# UNIT – 1

# INTRODUCTION

## Introduction to food technology, Scope and current trends in food technology

Today India is not only self-sufficient but also exports food and has a reserve because of advances in food technology. During the last decade many indigenous developments have taken place in the field of food technology reducing dependence on imported know-how. During these years increased industrialization and its social consequences accelerated the development of technology. As a result, food industries took birth and shape. The desire to spend less time in kitchen, importance attached to leisure, higher living standards, urge for eating outside home and weakening of family ties, create scope for pre-cooked and pre-packed food inconvenient and ready-to-eat forms. Special food for infants, growing children, convalescents, old people, astronauts, defense forces and expeditions have also been designed and produced.

Natural Food colors, bioactive principles from plant sources, value addition to the byproducts from various food processing industries, environmentally accepted technologies water conservation in the processing are the newer areas of development taking place in food technology. Food processing is generally regarded a traditional industry but advances in microelectronics, instrumentation and control, new materials, bio processing and biotechnology beginning to propel the industry at a faster rate. Food industry has been identified as priority industry in the union budget 2006.

## Genetically Modified Foods

Genetically modified (GM) foods are foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism. The technology is often called “modern biotechnology” or “gene technology”, sometimes also “recombinant DNA technology” or “genetic engineering”. Currently available GM foods stem mostly from plants, but in the future foods derived from GM microorganisms or GM animals are likely to be introduced on the market. Most existing genetically modified crops have been developed to improve yield through the introduction of resistance to plant diseases or of increased tolerance of herbicides. GM foods can also allow for reductions in food prices through improved yields and reliability.

In the future, genetic modification could be aimed at altering the nutrient content of food, reducing its allergenic potential or improving the efficiency of food production systems. All GM foods should be assessed before being allowed on the market. FAO/WHO Codex guidelines exist for risk analysis of GM food.

## Biofortification

Biofortification is the process by which the nutritional value of food crops is enhanced by various methods including plant breeding, agronomic practices and modern biotechnological techniques.

- Basically, biofortification is the process of growing crops to increase nutrition value from the seed on.
- In biofortification, the nutritional value of crops is improved during the plant growth stage, i.e., nutritional micronutrient content is embedded in the crop being grown.
- Crops can be biofortified through selective breeding or genetic engineering. In India, biofortification is done exclusively through selective breeding.
- The focus of biofortification research is iron, zinc and vitamin A deficiencies. These are the micronutrients whose deficiencies affect the most number of people worldwide. In India, the focus is on pearl millet (iron), wheat (zinc), sorghum (iron), rice (zinc), cowpeas (iron) and lentils (iron and zinc).
- Currently, biofortified pearl millet, rice, and wheat are available to farmers in India.

According to many researchers, hidden hunger can be solved by biofortifying food crops.

- Biofortification helps in achieving overall health improvement in the people.
- Such crops are more resilient to diseases, pests, droughts, etc. and provide better yields.
- It offers a food-based, sustainable and low-dose alternative to iron supplements.
- It has the potential to reach the poorest section of society (who cannot afford food supplements) and will also benefit farmers.
- It is highly cost-effective since once the initial research is done, the process can be easily replicated and scaled.
- Biofortification done through non-genetically modified methods (like traditional plant breeding done in India) is a better alternative then introducing GM crops that face implementation barriers.
- In a country such as India, that faces huge nutritional challenges, biofortification is a sustainable, cost-effective method that can help resolve this challenge.

**Convenience Foods**

Convenience food, also called tertiary processed food, is food that is commercially prepared (often through processing) to optimise ease of consumption. Such food is usually ready to eat without further preparation. It may also be easily portable, have a long shelf life, or offer a combination of such convenient traits. Although restaurant meals meet this definition, the term is seldom applied to them. Convenience foods include ready-to-eat dry products, frozen foods, shelf-stable foods, prepared mixes such as cake mix, and snack foods.

Bread, cheese, salted food and other prepared foods have been sold for thousands of years.

Extrusion technology, Retort processed foods, Energy bars, convenience meat products, fish based convenience foods are some of the advanced convenience foods.

## Space Foods

Space food is a type of food product created and processed for consumption by astronauts during missions to outer space. The food has specific requirements of providing balanced nutrition for individuals working in space, while being easy and safe to store, prepare and consume in the machinery-filled weightless environments of crewed spacecraft. Most space food is freeze-dried to ensure a long shelf life. Designing food for consumption in space is an often difficult process. Foods must meet a number of criteria to be considered fit for space. Firstly, the food must be physiologically appropriate. Specifically, it must be nutritious, easily digestible, and palatable. Secondly, the food must be engineered for consumption in a zero-gravity environment. As such, the food must be light, well packaged, fast to serve, and require minimal cleaning up. Finally, foods require a minimum of energy expenditure throughout their use; they must store well, open easily, and leave little waste behind (foods that tend to leave crumbs, for example, are ill-suited for space).

### Types

There are several classifications of space food, as follows:

- *Beverages (B)* - Freeze dried drink mixes (coffee or tea) or flavored drinks (lemonade or orange drink) are provided in vacuum sealed beverage pouches. Coffee and tea may have powdered cream and/or sugar added depending on personal taste preferences. Empty beverage pouches are provided for drinking water.
- *Fresh Foods (FF)* - Fresh fruits, vegetables, and tortillas delivered by resupply missions. These foods spoil quickly and need to be eaten within the first two days of the package's arrival to the ISS to prevent spoilage. These foods are provided as psychological support for astronauts who may not return home for extended periods of time.
- *Irradiated (I) Meat* - Beef steak that is sterilized with ionizing radiation to keep the food from spoiling. NASA has dispensation from the U.S. Food and Drug Administration (FDA) to use this type of food sterilization.
- *Intermediate Moisture (IM)* - Foods that have some moisture but not enough to cause immediate spoilage. Examples include sausage and beef jerky.
- *Natural Form (NF)* - Commercially available, shelf-stable foods such as nuts, cookies, and granola bars that are ready to eat.
- *Rehydratable (R) Foods* - Foods that have been dehydrated by various technologies (such as drying with heat, osmotic drying, and freeze drying) and allowed to rehydrate in hot water prior to consumption. Reducing the water content reduces the ability of microorganisms to thrive.
- *Thermostabilized (T)* - Also known as the retort process, this process heats foods to destroy pathogens, microorganisms, and enzymes that may cause spoilage.
- *Extended shelf-life bread products* - Scones, waffles, and rolls specially formulated to have a shelf life of up to 18 months.

