkbox"/> Weak wheat of low protein content with admixture of up to 20% of strong wheat
4	Self-raising flour	<input type="checkbox"/> Flour with added raising agents <input type="checkbox"/> Moisture should not exceed 13.5% to avoid premature reaction of aerating chemical
5	Flour for confectionery	<p><i>Cakes</i></p> <input type="checkbox"/> Undamaged starch granules, free from adhered protein and unattached by amylases <input type="checkbox"/> Protein content: 8.5 – 9.5% <input type="checkbox"/> Particle size: 90 μ <p><i>Buns</i></p> <input type="checkbox"/> Bread making flour <p><i>Pastry</i></p> <input type="checkbox"/> Strong baker's flour
6	Flour for soups	<input type="checkbox"/> Steamed flour in which enzymes have been inactivated
7	Flour for sausage rusk	<input type="checkbox"/> Low protein flour milled from weak wheat
8	Batter flour	<input type="checkbox"/> Low protein flour milled from grist comprising 90% weak wheat and 10% strong wheat

## **Bakery products: bread, biscuits & cakes**

### **TECHNOLOGY OF BREAD MAKING**

#### **11.1 Introduction**

Bread baking is one of the most important discoveries of mankind. Bread is made by baking dough which has for its main ingredients wheat flour, water, yeast and salt. Other ingredients which may be added include flours of other cereals, milk and milk products, fruits, gluten, etc. When these ingredients are mixed in correct proportions two processes commence: (i) the protein in flour begins to hydrate and forms a cohesive mass called as gluten (ii) evolution of carbon dioxide gas by action of the enzymes in the yeast upon the sugars. Three main requirements in making bread from wheat flour are formation of gluten network, aeration of the mixture by incorporation of gas, and coagulation of the material by heating it in the oven.

#### **11.2 Principle of Bread Baking**

There are three technological principles involved in baking of bread:

- (i) Conversion of starch: Wheat flour starch is partly converted into the sugar, which is being used by yeast during fermentation producing alcohol with simultaneous release of CO<sub>2</sub> gas is responsible for porous, open honeycomb texture of the baked bread.
- (ii) Mechanical stretching: The hydrated wheat protein forms gluten fibers, which are stretched mechanically to obtain a fine, silky structure. This structure remains permanent when the protein is denatured during baking. The stretching of gluten is partially achieved by development of CO<sub>2</sub> gas during yeast fermentation and partly by mechanical mixing.
- (iii) Flavour development: Bread flavor is because of the alcohol and other compounds generated during yeast fermentation, together with flavor compounds formed during baking.

### **11.3 Ingredients and their Functions in Bread Making**

#### **11.3.1 Essential ingredients**

##### ***11.3.1.1 Flour***

Flour is essential to the structure of dough and subsequently the bread. Gluten (Gliadin and Glutenin) is the principle functional protein of wheat flour. Gluten forms fibrillar frame work when hydrated and mechanically worked. Thus the wheat flour is converted into cohesive, elastic, extensible dough. This viscoelastic three-dimensional gluten network retains gas formed by sugar fermentation and contributes to structure of dough and bread.

Starch plays important role in dough during baking. When heat is applied, gas cells expand gluten networks stretches, starch granules take up water and get partially gelatinized. This viscous paste sets to gel after baking. Satisfactory protein content for bread flour is 11 – 13% and moisture content not more than 14%.

##### ***11.3.1.2 Water***

Water hydrates gluten proteins during mixing, gelatinizes starch during baking and serves as a dispersion medium for other ingredients such as yeast. Quality of water such as pH and hardness of water play important role in dough formation. Excessively alkaline water can retard the activity of yeast enzymes. Hard water containing calcium and magnesium ions, may have a “tightening” effect and soft water a “loosening” effect on dough.

##### ***11.3.1.3 Yeast***

Yeast produces carbon dioxide and ethanol by fermentation of fermentable sugars. During fermentation it also helps in formation of flavour precursors. Rate of fermentation of dough by yeast is controlled by temperature, nutrient supply, water, pH, sugar concentration, salt and level and type of yeast. Generally two type of yeasts are used in baking: Compressed yeast and dried yeast. Both the types consist of living cells of *Saccharomyces cerevisiae*.

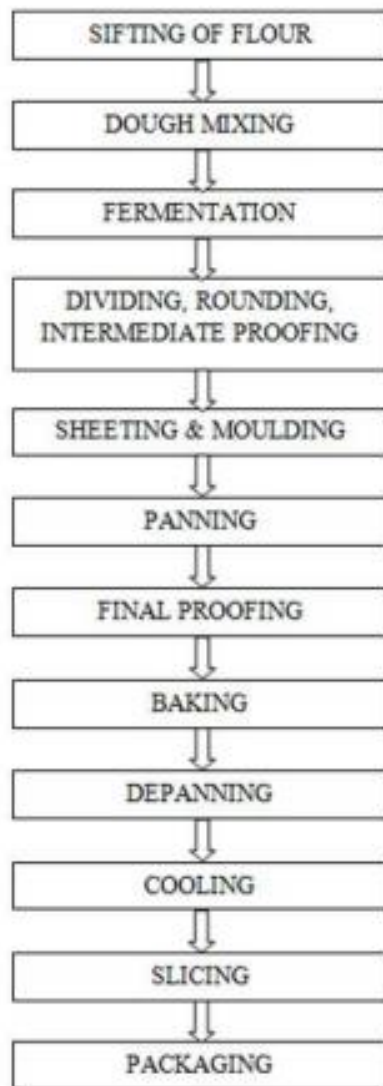
##### ***11.3.1.4 Salt***

Salt acts as flavour enhancer and helps control the fermentation by yeast. It also toughens the gluten and gives less sticky dough.

### **Bread Manufacturing**

Production of bread consists of number of steps. The first step of bread making involves sifting of flour to remove any foreign matter and coarse particles, and to aerate and make the flour more homogeneous. The next step is dough mixing, which is accomplished by various methods of preparation of dough. Once the dough is formed, it is divided into pieces of requisite size. The divided dough is rounded to a ball shape and then passed through intermediate proofer, where the roughly stretched gluten fiber get time to recover their extensibility so that they can be moulded well without breaking the surface skin. After intermediate proving, the dough is passed through a set of pairs of roller to form a sheet. The sheeted dough is now passed through pressure board to get moulded into cylindrical shape. The moulded dough

pieces are then placed into greased individual bread baking tins. The panned dough pieces are then passed through final prover under controlled temperature and humidity. After complete proofing, the dough tins are transferred to the baking oven. Once baking is completed, the breads are de-panned, cooled and then sliced. Sliced breads are then packaged in suitable packaging material, generally polypropylene pouches.



**Fig. 11.1 Flow diagram for bread manufacture**

### Technology of Biscuits

The name 'cookie' can be regarded as synonymous with biscuit but the cookies are more comprehensive in meaning in the USA and the latter in the UK. Groupings have been made in various ways based on

1. The method of forming dough and dough piece Fermented Developed Laminated Cut Moulded Extruded deposited Wire cut co-extruded
2. According to texture and hardness Biscuits Crackers Cookies



3. According to the recipe enrichments with ingredients like fat and sugar Another type of classification based on secondary processing are Cream sandwiched, chocolate coated, moulded in chocolate, iced (half coated with an icing that has been dried) and added jam or mallow (or both) The main raw materials for biscuits are flour, sugar and shortening. For protein enriched peanut flour or isolates, soy flour etc. can be added. Other ingredients include leavening agents, vitamins, minerals and flavours. In sweet biscuits, cane sugar is added while in salty biscuits, sodium chloride (0.5-1.0 percent is added).

The main steps involved in biscuit making are - 1. Mixing and kneading: Weighed amount of sifted flour, sugar, shortening and flavouring agents are mixed in mechanical mixer. Water and baking powder are added during mixing to obtain a dough of desired consistency. Kneading for 10-20 min produces biscuits with fine structure, smooth crust and better appearance. 2. Sheeting and shaping: The dough is then rolled into sheets of desired thickness by passing it through pairs of rolls. The sheets are then cut by mechanically worked stamped dividers fitted with dies. 3. Baking and cooling: the cut biscuits are then transferred to plate sheet or wire mesh bands travelling through ovens. The biscuits are generally baked at 450°F for 15 min and cooled to ambient temperature after baking. 4. Packaging: the biscuits should be packed in moisture and grease proof cellophane or metalized laminated foils.



**Fig. 12.3 Steps in involved in biscuit making**

## **Cake making methods**

### **Sugar batter method**

In this method fat is creamed and then sugar is added gradually. When adequate aeration is achieved, flour is added in the mixture along with raising agents. There should be minimum mixing action to avoid gluten formation. When all flour is mixed, remaining liquid is added to the batter to necessary consistency.

### **Flour batter method**

In this method fat and quantity of flour not exceeding the weight of fat is creamed together. Eggs and an equal quantity of sugar are whipped to a stiff froth. Then

remaining sugar is dissolved in water or milk and added to the mixture. Lastly remaining flour along with baking powder is added and mixed gently.