More common staples and condiments do not have a classification and are known simply by the item name.

## Food Fortification

Fortification is the addition of key vitamins and minerals such as Iron, Iodine, Zinc, Vitamins A & D to staple foods such as rice, wheat, oil, milk and salt to improve their nutritional content. These nutrients may or may not have been originally present in the food before processing or may have been lost during processing.

Role of food fortification:

1. Tackling the issue of hidden hunger: Deficiency of micronutrients or micronutrient malnutrition, also known as hidden hunger, is a serious health risk. It is an excellent method to improve the health of a large section of the population, all at once. As Nutrients are added to staple foods which are widely consumed through food fortification.
2. It is a safe method of improving nutrition among people. The addition of micronutrients to food does not pose a health risk to people. The quantity added is small and well under the Recommended Daily allowance (RDA) and are well regulated as per prescribed standards for safe consumption.
3. Food Fortification has a high benefit-to-cost ratio. It is a cost-effective intervention and does not require any changes in eating patterns or food habits of people. It is a socio-culturally acceptable way to deliver nutrients to people.

So food fortification is one of the key tools for solving hidden hunger issue and improving the health indicators of the country. It is a key tool for improving the socio economic condition of the people.

# UNIT - II

## Compositional, Nutritional and Technological aspects of Plant foods I.

### CEREALS AND MILLETS

### STRUCTURE OF CEREAL GRAIN

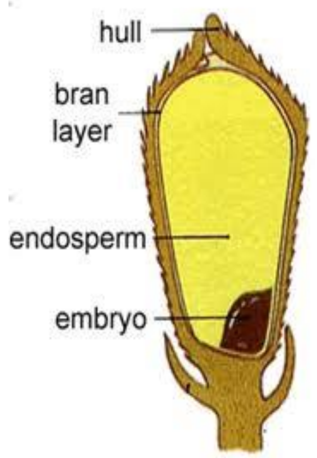
The whole cereal grains are composed of an outer bran coat, a germ and a starchy endosperm.

The outer chaffy coat that covers the kernel is eliminated when the grains are first subjected to milling. The outer layer of the kernel is Bran, which constitutes 5% of the kernel. During milling, the bran is discarded. The bran has a high content of fibre and minerals. It is also a good source of thiamine and riboflavin.

The aleurone layer is a layer located just under the bran. The cells are rich in protein, phosphorus and thiamine. They also contain some fat. The aleurone layer makes up about 8% of the whole kernel. This layer is also lost in the milling process along with the bran.

The Endosperm is the large central portion of the kernel and constitutes about 84-85% of the kernel. It contains most of the starch and protein of the kernel, but very little mineral matter or fibre, and only a trace of fat. The vitamin content of the endosperm is low.

The Germ is a small structure at the lower end of the kernel. It makes up 2-3% of the whole kernel. It is rich in fat, protein, minerals and vitamin. The germ serves as a store of nutrients for the seed when it germinates. During milling, some of the germ is lost along with the bran and aleurone layer.



**COMPOSITION AND NUTRITIVE VALUE OF CEREAL GRAIN**

The chemical constituents of cereals are carbohydrates, proteins, lipids, minerals and water together with small quantities of vitamins, enzymes and fibre.

**Energy:** Cereals are the main source of energy, contributing 70-80% of the requirement. Hundred grams give more than 340kcal of energy.

**Carbohydrates:** 80% of the dry matter of cereal is carbohydrate. Carbohydrates present in cereals are of two types.

1. Crude fibre such as cellulose, hemicelluloses and pentosans.

2. Soluble carbohydrates: Starch is the most important carbohydrate in all cereals. Small quantities of dextrins and sugars are also present. Sugars include simple sugars such as glucose and galactose and oligosaccharides like sucrose, maltose and raffinose. Of all the cereals, whole wheat, ragi and bajra contain high amount of fibre. Whole cereals are rich in fibre of their outer covering. Fibre absorbs water, swells and helps to eliminate the waste products from the gastrointestinal tract smoothly, thus preventing constipation. When atta is shifted, the fibre particles and some of the minerals and vitamins are removed. Therefore, it is wise to avoid shifting atta as far as possible.

**Proteins:** The protein content of cereals is 6-12%. The protein content of different cereals varies and that of rice is lower than that of all other cereals. The protein content of different varieties of the same cereal also varies. Proteins are found in all the tissues of cereal grains. Higher concentrations occur in the germ and aleurone layers than in the starchy endosperm. Within the endosperm the concentration of protein increases from the centre to the periphery. The types of proteins present in cereals are albumins, globulins, prolamines and glutelins. The storage protein of rice is oryzenin.

The proportions of these proteins differ in different cereals. The gliadins and glutelins are known as gluten proteins. The prolamines of wheat are gliadins. Gluten is present in wheat and barley. Gluten has elasticity and flow property of a unique value useful for baking bread and other products.

The amino acid composition of proteins in the cereal grains vary. They are generally low in lysine. The biological value of the proteins in germ and aleurone layer is higher than that of the endosperm proteins.

**Fats:** Lipids are present to an extent of 1 to 2 % in wheat, rice, rye and barley, 3 % in maize and 4 to 6% in oats. More lipids are present in germ and bran than in the other parts of the grain. The lipids are mostly the triglycerides of palmitic, oleic and linoleic acids. Cereals also contain the phospholipids, lecithin.

Considering the amount of cereal consumed it is estimated that fat present in cereals in our diets can meet more than 50% of our essential fatty acid requirement. Cereals together with pulses can nearly meet the essential fatty acid requirement of an adult.