#### Blending method

This is used for formulations containing more sugar than quantity of flour. All ingredients except sugar and milk are mixed together. Sugar, milk, colour and flavours are mixed and added to previous mixture followed by eggs and mixed to form a smooth batter.

#### Boiled method

Flour (more than two third portions) is added to melted butter or margarine and mixed well. Eggs are whisked with sugar followed by addition of colour and flavor. This is added to flour- fat mixture in equal parts, mixing thoroughly at each stage. Remaining flour is also added at this stage.

#### Sugar water

method Initially sugar is dissolved in water followed by addition of all other ingredients except eggs. Finally eggs are added and whisked well.

#### All in process

In this method, all the ingredients are put into the mixing bowl together. Aeration of the mixture is achieved by controlling the speed of mixer as well as mixing time. The batter is then put in greased pan. Only 2/3rd height of mould should be filled. Load the batter containing pan into oven as soon as possible. Bake the cake at 375° - 400°F for 25-30 min.

## **Chapter-2**

### **Rice**

#### **Introduction**

Rice (*Oryza sativa*, Linn.) is one of the oldest and most important food crops of the world. It is staple food for more than half of the World's population. Rice belongs to the Gramineae or grass family and the tribe Oryzeae. Rice is a semi-aquatic plant which can thrive under flooded soil condition. Rice plant possesses the roots of a dry land crop, which are able to pass moisture from roots to stem and oxygen from leaf through stem to roots. The total area of rice cultivation varied between 350 – 360 million acres globally during the last few years. About 92% of the World's rice crop is produced in the Asian continent (FAOSTAT).

#### **Rice Milling**

Rice milling is carried out either at small scale or large scale. The objective of the rice milling is to remove the husk and bran with minimum possible breakage of endosperm. Paddy is generally harvested at 18 – 25% moisture and then dried to 12 – 13% moisture either on farm or at the mill before processing.

#### **Milling Procedure**

Combine-harvested rice generally has a moisture content of about 20% (wet basis) and the grain must be dried immediately to about 12% for storage. Rice is consumed mostly in the form of whole kernels, and accordingly the processing of paddy is designed to give a high yield of unbroken kernel.

## 1. Cleaning

Cleaning of paddy comprises removal of sticks, stones, dust and other foreign materials. This is accomplished by use of various separation methods. The paddy is first passed over a screen to remove larger particles, straws and string. After that it is passed through second screen, which is having smaller perforations than first screen, to remove weed seeds and sand. The paddy then flows in the form of a thin layer into a channel where an air current removes dead grains and other lighter impurities. At the last, paddy are passed through magnetic separator to remove metal particles.

## 2. Hulling/Shelling

Cleaned paddy is then passed through machine (disc huller/sheller) comprising emery/rubber rolls running in opposite directions; aspirated to remove husk and then sieved to separate from the unhusked and broken rice. The rice with the hull removed is commonly known as “brown rice”/“rough rice”.

## 3. Scouring/Pearling/Whitening

Gradual removal of germ and bran from the rough rice is known as scouring/pearling/whitening process. The hulled rice is passed through a series of “pearling cones”. In pearling cones rice passes through the narrow annular space left between an inverted cone coated with abrasive revolving in a conical casing made of steel wire cloth. As it passes down, the bran is pushed through the interstices of the wire cloth. By-product of scouring process is known as “rice-bran” which is used as animal feed. It is also used to extract rice bran oil.

## 4. Polishing

The rice grain consisting inner layers of bran is passed through polishing machine often referred to as “brush”. In this machine last bran fraction is removed. The grain is now called “polished rice”.

## Parboiling of Rice

The technique for parboiling of rice was developed in India to prevent losses occurring due to breakage during hand pounding, especially the long grained varieties. In this technique paddy is soaked in excess water and later on cooked in its husk, the objective being pregelatinizing the starch. Any hairline cracks are sealed due to homogeneous mass of gelatinized starch and thus prevent breakage during milling. The paddy is then drained and dried. Parboiling can be accomplished in variety of ways. The general scheme is to hydrate (steeping) paddy to 32 – 38% moisture and partially gelatinize the starch by steam heating at 15 lb. pressure for 10 – 20 min. Parboiling causes certain physico-chemical changes such as improved milling yields (66 – 70%), increased resistance to insects and firmer cooked rice texture accompanied by a darker and more yellow endosperm. Parboiling has further advantages like: during soaking and cooking the water soluble vitamins (niacin, riboflavin, and thiamine) which are present in germ and pericarp gets migrated into endosperm and thus improves the nutritional value of parboiled rice. Even proteins

present on the grain surface are denatured, become insoluble, and therefore are not removed during washing and cooking.

#### Advantages of parboiling of rice

1. Dehusking of parboiled rice is easy and the grain becomes tougher resulting in reduced losses during milling
2. Higher yield of head rice from milling because kernel is more resistant to breakage.
3. Milled parboiled rice has greater resistance to insects and fungus infection.
4. The nutritive value of rice increases after parboiling because the water dissolves the vitamins and minerals present in the hulls and bran coat and carries them into the endosperm.
5. The water soluble B vitamins, thiamine, riboflavin and niacin are higher in milled parboiled rice than in milled raw rice.
6. Parboiled rice does not turn into a glutinous mass when cooked.

#### Disadvantages of parboiling of rice

1. It has a bad smell due to prolonged soaking.
2. It has a dark colour due to heat treatment.
3. It requires prolonged cooking time and more fuel.
4. Since the oil content is more, the polisher may get choked.
5. The heat treatment may destroy antioxidants. Hence, rancidity may develop.
6. Due to the high moisture content, mycotoxins may be formed.
7. Drying cost is added to the total processing cost, extra capital investment.

#### **Cooking/eating quality indicators**

Cooking and processing characteristics of the rice are the factors of primary importance in rice eating areas of the world. Milling, cooking and processing qualities are the fundamental components of quality that determine and establish economic value of rice. Upon cooking, long grain rice is dry and fluffy with individual grains, whereas medium and short grain types are moist and chewy with grains that tend to stick or clump together. Major cooking quality parameters are discussed hereunder.

##### 1. Amylose content

Amylose content is considered as the single most important characteristics for predicting rice cooking and processing behavior. In rice it varies roughly from

15-37%. A high amylose content is usually associated with non-sticky cooking characteristics and vice-versa. Glutinous or waxy rice, which has no or very little amylose content, becomes very sticky on cooking.

## 2 Gelatinization temperature

The gelatinization temperature of starch is the range of temperature within which the starch starts to swell irreversibly in hot water with a simultaneous loss of crystallinity, and usually varies from 56° to 79°C. It is correlated with the extent of disintegration of milled rice in a dilute alkali solution (1.7-2.0% KOH) measured in terms of alkali spread value. Gelatinization temperature is also positively correlated with the cooking time but not with the texture of cooked grains.

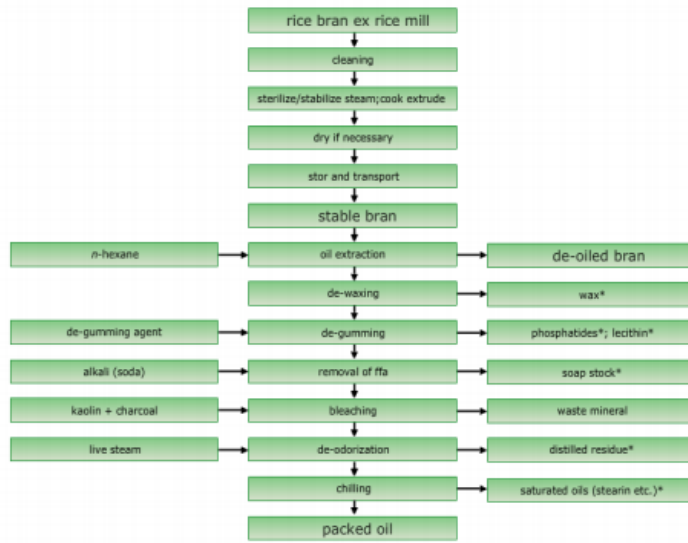
## 3 Gel consistency

The gel consistency test is the index of cooked rice hardness among high amylose rice. Rice is classified on the basis of gel length as soft, medium and hard. Soft to medium gel consistency is preferred to hard gel consistency. Among high amylose rice, intermediate gelatinization temperature and soft gel consistency are preferred by consumers over low gelatinization temperature and hard gel consistency.

## **By Products of Rice**

### 1. Processing of Rice Bran Oil

Rice bran makes up only some 2% of the paddy but it is a valuable source of edible oil and proteinrich animal feed. Rice bran consists of 12 – 15% protein, 15 – 20% lipid, 40 – 50% carbohydrates, 7 – 11% crude fiber and 6 – 9% ash. Heat generated during milling triggers enzymatic activity, resulting in the hydrolysis of lipid, and oxidative changes leading to rancidity. Hence, the bran must be stabilized as quickly as possible after production to prevent the rancidity. Stabilization of rice bran can be achieved by dielectric heating, treatment with hydrochloric acid and treatment with sodium metabisulfite. Recently, extrusion-cooking process has proved very successful and cheaper. Rice bran oil is extracted with light petroleum spirit (n – hexane); the process is thus hazardous.



**Fig. 3.1 Flow diagram for rice bran oil extraction**



## **Chapter- 3**

### **Corn**

Corn or Maize (*Zea mays*, L) is used for animal feeding, for human consumption and for the manufacture of starch, corn syrup solids, sugar, beer, industrial spirit, etc. The products of milling include maize grits, meal, flour, and protein and corn steep liquor. Corn is consumed as human food in many forms. In its harvested wet form, it is consumed as vegetable. The ready-to-eat breakfast cereal ‘corn flakes’ is made from maize grits. Popcorn – the first snack food is undoubtedly the oldest snack food. The majority of corn consumed as human food has undergone milling and is consumed as a specific or modified fraction of the original cereal grain. Like other cereal grains, corn is milled to remove hulls and germ.

#### Corn Classification

Maize or corn is classified commercially into four main classes as follows: 1. Dent varieties, which, when mature have a pronounced depression or dent at the top of the kernel. These have hard patches of densely packed endosperm cells at the outer edges of their endosperm and soft, opaque cells toward their center. Their shapes vary from long and narrow to wide and shallow. 2. Flint varieties, which have a continuous hard

layer surrounding the endosperm. When these kernels dry, they dry evenly and therefore do not form a dent. 3. Flour or soft varieties, which are almost entirely opaque and soft. It is the soft maize varieties that are normally used to make corn flour. 4. Waxy maize varieties that have a waxy appearance especially when broken. The starch consists of very little amylose and is effectively 100% amylopectin (maize starch is normally about 30% amylose and 70% amylopectin).

## Corn Processing

Maize is processed by dry or wet milling. Dry milling may or may not include de-germing as a preliminary step. Non-de-germing dry milling is carried out on a local basis in small grist mills or in modern roller mills using sifters and purifiers. The maize is ground to make coarse wholemeal of 85 – 95% extraction rate. This wholemeal is highly susceptible to the rancidity as the germ is retained which has a high oil content. Wet milling and dry milling involving de-germing are carried out in large commercial mills.

### Dry milling

- Two different systems are used for dry milling of corn.
  - The non-degerming system grinds corn into mill with hardly any separation of germ. This corn meal has comparatively shorter shelf-life, as the germ is retained, which contains 32 – 35% oil. This oil in presence of oxygen and lipolytic enzymes is prone to oxidative and hydrolytic rancidity.
  - Hence, it is necessary to remove the germ from corn to produce corn products with much lower fat content and greater shelf-life.
  - Tempering and degerming system remove most of the germ and hull and leave the endosperm as free of oil and fiber as possible to recover maximum yield of endosperm and germ as large clean particles.
    - Corn is cleaned to remove dirt, stones, insects, tramp iron, broken kernels and extraneous plant materials.
    - The corn is then conditioned by adding water to increase the moisture content to 20%, and the moistened corn is allowed to equilibrate for 1 – 3 hrs. The objective of conditioning is to loosen the germ and toughen the bran and to mellow the endosperm so as to obtain a maximum yield of grits and a minimum yield of flour in the subsequent milling.
- Degerming and dehulling is carried out in one of the three ways:
  1. Beall de-germinator (De-germer and corn huller)
  2. With roller mills and sifters
  3. With impact machines such as entoleters and gravity separators.

- Once the germ and hull are removed, the endosperm is reduced in size to grits with roller mills. A complex array of additional roller mills and particle size separating equipments is used to purify and size endosperm particles. All products must be dried prior to packaging or bulk storage.

### Wet milling

- Wet milling of corn is achieved by a combination of chemical and mechanical means. Wet milling begins with steeping of cleaned corn for 30 – 48 hours with water. Sulfur dioxide is added to the water at the rate of 0.1 – 0.2% and the solution is heated to about 50°C. This condition prevents growth of putrefying microorganisms.
  - During steeping, the kernel absorb solution and swell, activating enzymes native to the kernel to assist in breaking down the structure; the bisulfite ion reduces disulfide bonds in the protein matrix, increasing protein solubility and diminishing interactions between starch and protein; the lactic acid and/or exogenous enzymes produced by the lactobacilli help soften the endosperm.
- After steeping corn is ready for grinding and fractionating in disc attrition mill. The ground slurry is then pumped to hydroclones (liquid cyclones) to separate lighter-weight germs. The germs are dried and processed for oil and meal. The heavier underflow from the hydroclones is screened, and larger particles are finely reground with an impact mill to free the starch, protein, and fiber from each other.
- Fiber is separated and washed over series of screens.
- The remaining stream of starch and protein is passed through disc nozzle type centrifuges, where heavier starch is separated from the gluten.
  - The gluten is dewatered using additional centrifuges and vacuum filters. The remaining starch slurry is washed and passed through hydroclones. Centrifuges and/or vacuum filter dewater the purified starch.

## **Subject-4**

### **Barley**

Barley (*Hordeum vulgare* L.), a major world crop ranks among the top 10 crops and is fourth among the cereals. Barley contributes significantly to the world's food supply as human food, malt products, and livestock feed. However, the barley crop may be considered relatively under-utilized with regard to its potential use as an ingredient in processed human foods. Barley belongs to the genus *Hordeum* and can be considered one of the most ancient crops.

#### **Barley Classification**

Barley is a grass belonging to the family Poaceae, the tribe Triticeae. The chief taxonomic characteristic of *Hordeum* is its one-flowered spikelet. Three spikelets alternate on opposite sides at each node of the flat rachis of the spike or head. Thus is formed a triplet of spikelets at each node— the central and the two laterals. Each spikelet is subtended by two glumes. When all three spikelets are fertile, the spike is described as six-rowed. When only the central spikelet is fertile, the spike is two-rowed. Most barleys grown for commerce are husked, that is the palea and lemma of the floret adhere to the outside of the grain. Huskless barley are not suitable for malting, but they are used for human foods as their digestibility is higher than the hulled type.

#### **Chemical Composition of Barley Grain and Malt**

Carbohydrates constitute about 80% by weight of barley grain. Starch is the most abundant single component, accounting for up to 65%, but polysaccharides of cell wall origin are also quantitatively important and may represent more than 10% of grain weight. Barley malt is produced by controlled steeping and germination schedule. The gross chemical changes observed during malting are the net result of degradation of reserve substances.

#### **Malting of Barley**

In the production of malt based beverages and malted milk food, barley grain is first converted into malt. The malting process commence with the steeping of barley in water at a temperature of about 12°C for 36 hours with frequent aeration, to achieve a moisture level sufficient to activate metabolism in the embryonic and aleurone tissues,

leading in turn to the development of hydrolytic enzymes. The wet barley is germinated around 14°C for a period of about 144 hours. During germination, enzymes migrate through the starchy endosperm, progressing from the embryo end of the kernel to the distal end. In this mobilization phase, generally referred as “modification”, the cell wall and protein matrix of the starchy endosperm are degraded, exposing the starch granules. After a period of germination, the “green malt” is kilned at a temperature not exceeding 85°C, to arrest germination and stabilize the malt by lowering the moisture levels, typically to less than 5%. In the process, undesirable raw flavours are removed and pleasant “malty” notes are introduced. The kilning process is also responsible for developing the colour of the malt.

- Biochemistry and chemistry of malting

Essentially, malting allows the optimal development of hydrolytic enzymes by the aleurone cells of barley and controlled action of these enzymes to eliminate structural impediments to subsequent easy and complete extraction during mashing. Elucidation of the part played by gibberilic acid in stimulating secretion of  $\alpha$ -amylase, endopeptidase, endo- $\beta$ -glucanases and inorganic ions from the aleurone to the central endosperm has encouraged the development of malting modifications.

- Steeping

In many respect, the steeping operation is the most critical stage in malting. To produce homogeneous malt, it is necessary to achieve even moisture content across the grain bed. Most barley requires a steeping regime that takes them to 42 – 46% moisture. At the commencement of steeping, the embryo and husk absorb water far more rapidly than does the starchy endosperm. Besides water, barley requires a supply of oxygen to support respiration. Oxygen access is inhibited if the grain is submerged in water for prolonged periods, a phenomenon that dictates use in modern malting regime of steeps interrupted by air rest periods. Additionally the steep water may be aerated or oxygenated. Air rests serve the added role of removing carbon dioxide and ethanol, which are the products of respiratory metabolism and may inhibit germination. A typical steeping regime may involve an initial steep to 32 – 38% moisture, an air rest of 10 – 20 h, followed by a second steep to raise moisture to 40 – 42%. The entire steeping operation in the modern malting plants is likely to cover 48–52 h.