**Minerals:** The husk of the cereals is rich in minerals. The kernels of cereals also contain minerals. The minerals present in cereals are phosphates, sulphates, potassium, magnesium and calcium. A considerable part of phosphorus in cereals is present in the form of phytin, calcium and magnesium salts of phytic acid. Phosphorus and calcium present in phytin are not available for absorption. Some mineral elements like copper, zinc, manganese and iron are also present in very small quantities in cereals. Oats and bajra are particularly rich in iron. Rye and oats have the highest calcium content among all cereals. Ragi is also rich in calcium and iron.

**Vitamins:** B-group vitamins are present in all cereals more or less to the same extent except niacin. Niacin is more in wheat, rice and barely. The distribution of the vitamins in different grains and in different parts of the same grain is not uniform. Oils from cereal grains are rich in vitamin E.

**Enzymes:** Cereal grains contain amylases, proteases, lipases and oxidoreductases. The proteases are relatively more in the germ. The lipases of cereals are responsible for the changes in fats during storage.

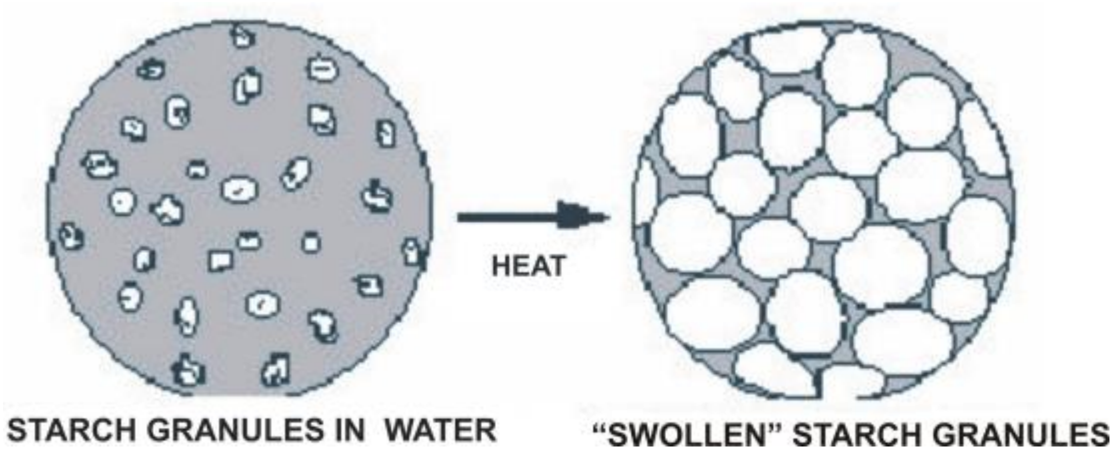
## GELATINIZATION OF STARCH

Starch granules do not dissolve readily in cold water but they will form a temporary suspension with the starch tending to settle out as soon as the mixture is allowed to stand. When heated with water the intramolecular hydrogen bonding is broken and grains absorb water and swell, the viscosity increases until a peak thickness is reached and the translucency of the mixture also increases. The term gelatinisation is used in general to describe these changes. The changes appear to be gradual over a temperature range during gelatinisation and the change transforms the temporary suspension into a more permanent one.

The swelling of starch particularly amylase result in the formation of a gel with water is believed to occur through the binding of water. In starch the amylase and amylopectin molecules are loosely bound together by hydrogen bonds of hydroxyls.

As the temperature increases of the starch water mixture, the hydrogen bonding decreases and water molecules begin to penetrate freely between the starch molecules. The starch mixture will thicken between 70ºC and 88ºC but complete gelatinization will not occur until the mixture is close to or at the boiling point. This will vary with the type of starch and size of grain. Large grains swell at a lower temperature.

Application in food industry – in making sauces, puddings, creams and other food products, providing a pleasing texture.




**GLUTEN**

Among cereal flours, only wheat flour forms a visco-elastic dough when mixed with water. The visco-elasticity is due to the gluten, a protein present in wheat. The presence of glutelin and gliadin in the wheat makes it suitable for certain recipes. While mixing the wheat flour with water the protein fractions of glutelin and gliadin form tough elastic complex termed gluten. Due to its elastic property, the dough can be rolled to prepare chapathi or puri. The gluten proteins are water soluble and thus will swell and interact. Wheat flour doughs are unique in their ability to retain gas, due to slow rate of gas diffusion within the dough. The ability to retain gas results in production of light leavened products attributed to gluten protein.

**Factors affecting gluten formation**

**Variety of wheat** – Hard wheat are better suited for making bread as they have more gluten than soft wheat. Thus choice of variety will depend on the characteristics desired in the final prepared product.

**Amount of water added to make the dough/batter** – Gluten should be well hydrated to develop completely. If the liquid content is insufficient, a hard dough is formed and the gluten development may be poor. However addition of excess water may produce a runny batter which may be difficult to manipulate.

**Kneading time and keeping time –** Greater the kneading or manipulation of the dough or batter greater the gluten development. However, over manipulation may break the gluten network.

**Presence of fat/oil –** Fat or oil added to the dough in large quantities hinders development of gluten. A small amount of oil is added to the dough. Refined oil, butter or vanaspati are used in cakes and biscuits.

**Fineness of milling** – Wheat flour that has been milled finely has a greater gluten development capacity than coarsely milled flour.

The insoluble gluten can be separated readily from flour by adding water to form a stiff dough and by kneading in water to wash away the other constituents, largely starch. The wet gluten is a cohesive elastic mass that expands greatly on baking to form a light porous ball. Baking the gluten shows that it expands greatly as the steam within it expands and it coagulates when heated to form the structure of the baked product.

## PULSES

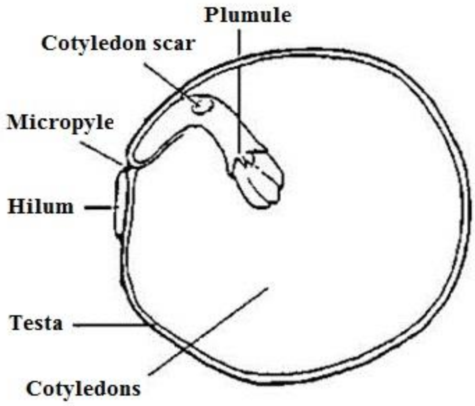
### STRUCTURE OF PULSES

The term pulses is limited to crops harvested solely for dry grain, thereby excluding crops harvested green for food mainly as vegetables (peas, beans, etc.), crops used mainly for oil extraction (e.g. soybean and groundnut) and leguminous crops for sowing purpose (e.g. seeds of clover and alfalfa). A legume is a plant in the family *Fabaceae* (or *Leguminosae*), or a fruit of these specific plants. A legume fruit is a simple dry fruit that develops from a simple carpel and usually dehisces (opens along a seam) on two sides. A common name for this type of fruit is a pod. Well-known legumes include peas, beans, lentils, black gram, green gram, soy and groundnut.

Pulses all have a similar structure, but differ in color, shape, size, and thickness of the seed coat. Mature seeds have three major components: the seed coat, the cotyledons, and the embryo.

The seed coat or hull accounts for 7-15% of the whole seed mass. Cotyledons are about 85% of the seed mass, and the embryo constitutes the remaining 1-4%. The external structures of the seed are the testa (i.e., seed coat), hilum, micropyle, and raphe. The testa is the outer most part of the seed and covers almost all of the seed surface. The hilum is an oval scar on the seed coat where the seed was attached to the stalk. The micropyle is a small opening in the seed coat next to the hilum. The raphe is a ridge on the side of the hilum opposite the micropyle.

When the seed coat is removed from grain, the remaining part is the embryonic structure. The embryonic structure consists of two cotyledons (or seed leaves) and a short axis above and below them. The two cotyledons are not physically attached to each other except at the axis and a weak protection provided by the seed coat. Thus the seed is unusually vulnerable to breakage.




**COMPOSITION AND NUTRITIVE VALUE**

**Energy:** Pulses give 340calories per 100g which is almost similar to cereal calorie value.

**Carbohydrates:** Pulses contain about 55-60 % of total carbohydrates including starch, soluble sugars, fibre and unavailable carbohydrates. Starch occupies major portion. The unavailable sugars in pulses include substantial levels of oligosaccharides of the raffinose family of sugars, which are notoriously known for the flatulence production in man and animals. These sugars escape digestion 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, fermentation, autoclaving etc, reduce considerable amounts of oligosaccharides.

**Proteins:** In a vegetarian diet, pulses are important source of proteins. They give 20-25% proteins that is double the amount of protein compared to cereals. They contain chiefly globulins. Albumins can also be seen in pulses.

The proteins of pulses are not of good quality as they are deficient in methionine. However pulses are rich in lysine. Hence they can supplement cereal protein. A mixture of cereals and pulses gives a complete protein.

**Fats:** Fats form about 1.5% of the dry matter in pulses except in groundnuts and soya beans. Most of the pulse lipids contain high amounts of polyunsaturated fatty acids.

**Minerals:** Pulses are important sources of calcium, magnesium, zinc, iron, potassium and phosphorus.

**Vitamins:** Legume seeds are excellent source of B complex vitamins particularly thiamine, folic acid and pantothenic acid. Like cereals they do not contain any vitamin A or C but germinated legumes contain some vitamin C.

**TOXIC CONSTITUENTS IN PULSES**

Many legumes such as field beans and soya beans have substances which inactivate the enzyme trypsin and consequently prevent proteins from being digested. Such legumes are therefore toxic, unless these inhibitors are destroyed.

**Trypsin inhibitors:** Trypsin inhibitor is a protein found in a number of pulses. This inhibitor suppresses the release of amino acids and thus do 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 impairs its activity. They are present in redgram, Bengal gram, cowpea, doublebeans, soyabeans and peas.

**Haemagglutinins:** Haemagglutinins are also proteins, they combine with products of digestion and thus impair the efficiency of absorption of digested products. They occur widely in leguminous seeds.

**Cyanogenic glycosides:** Cyanogenic glycosides cause cyanide poisoning. On hydrolysis of the glycoside by the enzyme, β-glucosidase, hydrogen cyanide is liberated. However, cyanide content in the range of 10 to 20 mg per 100 g of pulses is considered safe. Many legumes except lima bean contain cyanide within this limit.

**Saponins:** These 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 soya beans, sword beans and jack beans. Toxic saponins cause nausea and vomiting. These toxins can be eliminated by soaking prior to cooking.

**Alkaloids:** These are known to occur in the seeds of many legumes but they are relatively less harmful.

**Aflotoxins:** Mycotoxins produced by some moulds *Aspergillusflavis* or *Aspergillusparasiticus* are known as aflotoxins. Aspergillus develops in many foods, particularly in groundnuts, cotton seed and their cakes and flour.

**Goitrogens:** These substances interfere with iodine uptake by thyroid gland. Excess intake of soyabeans, groundnuts in the face of marginal intake of iodine from foods and water may lead to precipitation of goitre.

**Lathyrism:** It is a paralytic disease affecting the lower limbs. The incidence of the disease is higher in males than in females and recovery from this disease is rare. Serious outbreaks of lathyrism have occurred in this country quit 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 this 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).

**Favism:** Favism is haemolytic anaemia. This disease is mostly confined to persons living in the Mediterranean basin. In sever cases of favism death may occur within 24 – 48 hrs of the onset of the attack. Children are more liable than adults. If the victim survives, it takes about four weeks for recovery. Favism is caused by eating broad beans or by inhaling the pollen of its flowers. The victim suffers from an inherited biochemical abnormality, which affects the metabolism of glutathione in red blood cells and results in decreased activity of the enzyme glucose-6-phosphate dehydrogenase. In the 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.

**Tannins:** Tannins are present in high amounts in seed coats of most legumes. Tannins bind with iron irreversibly and interfere with iron absorption. Tannins interfere with digestive action of trypsin and α- amylase rendering the dietary protein and carbohydrate indigestible. Tannins also bind proteins and reduce their availability. They also affect B- vitamin absorption. Removal of seed coat of legumes reduces the tannin content.