- Germination

Germination is generally targeted to generate the maximum available extractable material by promoting endosperm modification through the development, distribution and action of enzymes. Enzyme synthesis occurs during germination in the aleurone and subsequently migrates into the endosperm to effect hydrolysis. During hydrolysis enzyme development follow the sequence: cell wall degrading enzymes, proteases,

and then amylases. The process is controlled by maintaining moisture levels within the grain, supplying oxygen, removing carbon dioxide, and eliminating excess heat formed by respiration. Temperature is controlled throughout the germination period, typically in the range of 16 – 20°C. Modification of the barley commences at the proximal end of the grain, adjacent to the scutellum . The rate of modification depends on: (1) the rate at which moisture distributes through the starchy endosperm, (2) the rate of synthesis of hydrolytic enzymes, (3) the extent of release of these enzymes into the starchy endosperm, and (4) structural features of the starchy endosperm that determine its resistance to digestion. Fig. 7.2 Germination of barley grain

- Kilning

Through the controlled drying of green malt, the maltster is able to: (1) arrest modification and render malt stable for storage, (2) ensure survival of enzymes, where appropriate, for subsequent employment in processing, and (3) introduce desired colour and flavour characteristics. Kiln drying is divided into four major phases: (1) free drying down to approximately 23% moisture, (2) an intermediate stage, to 12% moisture, (3) the bound water stage, from 12 to 6% moisture, and (4) curing, in which the moisture is typically taken to 2–3%. Principle changes occurring during kilning is the browning or Maillard reaction. The interaction of reducing sugar and amino acids produces reductones, which in turn can be converted by polymerization to the colourful melanoidins or, by alternative routes, to the heterocyclic pyrazines, thiophenes, pyrroles, and furans. The oxygen heterocyclics are responsible for toffee or caramel flavours. The pyrazines impart the roasted, coffee like flavours.







## **Lesson 15**

### **METHODS OF PULSE MILLING – WET AND DRY METHOD, DOMESTIC AND COMMERCIAL MILLING**

#### **15.1 Introduction**

Pulses are defined as dried edible seeds of cultivated legumes. Pulses occupy important place in human diet. They serve as major sources of dietary protein and energy. The production of pulses in India was 13.19 million tones in 2001-02, which was 27% of the World's production. Bengal gram/Chick pea (chana), pigeon pea (tur/arhar), cow pea (lobia), black gram (urad), green gram (moong), lentils (masur), peas (matar) are some of the major pulses grown in India.

Pulses are consumed in its dehusked and split form which is termed as dal. Pulse milling (dal milling) is accomplished in three major steps namely: loosening of husk, dehusking and splitting of pulses. Pulses are generally consumed in the form of Dal. Traditional methods for processing of pulses were labour intensive, time consuming and incurred losses. Modern technologies for processing of pulses have replaced old age methods and thus avoid losses and saves time. Processing of pulses involves two basic steps – (i) seed coat/husk loosening and its removal and (ii) conversion of seed grain into splits and grinding into flour depending upon its end-use. Various methods are employed for pulse/dal milling. Pulses undergo some basic unit operations during pulse milling such as cleaning and grading, drying, loosening of husk, dehusking, splitting and polishing.

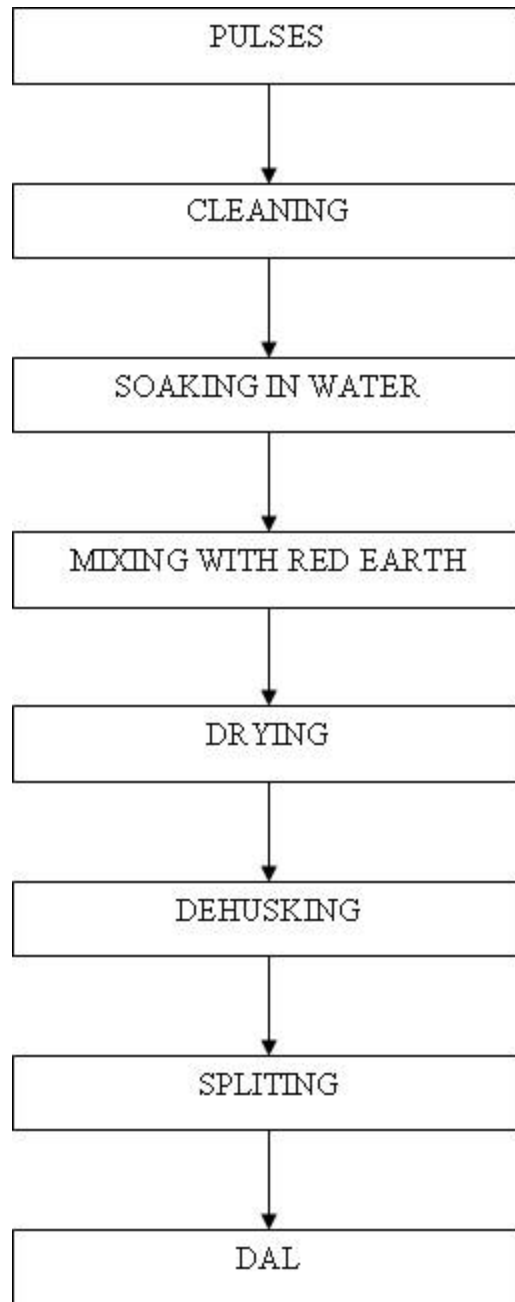
#### **15.2 Methods of Pulse Milling**

##### **15.2.1 Wet milling of pulses**

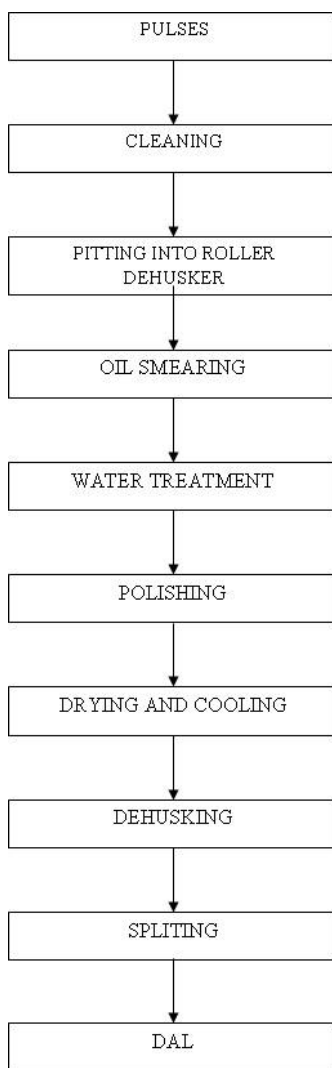
Wet method of pulse processing (Fig. 15.1) involves cleaning to remove dust, dirt, chaff, stone pieces, immature grains and other seeds. The easy to dehusk pulses are then soaked into water for a period of 2 – 8 hrs whereas difficult to dehusk type of pulses (pigeonpea, black gram, green gram) are often treated with red earth. The pulses are subsequently dried and then subjected to dehusking and splitting to obtain Dal.

### **15.2.2 Dry method of pulse milling**

In case of dry method of pulse milling (Fig. 15.2), the pulses after cleaning are fed into roller dehusker where a scratch, dent and crack is formed on the outer seed coat. Pitted pulses are then stored for ½ day to 3 days after applying oil on the surface. Generally 150 – 250 gm oil per 100 kg pulses is applied. The oil diffuses between husk and cotyledon and thus facilitates loosening of the husk. Water treatment (2.5 – 3.5 kg water/100 kg pulses for overnight period) helps in further loosening of the husk. Then the pulses are subjected to drying and cooling. Now, the dried pulses are dehusked and split to obtain dal.



**Fig. 15.1 Wet milling of pulses**



**Fig. 15.2 Dry milling of pulses**

### 15.3 Home Scale Milling of Pulses

The home scale method of processing of pulses involves pounding of pulses into mortar and pestle. Home scale method of pulse milling is different for different pulses and varies from region to region. In this method, the husk is loosen either by wet or dry method; treating the pulses with water and/or oil. The pulses are then generally stored overnight and the next day they are sun dried. The removal of husk is then carried out in pestle and mortar or by a hand operated stone mill. The husk then is separated by winnowing.

## **15.4 Commercial Scale Milling of Pulses**

### **15.4.1 Cleaning and Grading**

Pulses received at the mill needs to be cleaned and size graded for yielding good quality dal with higher recovery. Even during dehusking operation, pulses are subjected to sieving to separate out husk, broken, splits, gota (dehusked pulse) and whole (unhusked) pulses. Usually two, types of cleaners are used: reciprocating air-screen cleaners and reel screen cleaners.

In reciprocating air screen cleaners air is blown through two screens (sieves) which separate out lighter material such as dust, stalk, dried leaves, husk etc. The upper screen has bigger perforations while second screen has smaller perforations. The reel screen cleaners consist of 2-4 cylindrical compartments. The frame of the machine is made of wooden or mild steel sheet. In these compartments different size perforation screens are fitted on a 5-7.5 mm diameter shaft. The machine is fitted at an inclination of 2-3°. The cylindrical screen drum rotates at 5-35 rpm.