**Elimination of toxic factors:** 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 elimination of toxic factors is by fermentation, which yields products more digestible and of higher nutritive value than the raw pulses.

## NUTS AND OIL SEEDS

To prepare foods into a variety of palatable and tasty preparations like vegetable curries, cutlets, pakodas, samosas, puris, halwa etc, fats or oils are needed. We use fats or oils for cooking and frying and to give richness and flavour to our food. They are also an important concentrated source of energy and certain essential nutrients. A number of fats and oils are available in the market. They are extracted from their natural source and then refined. Some are expensive than others. Ghee and vanaspathi are solid in the temperature range of 18 – 24$^0$C and are called fats, whereas vegetable oils are liquids (known as oils).

Nuts are seeds of fruits consisting of an edible usually fat containing kernel and surrounded by a hard or brittle shell. Nut trees often thrive in areas unsuitable for other crops and some of them give high yields. Nuts therefore could help to improve the food resources of the world and particularly of the developing countries.

## NUTRITIVE VALUE

- These are concentrated sources of energy. Weight for weight they furnish 2.25 times more energy than proteins and carbohydrates. All oils and fats except butter give 900 kcal per 100 g.

- They reduce bulk in the diet.
- They are excellent sources of fat-soluble vitamins A, D, E and K. Butter contains 15,000 I.U of vitamin A. Vegetable oils are good sources of vitamin E.
- They play an important role in biosynthesis of several long chain fatty acids
- They provide essential fatty acids. They are also used by the body to make prostaglandins, which are involved in a variety of vital physiological functions. Fish oils are excellent sources. They particularly prevent the blood-clotting and thus reduce the risk of clots blocking the coronary arteries.
- Fats are slowly digested and absorbed. Therefore, after taking a fatty meal, the feeling of hunger is delayed.

**TYPES**

**Coconut:** Coconut water is the most refreshing drink which is also hygienic. It is rich in electrolytes. The white flesh is rich in calories though not a good source of protein. The white flesh when dried is called khopra. It has a high content of oil. The residual cake after been extracted is used as cattle feed.

**Groundnut:** Also known as peanuts, earthnuts, monkeynuts. Groundnuts are in fact the seeds of a leguminous plant. Groundnuts resemble other legumes in general nutritive value except that they are rich in fat. The whole seed contains about 40% fat. They are exceptionally rich in niacin. Groundnuts are rich in the antioxidant flavonol. The milk obtained from peanuts can be used as a supplement to the diets of pre-school and school children or it can be used as substitute for ordinary milk, in the case of allergies to milk.

**Sesame seeds (Gingely seeds):** This is also a legume containing high protein and fat. It is used as such in the preparation of candy and as an addition in other foods. The protein is lacking in lysine but rich in methionine in which many common food grains are deficient. Its addition to legumes or cereal legume combination is beneficial. Sesame seeds can be roasted and made candy with jaggery syrup to give a highly acceptable product. These can be roasted and added to cakes, biscuits, snacks etc, to improve their flavour. Deoiled sesame cake is also used in the manufacture of processed weaning foods.

**Soyabeans:** The whole dry grain contains about 40% protein and also upto 20% fat. The proteins of soyabean yield all the essential aminoacids in adequate amounts except methionine and cysteine. Soyabean is rich in lysine and can be used to supplement a staple rice diet. Soyabeans are rich in iron and B-vitamins like thiamine, riboflavin, niacin and folic acid. Soyabeans is valued nutritionally for unsaturated fattyacids, protein and fibre content. Soya protein has health benefits such as cancer prevention, cholesterol lowering, combating osteoporosis and menopause regulation. Soya milk is used as a substitute for normal milk. In case of lactose intolerance children are generally fed with soya milk.

## FUNCTIONS OF FATS AND OILS

### Fat or oil used as medium of cooking:

Fats and oils are used as a medium of cooking. This may be in sauting, shallow frying or deep-frying. Pan-frying is cooking of food in a light greased pan, e.g: frying of dosa, omlette, fried eggs, pancakes etc. The food must be turned often from one side to another for complete cooking.

In deep frying the food is dipped into the oil/fat while it is cooked. It is used for preparations like puris, samosas, chips, cutlets, pakodas etc. This method is similar to boiling but as oils and fats can be heated to a much higher temperature than boiling water, the food can be cooked rapidly and it needs constant and careful attention.

### Fat improves the texture of foods:

Fat is used as a shortening agent in baked foods like biscuits, cakes, pastries and fried foods like kachoris. The shortening effect brings about a crisp texture of fried and baked products.

### Fat improves palatability:

Fat gives taste and flavour to the food. Fat has the ability to dissolve aromatic flavour substances in foods.

### Improves the quality of the product:

Due to the high temperature used in frying, microorganisms present in food are destroyed. Fat also improves keeping quality by reducing moisture content.

## UNIT - III

## Compositional, Nutritional and Technological aspects of Plant foods II.

## Fruits and Vegetables

### FRUITS

Fruits are the mature ovaries of plants, which contain the seeds. Fruits are produced from a flower or flowers. The edible portion of most of the fruits is the fleshy part of the pericarp surrounding the seeds. Fruits on ripening soften with distinct desirable changes in colour and flavour. Fruits are pulpy, often juicy with a blend of sweet and sour taste, fragrant aroma and flavour. Ripe fruits have good aroma, colour and flavour. Usually fruits are sweet with a wide range of flavours, colours and textures.