### **15.4.2 Drying of Pulses**

Drying of pulses is necessary to ensure safe storage before milling as pulses received at mill have generally higher moisture content. After steeping of pulses for loosening of husk, it is also necessary to dry pulses. During splitting operation too, it is very much essential to dry the pulses to separate cotyledons. Sun drying of pulses is economical option for drying of pulses. The sun drying is done for 1-6 days as per the requirement. The pulses are spread over floor/roof in 5 to 7.5 cm thick layer which are intermittently stirred manually with the help of rakes or turning by foot. At night, the drying pulses are collected in heaps and covered with canvass sheet to preserve the heat. Mechanically heated air dryers, either batch type or continuous flow type are also used by the millers. The temperature of heated air for drying varies from 60° to 120°C.

### **15.4.3 Loosening of Husk**

This is very important step in pulses milling as it decides the total recovery and quality of milled dal. Loosening of husk is accomplished in two different ways: wet method and dry method.

#### ***15.4.3.1 Wet Method***

Cleaned and graded pulses are soaked in water for 4-12 hours for steeping, mixed with red earth for 12-16 hours and then sun dried to keep the moisture content about 10-12 %. During steeping the husk becomes loose and thus facilitates easy dehusking and splitting. Yield is also increased

due to lesser breakage. But cooking time increases when the dal is obtained by this method. Red earth is used as it impart a good yellow colour to the end product and also helps to remove small patches of adhering husk due to its mild abrasive quality.

### **15.4.3.2 Dry method**

In this method, husk is loosened by sequence of operations such as: oil smearing, water application, tempering and sun-drying. Cleaned and graded pulses are passed through roller dehusker in which scratches, cracks and dents are created on hard seed coat of pulses. This is known as 'pitting' of pulses. The pitted pulse grains are then passed through the sieve cleaner to separate out the splits, husk and powder and later smeared with oil (100-500 gram per quintal of pulses) either manually or with auger mixer and stored for 1-5 days. During this tempering period oil diffuses in between the husk and cotyledons and weakens the bond and thus facilitates loosening of the adhering husk. At the end of storage period, water is applied to the grains (1-5 kg/q) and stored for further 12-14 h (overnight) and at last sun-dried for 1-3 days before subjecting to milling.

### **15.4.4 Dehusking**

Roller dehuskers coated with carborandum are used to dehusk the pulses. Two types of rollers viz. cylindrical and tapered are available for dehusking. Tapered rollers are placed horizontally and the diameter of roller increase from feeding side to discharge side. The difference in diameter helps to gradually increase the pressure on pulse grains and thus helps in gradual dehusking. The cylindrical rollers are installed at an angle of 10-15° which enables forward movement of pulse grains inside the machine. Annular gap between rollers varies depending upon the type of pulses being dehusked. Inlet and outlet of the roller machine can be adjusted for regulation of grain flow and retention time respectively. Small dal mills use under run disc shellers or burr mills for dehusking operation in place of Roller mills.

Conditioned pulse grains subjected to mild abrasion inside the roller machine, removes 10-25% of husk in one pass. Shelled husk, cotyledon powder, brokens and splits are separated out by Air-screen cleaners after passing the grain lot once or twice through the roller machine. Depending upon adherence of husk to grain, the pulse grains are passed through mill for two to eight times.

For hard-to-dehusk pulses (arhar, moong, urad), the recovery is between 70-75% while for easy-to-dehusk pulses (bengal gram, lentil, kesari and peas), it varies in between 78-85%.

#### **15.4.5 Splitting**

Splitting operation involves loosening the bond between the cotyledons and splitting. For cotyledons loosening, water at the rate of 1-5 kg/quintal is applied to dehusked pulse grain (gota) and is stored for 2-12 hours and later sun-dried for 4-8 hours. For splitting, machines like under-run-disc sheller (URD), impact machine (Phatphatia), roller mill, and hitting the gota against the metal sheet at discharge side of bucket elevator are used. In this operation the embryo attached to two cotyledons breaks away, thereby, causing a loss in dal recovery by 1.5 to 2%.

#### **15.4.6 Polishing**

In this operation dal is imparted with a glazing appearance to improve its consumer's acceptance and market value. Depending upon the need, different materials like water, oil, soapstone powder and 'selkhari' powder are applied to dal surface. Sometimes removal of sticking powder from dal surface is considered sufficient to improve its surface glaze.

##### ***15.4.6.1 Removal of powder/dust***

Cylindrical rollers mounted with the rubber mats, leather strips, emery rollers are used for the purpose. The dust particles sticking to dal surface are removed by gentle rubbing action on the roller surface.

##### ***15.4.6.2 Water polish***

This is used for hard-to-dehusk pulses. In this method 1-1.5 kg of water per quintal of dal is applied while passing it through polisher.

##### ***15.4.6.3 Buff polish***

In this method 2-2.5 kg of water and 200-250g of oil per quintal of dal is applied while passing it through polisher.

##### ***15.4.6.4 Nylon polish***

Soapstone powder or 'selkhari' powder (1-1.5kg/q) is applied to the surface along with water (1-1.5 kg/q) while passing through the polisher. Screw conveyors battery for repeated rubbings is used. The flights and shafts are covered with nylon rope to impart gentle rubbing.

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### *15.4.6.5 Teliya dal*

2.5 to 3.0 kg of castor oil is mixed per quintal of arhar dal to make it look glossy. The storage life of teliya dal is short.





## **LESSON 16**

### **ROASTED, GERMINATED, FERMENTED AND CANNED LEGUME PRODUCTS**

#### **16.1 Introduction**

Pulses are consumed in its dehusked and split form which is termed as dal. Pulse milling (dal milling) is accomplished in three major steps namely: loosening of husk, dehusking and splitting of pulses. Pulses are generally consumed in the form of Dal. Processing of pulses is important in improving their nutritive value. The processing methods used are soaking, germination, decortications, cooking and fermentation.

#### **16.2 Processing Methods**

##### **16.2.1 Soaking**

Soaking in water is the first step in most methods of preparing pulses for consumption. Soaking reduces antinutritional factors present in pulses. Soaking reduces the oligosaccharides of the raffinose family, which are responsible for flatulence after pulse consumption. Soaking also reduces the amount of phytic acid in pulses.

##### **16.2.2 Fermentation**

The processing of food pulses by fermentation increases their digestibility, palatability, and nutritive value. Soybean is very valuable pulse whose protein approaches the quality of animal protein. However, it cannot be directly used as food because of the anti-nutritional factors present in it. The anti-nutritional factors can be eliminated by fermentation process. The common examples of fermented product are idli and dosa (blend of fermented black gram and rice). This fermentation process improves the availability of essential amino acids.

##### **16.2.3 Germination**

Germinated legumes are also occasionally used as traditional legume foods. Sprouting causes partial breakdown of starch and proteins and contributes to the better digestibility. Sprouting also improves flavour of the legume. Sprouted legumes can also be used as a ready-to-use marketable

product. Sprouting causes hydrolysis of the oligosaccharides, also responsible for causing flatulence of legumes.

### **16.2.4 Puffing**

Puffed legumes are cheap and popular food for the common man. Puffing and toasting of pulses is practiced all over the country. The flavour and light texture of the product makes it popular among all age groups. These products are traditionally used as snacks. Puffing is effected by manual or mechanical roasting of conditioned legumes in hot sand. The increase in size is 1.5 to 2 times of its original size. Bengal gram and peas are best suitable for puffing. The puffing expansion during roasting is maximum in Bengal gram which is most popular for puffing.

The grains are first soaked in water for short duration (1-3 minutes), mixed with sand heated to 250°C and toasted for 15-25 seconds with agitation. After sieving off the sand, the grains are dehusked between a hot plate and a fast rotating rough roller. The yield of puffed product is about 65-70% by weight.

## **16.3 Legume Products**

### **16.3.1 Canned legume products**

Many pulses are required to be cooked soft for consumption. The cooking time needed for softening is long (15-45 min.). Instant or quick cooking pulses is necessary for modern urban consumers. Retort processed pulses in cans are now available in the super markets.

### **16.3.2 Besan manufacture**

Besan is made from chana dal (Bengal gram). Its production involves three major steps namely size reduction, sieving and packaging. Besan is made in rural areas and at home scale level in burr mills (*atta chakki*). Capacities of such machines vary in between 50-100 kg per hour.

Some manufactures employ Pulverizers (hammer mill) along with reel sieves (recovery of besan is 98%). The reel sieve is generally fitted with a fine nylon cloth (112 mesh). It has a blower rotating on its axis at 350 rpm. This helps in blowing out the fine powder out of the reel which is collected at one end by auger. The coarse powder discharged at other end is fed back to hammer mill by a bucket elevator.

### **16.3.3 Papad manufacture**

Papad is a thin round rolled sheet of dried papad flour. Papad flour is made by combining few pulses flours like urad, moong etc. In some papad flours, gram pulse is also added. Rolling papad is generally a manual operation done by women folks. The papad flour along with spices like black pepper, jeera, baking soda and salt is tightly kneaded with water and then rolled.

CFTRI has developed a papad mill where kneaded papad flour is pressed in round thin sheet by keeping the dough in between two polyethylene sheets and placing it in between two parallel discs. One disc is pressed against other with the help of foot through a lever. The capacity this machine is about 500 papad an hour.



## Lesson 17

### DEHULLING AND EXTRACTION OF OIL FROM OILSEEDS, PROCESSING OF VEGETABLE OIL, PROCESSING AND UTILIZATION OF OILSEED MEALS

#### 17.1 Introduction

The major role of edible oils and fats in our diet is to supply energy. Fat provide 9 kilo calories for each gram consumed. Fat contain poly-unsaturated fatty acids (PUFA) which reduces blood cholesterol and is important in prevention of coronary heart diseases. They also contain essential fatty acids (EFA) which are required in the maintenance of normal growth, reproduction and skin permeability. Apart from these fatty acids, fats are the only source of fat soluble vitamins such as Vitamin A, D, E and K in our diet.

World's five major annual edible oilseeds are soybean (*Glycine max* (L.) Merr.), cottonseed (*Gossypium hirsutum* L.), rapeseed/canola (*Brassica napus* L. *B. rapa* L. and *B. juncea* L.), sunflower seed (*Helianthus annuus* L. var. *marcocarplus* DC.) and peanut/groundnut (*Arachis hypogaea* L.) Almost all oilseeds are processed commercially by oil expellers. Oilseeds are made up of tinny particles called cells. Oil glands are embedded in each cell which liberates oil on rupturing. Thus, the primary object of oilseed processing is to rupture the gland and cell wall which gives more yield of oil during processing. Recovery of oil (primarily triglycerides and phospholipids) from oilseeds is facilitated by rupturing the cell wall by heat and pressure during flaking, and by optional extrusion with an expander, followed by pressing or solvent extraction.

#### 17.2 Extraction of Oil from Oilseeds

Extraction of oil is typically done by following methods listed in Table 17.1. A general oil extraction flow diagram is shown in Figure 17.1

##### 17.2.1 Cleaning

Oilseeds received at mill may contain certain impurities entering from field, during storage and transportation, or accidentally. Frequently encountered impurities include: straws, chaff, sticks,

weed seeds, other grains, shrunken and broken seeds, infected seeds, mud, dust, stones, metal objects, etc. Cleaning of oilseeds comprises removal of all the impurities mentioned above.

### **17.2.2 Conditioning/Tempering**

The ground or flaked oilseeds are heated with live steam to about 90°C. The purpose of tempering is to facilitate oil recovery. The heat treatment ruptures all the cells, partly denatures the proteins and inactivates most of the enzymes. It is very essential to maintain the optimum temperature to avoid formation of undesirable colouring compounds and aromas. After conditioning and moisture adjustment to about 3%, the oil is obtained by pressing and/or solvent extraction.

### **17.2.3 Pressing**

The oil is removed by pressure from an expeller or screw press. The residual oil in the resultant oilseed meal is about 4–7%. It is, however, more economical to apply lower pressures and to leave 15–20% of the oil in the flakes, and then to remove this oil by a solvent extraction process (“prepress solvent extraction” process).

**Table- 17.1: Oil extraction methods**

<b>S. No.</b>	<b>Method of oil extraction</b>	<b>Employed for</b>	<b>% residual oil in meal/cake</b>	<b>Remarks</b>
1	Solvent extraction	Low oil seeds (less than 30% oil)	0.5 – 1.0%	<i>Oil is solubilized by solvent (n-hexane).</i>
2	Full/Hard pressing	High oil seeds (greater than 30% oil)	4.5 – 7.5%	<i>Seeds are passed through continuous screw press.</i>
3	Prepress-solvent extraction	High oil seeds (greater than 30% oil)	0.75 – 1.25%	<i>16 – 20% oil is extracted by screw press and the cake is then treated with solvent to achieve further extraction.</i>

### 17.2.4 Extraction

The ground seeds are rolled into thin flakes by passing them between smooth steel rollers. The extraction is then performed using non-polar solvents such as food grade hexane, as a solvent (boiling point 60–70°C). In addition to n-hexane, it contains 2- and 3-methylpentane and 2,3-dimethylbutane and is free of aromatic compounds. Solvent removal from the raw oil-solvent mixture, called miscella, is achieved by distillation. The maximum amount of solvent remaining in the oil is 0.1%. The oil-free flakes are then steamed to remove the solvent (“*desolventizing*”) and, after dry heating (“*toasting*”), cooled and sold as protein-rich feed for cattle. The crude oil obtained either by pressing or solvent extraction contains suspended plant debris, protein and mucous substances. These impurities are removed by filtration.

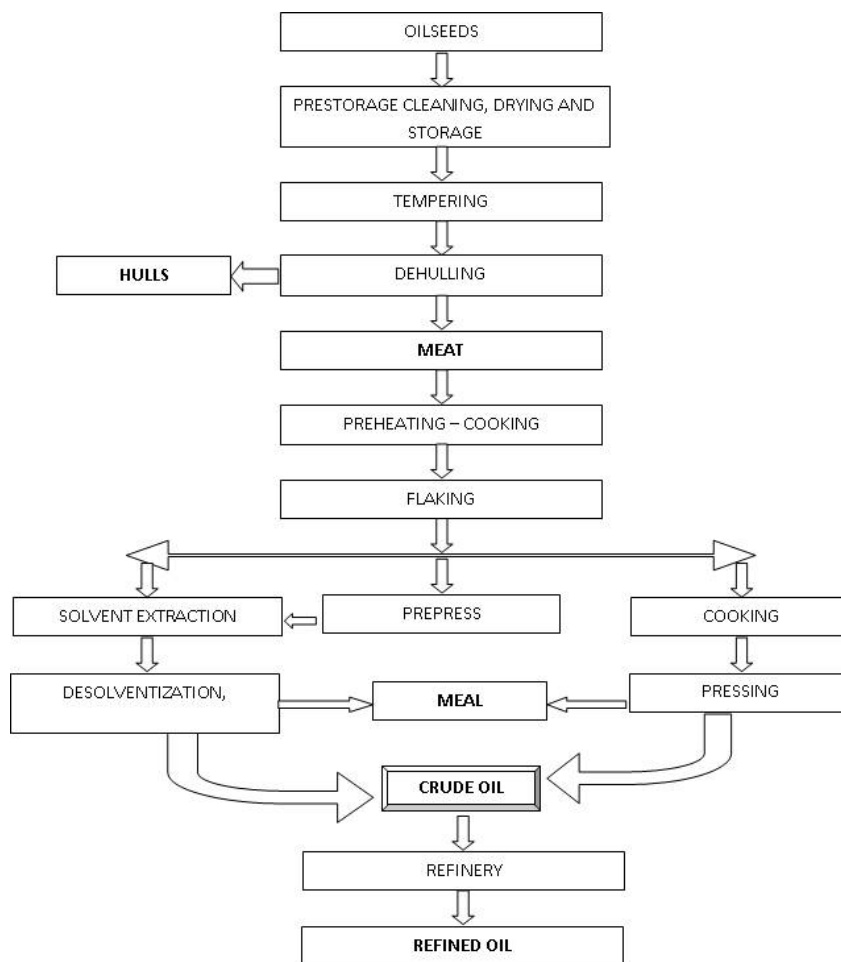


Figure 17.1 Flow diagram for oilseed extraction

### 17.3 Processing of vegetable oils

Many pathways exist for processing crude oil into various commercial oil and fat products (Fig. 17.2)