### CLASSIFICATION OF FRUITS

Fruits are classified according to the number of ovaries and flowers from which it develops. Some of the classes of fruits are citrus fruits, multiple fruits, drupes, pomes and aggregate fruits.

| Type of fruit | Name & description |
|---|---|
| Citrus fruits | Oranges, lemons, limes, grape fruit etc. |
| Multiple fruit | Develops from a cluster of several flowers e.g: Pineapple, custard apple |
| Drupes | Which have stone or pit to hold the seed e.g: mangoes, amla, apricots, cherries, peaches, plums. |
| Pomes | Which have sac that holds the seeds e.g: apples, pears. |
| Aggregate fruits | Which are developed from several ovaries in one flower such as strawberries, black berries, rasp berries etc. |

### COMPOSITION AND NUTRITIVE VALUE OF FRUITS

Fruits contain 80 to 90% of water. They are a very poor source of fat and protein. Butter fruit or avocado is the exception contains fat up to 25%. The polysaccharides, celluloses, hemicelluloses and pectic substances are the structural components of fruits. These make fruits important sources of roughage or bulk in the diet. Fruits are not good sources of calories. Fruits like bananas give good amount of calories. Various sugars are found in fruits whose content varies in different fruits. Ripe fruit contains a higher percentage of sugars than unripe fruit. Sugar is chiefly in the form of sucrose, fructose and glucose.

Fruits are good sources of vitamins. Citrus fruits are excellent sources of vitamin C. Strawberries, melons and tropical fruits are also good sources of ascorbic acid. Yellow fruits like papaya, mango and pumpkin contain carotenoids, which are the precursors of vitamin A. Vitamin B occurs in relatively low concentration in fruits. Minerals are not particularly high in fruits. However, sulphur, phosphorus, potassium, iron and calcium are found in many fresh fruits.

**Pectic substances:**

Pectic substances are cementing substances holding the cells of the fruits together. In immature fruits most of the pectin will be present as protopectin. As the fruit ripens these changes to pectin and pectic acid. These changes are partially responsible for the softening of fruit tissue during ripening. Starch content is relatively high in unripe fruit but it changes to sugar in ripe fruits.

## VEGETABLES

Vegetables are plants or their parts served with the main course of a meal. Apart from the nutritive value, vegetables probably do more than any other group of foods to add appetizing colour, texture and flavour to our daily food. With a wide choice of colour of vegetables, it is possible to select a vegetable with desired colour to heighten the appearance of a meal.

## CLASSIFICATION OF VEGETABLES

Vegetables are classified on the basis of the parts consumed from plants such as roots, stems, leaves, flowers etc. Vegetables can also be divided into two main groups such as rabi or summer and kharif vegetables according to their growing season.

| Plant part | Vegetable |
|---|---|
| Flowers | Cauliflower, Plantain flower |
| Root vegetables | Carrot, radish, turnips, beetroot, yam, colacacia |
| Fruit vegetables | Tomato, cucumber, pumpkin, brinjal etc. |
| Leafy vegetables | Spinach, amaranth, gogu, colacacia leaves, mint etc. |
| Tubers | Potato, Sweet potato, tapioca etc. |
| Bulbs | Onion, garlic etc. |
| Leguminous vegetables. | Peas, beans. |

## NUTRITIVE VALUE AND COMPOSITION OF VEGETABLES

Vegetables differ widely in their chemical composition. Vegetables have high water content particularly in the greens. The crispness of greens depends on the water in the cells. Partial dehydration of cells results in a change from a crisp to a limp leaf. The protein value of vegetables is very low except in legumes. The carbohydrates present in vegetables are cellulose, starch and sugars. Cellulose with hemicellulose and pentoses form the structural material of vegetables. Potato and tapioca contain high percentage of carbohydrates as starch.

In immature vegetables, the carbohydrate is mostly in the form of sugar. It gradually changes to starch as the vegetable matures. Vegetables contain non-volatile acids such as citric, malic, oxalic and succinic acids. These contribute to the flavour of vegetables. The very strong flavour characteristic of some of the vegetables like onion, garlic, cauliflower, cabbage etc, is due to sulphur containing volatile compounds.

Vegetables contain various chemical compounds responsible for a wide range of colours in their raw and cooked condition. The pigment of the green vegetables is due to chlorophyll. The yellow and orange colour of vegetables, such as carrots and tomatoes are due to caroteniods. Flavonoids are responsible for the colour of radish and red cabbage.

The nutritive value of different vegetables varies significantly. It is wise to serve a mixture of vegetables to ensure that all the necessary nutrients from the vegetable category are included in the diet. Vegetables as a group contribute to indigested fibre, minerals and vitamins to the diet. Most vegetables, except those containing starch provide a useful source of energy but low in calories. Leguminous vegetables provide proteins. Vegetables contain very low fat content and this is also responsible for their low calorific content.

Calcium and iron are two minerals found in significant amounts in vegetables. Green leafy vegetables and legumes contain these minerals in good quantities. In some vegetables, calcium combines with oxalic acid present in the vegetable, forming insoluble calcium oxalate that cannot be absorbed by our body. Vegetables also supply the other essential minerals required by the body.

Vegetables are good sources of vitamin A and C. Dark green leafy vegetables are rich in carotenes which are the precursors of vitamin A. The leafy vegetables are also rich sources of vitamin C. The indigestible fibre content of vegetables contributes to the roughage promoting mobility of food through intestine.

## ENZYMATIC BROWNING

Normally the natural enzymatic compounds present in intact tissues of fruits do not come into contact with the phenol oxidases present in some tissues. When the tissues are cut or injured and the cut surface is exposed to air the phenol oxidase enzyme released at the surface acts on the polyphenols present and oxidise them to orthoquinones. The orthoquinones rapidly polymerise to form brown pigment. Tyrosine, chlorogenic acid, various catechins and several mono and dihydroxyphenols are among the many compounds that can serve as substrates for oxidation by polyphenoloxidase to cause browning or other discolouration in these foods. The optimum pH for the activity of enzyme polyphenolase is between 5 and 7.

Cut fruits containing catechins, tyrosine, chlorogenic acid,

Mono and di hydroxyl phenol

↓ $O_2$ Polyphenolase

DOPA (Dihyroxy phenylalanine)

↓ $O_2$ Polyphenolase

Orthoquinones

↓

Melanin (brown coloured pigment)

**Prevention of enzymatic browning:** It can be prevented by either inactivating the enzyme or cutting off the oxygen.

Following are some measures to prevent enzymatic browning:

**1**. **Temperature:** The most commonly used method is blanching. This method has several limitations. The enzyme is fairly heat stable and requires heating at $100^0$C for 2–10 minutes for complete inactivation. This may not be possible in practice as cooking for long periods will affect the flavour and texture of the fruits. The optimum temperature for browning is 43 - $50^0$C. If food is kept at higher or lower temperature browning is reduced. Coagulation of protein occurs during blanching, thereby inactivating the enzyme. Polyphenoloxidase activity can be retarded by lowering the temperature.