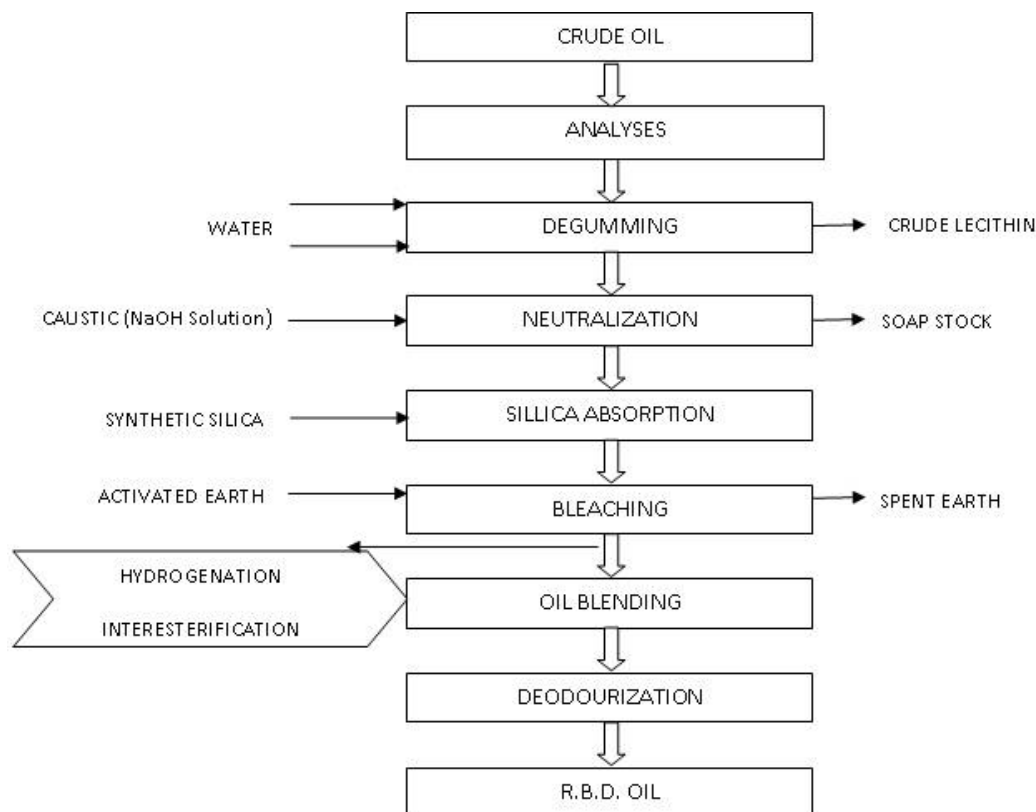


Figure 17.2 Flow diagram of vegetable oil processing

#### 17.3.1 Analyses of crude oil

Before starting processing, oils are brought from storage tanks into a 'day tank', which is thoroughly mixed and sampled for analyses to determine the treatments to be applied. These tests include free fatty acids, phosphorous, moisture, insoluble impurities and colour.

#### 17.3.2 Degumming

Degumming is the process of removing phosphatides by hydration with water. The phosphatides must be removed to prevent darkening of the oil during the high temperatures of deodourization and in later applications like frying and to extend oil shelf life. Degumming is practiced for recovering crude lecithin for later purification. Approximate phosphatides content of the major crude oils vary between 0.5 to 3.5%.

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Crude oil is heated to 60-80°C and soft water at the rate of 75% of the weight of phosphatides is added into oil, and hydration allowed to occur with the mixing for 30-60 min. Although the hydrated gums will settle by gravity, in commercial installations, separation is accelerated by use of decanters and disc type centrifuges. Simple water degumming typically reduces phosphorus content of soybean oil from 500-800 ppm to well under 50 ppm. Levels of 0-5 ppm phosphorus are desired in oils going to be deodourized. To obtain this, it may be necessary to solubilise the nonhydratable phosphatides by acid degumming. Phosphoric and citric acids are used to chelate and withdraw the divalent cations and restore phosphatide solubility in water.

### **17.3.3 Neutralization**

Neutralization is the step of converting the free fatty acids in crude oils to soaps. It is some times called 'alkali neutralization' or 'refining'. Sodium hydroxide is the most popular neutralizer used for refining of crude oils. Two continuous refining systems are used: long mix process and short mix process.

The long mix process uses a lower concentration of caustic and is conducted at ambient temperature 33°C with 8-15 minutes. Then the oil is heated to 70°C, to assist breaking the emulsion and the mixture is passed through centrifuge.

The short mix process is conducted at 90°C, uses a more highly concentrated caustic, and a mixing and centrifuging time of less than 1 minute.

### **17.3.4 Silica absorption**

In traditional refining, oil from primary centrifuge is washed with warm soft water to remove residual soap and passed through secondary centrifuge. In modern method degummed, caustic neutralized, partially vacuum dried oil is mixed with synthetic silica. Synthetic silica hydrogels, effective in removing 7-25 times more phosphatides and soaps than clay on a solid basis.

### **17.3.5 Bleaching**

The objective of the bleaching is to remove various contaminants, pigments, metals and oxidation products before the oil is sent to the deodourizer. Types of bleaching material available include: natural earth, acid activated earth and activated carbon. A typical vacuum bleaching process is 20-30 minutes at 100-110°C and 50mmHg absolute.

### **17.3.6 Hydrogenation**



Hydrogenation is the process of adding hydrogen to saturate carbon-to-carbon double bond. It is used to raise triglyceride melting points and to increase the stability against oxidation. Most of the catalysts that assist hydrogenation are nickel-based. Efficient hydrogenation requires cleanest possible feed stock and the purest, driest hydrogen gas possible. The catalyst must be completely removed by filtration before further processing of the oil.

### **17.3.7 Interesterification**

Controversies exist about the healthfulness of trans fatty acids produced during hydrogenation. Interesterification is a technique for positioning or rearranging fatty acids on triglycerides. This technique is followed as a means of obtaining trans-free margarines, spreads and shortenings. Interesterification mainly uses sodium methylate, sodium ethylate or other catalysts and is assisted by temperature manipulation. Position specific enzymes such as 2-glycerol and 1,3-glycerol position are also employed for interesterification. The catalyst must be deactivated and the resulting oil purified before further processing.

### **17.3.8 Chill fractionation**

Chill fractionation is a process of chilling oil to a selected temperature to cause crystallization of a fraction. The crystals can be removed by vacuum belts or frame pressure filters equipped with inflatable air bladders.

Essentially all the palm oil is chill fractionated. The fraction seen most as palm oil is the olein.

### **17.3.9 Oil blending**

Oil blending is an optional step, used primarily when oils with specific solid temperature profile are prepared. If blending does not occur, the oil may go directly from bleaching to deodourization.

### **17.3.10 Deodourization**

The last treatment given to oil before leaving a refinery is deodourization to reduce its peroxide value to essentially zero. Deodourization is essentially steam distillation process for removing peroxides as well as flavours and odours from the oil. Soybean oil is deaerated, then deodourized in continuous deodourizers for 15-60 minutes at 252-266°C with an absolute pressure of 1-6 mmHg, using stripping steam at the rate of 1-3% of the weight of oil.

### **17.3.11 RBD Oil**

Some countries want characteristic flavours and colours left in their oils. In contrast, RBD (Refined, bleached, deodourized) oils are light coloured and bland regardless of the species. Supplier specifications generally are tighter than trade association specifications. Several suppliers offer soyben oil with <0.05% free fatty acids and 1.0 meq peroxide value.

#### **17.4 Utilization of Oil Seed Meal in Food Formulations**

Oil seed meal refers to coarse residue obtained after oil is removed from various oilseeds. It is relatively rich in protein and minerals and generally used as poultry and other animal feed. It may be broken up and sold or be ground into oil meal. Oil meal from certain seeds such as castor beans and tung nuts are toxic and are used as fertilizers rather than feed.

Oilseeds from which oil meal used as feed is produced include soybeans, peanuts, flaxseed (linseed), rapeseed, cottonseed, coconuts (copra), oil palm, and sunflower seeds. Cottonseed and peanuts have woody hulls and shells, which are generally removed before processing. The pressed cake from the production of cottonseed oil must also be processed to remove a toxic pigment called gossypol, before it can be used as feed for non-ruminants such as pigs and poultry.

##### **17.4.1 Food uses of oil cakes**

To cope up with protein deficiency malnutrition, cereal based products play a pivotal role as a vehicle for value-addition being consumed by masses. Defatted oil cake meal is widely used in various food formulations to improve quality characteristics and nutritional values.

The products in which oil cake meal are successfully used are shown in Table-17.2

**Table 17.2 Uses of oil cake meal in food formulations**

<b>Sr. No.</b>	<b>Food Product</b>	<b>Results</b>
1	Comminuted meat products	<input type="checkbox"/> Improved sensory quality <input type="checkbox"/> Improved yield
2	Frankfurters	<input type="checkbox"/> Batter stabilizing effect <input type="checkbox"/> Improved nutritional value

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3	Macaroni	<input type="checkbox"/> Longer dough mixing time <input type="checkbox"/> Higher water absorption <input type="checkbox"/> Improved protein content and amino acids profile
4	Bakery products	<input type="checkbox"/> Improved the amino acid and mineral composition



## **Lesson 18**

### **PROCESSING OF SOYBEAN AND OTHER OILSEEDS; DAIRY ANALOGUES**

Most of the unit operations involved in processing of oil seeds are discussed in the lesson no. 17 (Fig.17.1). In this lesson special requirements for processing of soybean and other oilseeds are discussed.

#### **18.1 Soybean**

Soybean can be processed at 12% moisture if not dehulled to make 44% protein content meal. In earlier years, in order to make high protein content soybean meal, hulls were loosened by drying the seeds from 13% moisture to 10% moisture at 65°C, cooling and holding for 1-5 days before dehulling. The hot dehulling process was developed to eliminate double heating of soybean. Soybean at 13% storage moisture are heated to 60°C during a period of 20-30 minutes to allow the moisture to migrate to the surface. Then they are rapidly heated to surface temperature as high as 85°C to loosen the hulls. During this process moisture is reduced by 1-3%. The soybeans are then cracked into six to eight pieces and flaked at 60-65°C and 10-11% moisture.

The phospholipase enzyme activity can be minimized by the following: drying seeds adequately before storage, avoiding breakage in handling, moving seed rapidly from dehulling to extraction with minimum addition of water, operating outside the optimum activity temperature range of the enzyme.

Soybean oil is the main source of commercial lecithin harvested by a degumming operation before alkali neutralization.

#### **18.2 Rapeseed/Canola**

The majority of rapeseed/canola oil recovery is by press-solvent extraction, with about 60% of the total oil removed in the first operation. Seed often is flaked at 7.0-9.5% moisture in two stages: to 0.4-0.7 mm thickness in the first and to 0.2-0.3 mm in the second.

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Cooking reduces moisture content to 5-6% for hard pressing, denatures the protein and enhances coalescing of minute oil droplets into larger ones, inactivates the enzyme myrosinase (thus preventing hydrolysis of glucosinolates and reducing sulphur content of the oil), inactivates phospholipases and prevents development of monohydratable phosphatides in the oil.

### **18.3 Corn germ**

The distribution of oil in corn is approximately as follows: germ,83%; endosperm, 15%; bran, 1.3%; tip cap, 0.7%. Most corn germ is a by-product of starch and corn sweeteners production by wet milling or alcohol fermentation, and contains 44-50% oil when dried to 2-4% moisture content. Dried wet milled germ is moistened to 8%, heated to 90-105°C to soften its intracellular structure, flaked to 0.10-0.13mm in thickness, prepressed and solvent extracted to 0.5% residual oil.

### **18.4 Cottonseed**

Cottonseed requires special handling techniques. Flaked cottonseeds are extruded through an expander at 13% moisture and 100°C. The objective of flaking is to rupture both the spherosomes containing the oil and glands containing gossypol. The flaked cottonseed material is held hot for 20 minutes, retextured at 113°C, dried/cooled to 11% moisture at 57°C before solvent extraction.

The residual oil content in cake from a press is in the range of 4.0-6.5%. Solvent extracted meal contains 0.5-0.7% residual oil.

### **18.5 Peanut**

The processing of peanut poses special problems. They mature in soil, and additional efforts are needed to remove small stones and sand to reduce wear on machines. Aflatoxin contamination is a potential and must be monitored constantly.

Shelled peanuts contain 50% oil. Generally peanuts are processed by full press or prepress solvent extraction. To provide traction in the screw press, peanuts are cooked to 5% moisture content. If only a prepressing is given, the cake is crumbled and solvent extracted.

Direct solvent extraction process uses two stages:

1. The kernel are cooked and sent to roll stand equipped with an upper set of corrugated rolls and a lower set of smooth rolls. They are cracked into quarters by the upper rolls, then given a light flaking in the lower rolls without production of fines.

2. After the first extraction stage, the flakes are rolled again and re-extracted.

### 18.6 Sunflower seed

Sunflower seed is the only major raw crop oilseed that does not have identified antinutritional factors requiring inactivation during processing. Oil type seeds are black in colour and consist of 20% hull and 40-45% oil. The seed clings to hull, which is thin, flexible and difficult to remove. Typically, oil-type sunflower seed are dehulled to the desired fiber content, heated, flaked, prepressed and than solvent extracted.

### 18.7 Vegetable Protein Concentrates and Isolates

Due to high protein content and ease of extraction, soybean is widely used to obtain protein for special food uses. Soy protein is made from dehulled, defatted soybean meal. Dehulled and defatted soybeans are processed into high protein commercial products such as soy protein concentrates and soy protein isolates. Soy protein is used in a variety of foods such as salad dressings, soups, imitation meats, beverage powders, cheeses, non-dairy creamer, frozen desserts, whipped topping, infant formulas, breads, breakfast cereals, pastas, and pet foods. Soy protein is used for emulsification and texturization in various products. Specific applications include as adhesives, asphalts, resins, cleaning materials, in cosmetics, inks, leather, paints, paper coatings, pesticides/fungicides, plastics, polyesters, and textile fibres.

#### 18.7.1 Production methods

Edible soy protein isolate is derived from defatted soy flour with a higher solubility in water. The aqueous extraction is carried out at a pH below 9. The extract is clarified to remove the insoluble material and the supernatant is acidified to a pH range of 4-5. The precipitated protein-curd is collected and separated from the whey by centrifugation. The curd is usually neutralized with alkali to form the sodium proteinate salt before drying.

Soy protein concentrate is produced by immobilizing the soy globulin proteins while allowing the soluble carbohydrates, soy whey proteins, and salts to be leached from the defatted flakes or flour. The protein is retained by one or more of several treatments:

- Leaching with 20-80% [aqueous](#) alcohol/[solvent](#)
- Leaching with aqueous acids in the isoelectric zone of minimum protein solubility (pH 4-5)

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- Leaching with chilled water (which may involve calcium or magnesium cations)
- Leaching with hot water of heat-treated defatted soy meal/flour.

All of these processes result in a product that contained  $\geq 70\%$  protein, 20% carbohydrates (2.7 to 5% crude fiber), 6% ash and about 1% residual fat, but the solubility may differ. One tonne of defatted soybean flakes will yield approximately 750 kg of soybean protein concentrate

### **18.7.2 Product types**

#### ***18.7.2.1 Isolates***

Soy protein isolate is a highly refined or purified form of soy protein with a minimum protein content of 90% on a moisture-free basis. It is made from defatted soy flour which has had most of the non-protein components, fats and carbohydrates removed. Because of this, it has a neutral flavour and will cause less flatulence due to bacterial fermentation.

Soy isolates are mainly used to improve the texture of meat products, but are also used to increase protein content, enhance moisture retention, and as an emulsifier. Pure soy protein isolate is used mainly by the food industry. It is available in health stores or in supermarket as pharma food. It is usually used in combination with other food ingredients.

#### ***18.7.2.2 Concentrates***

Soy protein concentrate must contain not less than 70% soy protein and is basically defatted soy flour without the water soluble carbohydrates. Soy protein concentrate retains most of the fiber of the original soybean. It is widely used as functional or nutritional ingredient in a wide variety of food products, mainly in bakery products, breakfast cereals, and in meat products. Soy protein concentrate is used in meat and poultry products to increase water and fat emulsification and to improve nutritional values (more protein, less fat).

Soy protein concentrates are available in different forms: granules, flour and spray-dried. Because of their higher digestibility, they are well-suited for children, pregnant and lactating women, and the elderly. They are also used in pet foods, as milk replacer for infants ([human](#) and livestock), and even in some non-food applications.

## **18.8 Dairy Analogues**

The rising demand by the consumers for healthy food has led to the alternative demand and development of dairy-like products, such as soy-based analogues. Soybean can be processed into many soy products which are analogous to dairy products such as soy beverage (soy milk), tofu (soy paneer), soy yoghurt.

### **18.8.1 Soy milk**

Soy milk/soy beverage is a water soluble extract from whole soy beans. It is an off-white emulsion or suspension containing water soluble proteins, carbohydrates, and lipids. It resembles dairy milk in appearance. However, it is lactose free and represents an alternative to dairy milk.

Commercial soy beverages can be classified according to their composition such as: high solids soy milk (bean to water ratio of 1:5), dairy like soy extract (bean to water ratio of 1:7) and lower solids soy beverage (bean to water ratio of 1:20). Depending upon the processing parameters and water to soybean ratio, soymilk would have a typical solids content around 8-10%. Within this, protein is 3.6%, fat 2.0%, carbohydrates 19.9% and ash 0.5%.

Soy milk is healthy drink as it is cholesterol and lactose free. It also contains phytochemicals, which has proven health benefits.

### **18.8.2 Tofu**

Tofu is a high protein food made from soybeans. It is used as meat or cheese substitute. It is sold as ready to eat cakes that resemble paneer or soft white cheese. The preparation of tofu involves extraction of soymilk and then coagulation of this extract to form curd. The curd is then pressed to form tofu cakes.

Typical wet composition of tofu is 85% moisture, 7.8% protein, 4.2% lipid. The remaining constituents are carbohydrates and minerals. The typical dry composition is made up of 50% protein, 27% fat and 23% carbohydrates and minerals.

Tofu can be categorised as silken or pressed tofu. Silken tofu production involves soy extract being finely filtered and heated before cooling to a temperature of 65-70°C. Calcium sulphate/magnesium chloride of low concentration is added to the extract. A fine, smooth and firm curd forms after 30-60 minutes. This curd is left unbroken.



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In case of pressed tofu, coagulant is vigorously stirred into hot soy extract. The curd is broken and pressed. Pressed tofu contains about 22% protein and 61.6% moisture.

### **18.8.3 Soy yoghurt**

While milk based yoghurt has long been consumed in many countries, soy yoghurt, also known as soghurt, is a relatively new product. It is produced through the fermentation of soymilk by different cultures of bacteria to form soft, fragile, custard like texture, generally containing 12-14% total solids and possessing a clean tart flavour.

There are several types of soghurts. Soghurt can be produced in the form of a highly viscous texture, a softer gel or in frozen form as a dessert or drink. Generally they can be classified as: set type soy yoghurt, stirred type and drink type.