**2**. **Change in pH:** The optimum pH for polyphenolase activity is between 6.0 and 7.0. Lowering of the pH to 4.0 by the addition of citric acid inhibits the phenolase activity. It is because the citric acid reacts with the copper present in the enzyme. Malic acid is also found to be effective. Lemon juice contains both citric acid and ascorbic acid and both are effective to decrease pH.

**3. Use of antioxidants:** Sulphur dioxide, sulphites and bisulphites inhibit browning effectively. A sulphite concentration sufficient to maintain a free sulphur dioxide concentration of 10 ppm will completely inhibit phenolase. Being a reducing agent sulphite has an additional benefit of preserving the ascorbic acid level. Pineapple juice has a relatively high percentage of sulphydryl compounds which are active antioxidants. Fruits can also be dipped in dilute solution of sodium metabisulphite. If the sliced fruit is then immersed for a short time in the solution of dipotassium phosphate, the odour of sulphur is less pronounced and the fruit remains crisp and will not turn brown further.

Ascorbic acid retards browning by virtue of its reducing power. It is commonly used along with citric acid to reduce browning.

**4. Prevention of contact with oxygen:** Contact with oxygen can be reduced by immersing the fruits in water or liquids like milk, curd, fruit juice or honey after cutting or by covering with wet cloth.

Addition of sodium chloride or sugar to the cut fruit prevents browning. Due to osmosis, fruit is covered by leached solution and prevents contact with oxygen. High concentrations of sodium chloride or sugar solution depress the activity of plant oxidases including phenolases.

Packing the product under nitrogen prevents surface browning effectively.

Deoxygenation and vacuum closing are also used to diminish oxidation.

## PIGMENTS

Fruits and vegetables contribute to a variety of colours due to the presence of pigments. The main pigments in vegetables are carotenoids, chlorophyll, flavonoids, anthocyanins, tannins and anthoxanthins.

**Carotenoids:** These are fat-soluble pigments. The yellow orange coloured pigments are present in many vegetables and fruits such as carrots, pumpkin, papaya, mango etc. Its concentration is indicated by the intensity of the colour of the vegetables and fruits. Carotenoids are present in most green leafy vegetables also. However, the green chlorophyll masks the carotene colour and only the green colour of chlorophyll can be seen when both are present.

**Chlorophyll:** It is the green coloured, fat-soluble pigment present in many vegetables and fruits. The dark green colour of leafy vegetables is due to the presence of it.

**Flavonoids:** These are water-soluble pigments. They contain anthocyanins that are red, blue, purple pigments of plants. The anthoxanthins and flavones are creamy white in colour and tannins are colourless and are the derivatives of flavones.

**Anthocyanins:** The red blue pigments of this group are present in beet root, red cabbage, blue grapes etc.

**Tannins:** These are colourless but turn brown when the vegetables containing them are cut and exposed to air, e.g: brinjals, raw plantains, green chillies etc.

**Anthoxanthins:** The creamy white pigments of this group are present in many plant foods. The colour of potatoes and cauliflower is due to these pigments.

## DIETARY FIBER

Dietary fiber, also known as roughage or bulk, includes the parts of plant foods that body can't digest or absorb. Unlike other food components, such as fats, proteins or carbohydrates which the body breaks down and absorbs, fiber isn't digested by our body. Instead, it passes relatively intact through our stomach, small intestine and colon and out of our body.

Fiber is commonly classified as soluble, which dissolves in water, or insoluble, which doesn't dissolve.

- **Soluble fiber:** This type of fiber dissolves in water to form a gel-like material. These include pectins, gums and mucilages. It can help lower blood cholesterol and glucose levels. Soluble fiber is found in oats, peas, beans, apples, citrus fruits, carrots, barley and psyllium.
- **Insoluble fiber:** Structural parts of plant cell walls (cellulose, hemi–cellulose and lignin), which are not soluble in water, are called as insoluble fiber. This type of fiber promotes the movement of material through the digestive system and increases stool bulk, so it can be of benefit to those who struggle with constipation or irregular stools. Whole-wheat flour, wheat bran, nuts, beans and vegetables such as cauliflower, green beans and potatoes are good sources of insoluble fiber.

### Benefits of a high-fiber diet

A high-fiber diet has many benefits, which include:

- **Normalizes bowel movements:** Dietary fiber increases the weight and size of stool and softens it. A bulky stool is easier to pass, decreasing the chance of constipation. If there is loose, watery stools fiber may help to solidify the stool because it absorbs water and adds bulk to stool.
- **Helps maintain bowel health:** A high-fiber diet may lower the risk of developing hemorrhoids and small pouches in the colon (diverticular disease). Some fiber is fermented in the colon. Researchers are looking at how this may play a role in preventing diseases of the colon.
- **Lowers cholesterol levels:** Soluble fiber found in beans, oats, flaxseed and oat bran may help lower total blood cholesterol levels by lowering low-density lipoprotein, or "bad," cholesterol levels. Studies also have shown that high-fiber foods may have other heart-health benefits, such as reducing blood pressure and inflammation.

- **Helps control blood sugar levels:** In people with diabetes, fiber particularly soluble fiber can slow the absorption of sugar and help improve blood sugar levels. A healthy diet that includes insoluble fiber may also reduce the risk of developing type 2 diabetes.
- **Aids in achieving healthy weight:** High-fiber foods tend to be more filling than low-fiber foods, so likely to eat less and stay satisfied longer. And high-fiber foods tend to take longer to eat and to be less "energy dense," which means they have fewer calories for the same volume of food.

Another benefit attributed to dietary fiber is prevention of colorectal cancer. However, the evidence that fiber reduces colorectal cancer is mixed.

**Fiber rich foods**

- Whole-grain products
- Fruits
- Vegetables
- Beans, peas and other legumes
- Nuts and seeds

**Recommended intake:** Total dietary fiber intake should be 25 to 30 grams a day from food.

## POST HARVEST CHANGES IN FRUITS AND VEGETABLES

Virtually synthesis of all organic compounds halts after harvest, but numerous physiological changes continue in fruits and vegetables during storage. Bulbs, roots, tubers and seeds become relatively dormant during storage whereas climatric fruits undergo ripening after maturation and then continue to senescence. Senescence occurs quite rapidly with an accompanying loss of palatability.

Even after harvesting fruits and vegetables continues to respire. Respiration is the process by which stored organic materials are broken down into simple end products with a release of energy

**Respiration rate:**

Climatric fruits have high rate of respiration. Those fruits that exhibit this increase in respiratory rate just prior to senescence are termed climacteric fruits.  Peaches, peas, mangoes are climacteric fruits. Citrus fruits and grapes are non climacteric. Their respiration rate does not accelerate after harvesting. Non climacteric fruits are best when ripened before harvesting.

**Pectic substances**

Protopectin is the water insoluble form of pectic substances occurring in immature fruits and to a less extent in vegetables. Protopectin gives firm texture to unripe fruits. As fruit ripens, some demethylation and hydrolysis occur along the protopectin molecules due to the enzymes pectinesterases.

The transition takes place from a methylated water insoluble polymer protopectin to a shorter methylated compound capable of dispersing easily in water pectin. Pectin forms gel on heating with acid and sugar.

As the degradation of pectin continues the molecules gradually become shorter and lose all of their methoxyl groups. These shorter polymers of galactouronic acid are designated as pectic acid. Pectic acid is found in over ripe, very soft fruits and vegetables. This type of pectic substances has lost the gel forming ability characteristic of the longer methyl esters of galacturonic acid polymers.

During ripening protopectin → pectinicacid → pectin → pectic acid occur due to demythylation of pectinesterases.

| **Pectic substance** | **Occurrence** | **Chemical characteristic** | **Capacity to form gel** |
|---|---|---|---|
| Protopectin | Raw fruits and vegetables | Insoluble methylated polymer of galacturonic acid | Cannot form gel |
| Pectinic acid | Slightly ripened fruits | Polygalacturonic acids containing more than a negligible proportion of Methyl-Ester groups | Form a gel with very little sugar |
| Pectin | Optimum ripe fruits | Water-soluble shorter Methylated compound | Forms firm gel with acid and sugar |
| Pectic acid | Over ripe fruits | Polygalacturonic acids free from Methyl-Esters | Cannot form gel |

Cell wall components undergo changes after harvest a consequence of the action of various enzymes the pectic substance in cell walls and the middle lamella undergo degradation as a result of the increasing levels of two types of enzymes, pectinesterases and polygalacturonases.

**Climatric rise:** The climacteric rise is a stage of fruit ripening associated with increased ethylene production and a rise in cellular respiration. Its defining point is a sudden rise in respiration of the fruit, and normally takes place without any external influences.

**Physiological maturity:** Stage in the development of the fruit and the vegetable when maximum growth and maturation has occurred.

**Horticultural maturity:** Stage of development when a plant or a plant part possesses the pre-requisite for utilization by the consumer for a particular purpose.

## SPICES AND CONDIMENTS

India is considered the home of spices. The food is seasoned by the addition of flavouring agents, which include spices and condiments. According to the International organization for Standardization, there is no clear cut division between spices and condiments and so they are clubbed together. There are about 70 species of spices grown in different parts of the world out of which many are grown in India.

The world trade in spices in 1981 was about 300,000 tonnes, worth 550 million US dollars. India during that year, exported 68,400 tonnes valued at Rs 93 crores.

## CLASSIFICATION

Spices can be classified in different ways such as seeds, leaves and barks etc. Each of these has its own merits and demerits. Method of classification depends on the origin and principle compound in the spice.

Pungent spices: Pepper, ginger, chillies, mustard.

Aromatic fruits: Cardamom, nutmeg and mace, fenugreek, cumin, coriander.

Aromatic barks: Cinnamon.

Phenolic spices: Clove

Coloured spices: Saffron, turmeric.

Spices are mostly used as flavouring agents in a number of food stuffs, such as curries, bakery products, pickles, processed meats, beverages etc. They enhance the flavour of foods. Spices are also flavour disguisers; they mask the off-flavour of foods. Some spices possess antioxidant properties while others are used as preservatives in some foods like pickles and chutneys. Cloves and mustard possess strong antimicrobial properties and as such prevent food spoilage. Many spices also possess important physiological and medicinal properties.

**COMPOSITION AND NUTRITIVE VALUE:** Most spices owe their flavouring properties to volatile oils and in some cases, to fixed oils and small amounts of resins. In many spices no single compound is responsible for flavours. A blend of different components, such as alcohols, phenols, esters, terpenes, organic acids, resins, alkaloids and sulphur containing compounds contribute to the flavour. In addition to flavour contributing components, all spices contain the usual components of plant products, such as proteins, carbohydrates, fibre, minerals and tannins.

**GENERAL FUNCTIONS OF SPICES**

1. Spices add flavour and colour to food and make the food palatable and hence add variety to thediet. Cereals, pulses, vegetables or meat can be cooked in variety of forms by the addition of different kinds of spices.

2. Spices in general stimulate salivation and acid secretion of digestive enzymes like amylases. Spices increase the secretion of saliva containing more of ptyalin so that foods rich in carbohydrates are easily digested. Spices are used for digestion and to reduce flatulence.

3. Some spices have anti inflammatory, antibacterial and antioxidant properties.

4. Some spices help in improving the impaired blood glucose levels in the body and help diabetics.

5. Some spices reduce cholesterol levels and may be useful in preventing heart diseases.

6. Some spices are considered antimutagenic or anticarcinogenic.

## UNIT – IV

## Compositional, Nutritional and Technological aspects of Animal foods

### FLESH FOODS - MEAT, FISH, POULTRY

### MEAT

Man has satisfied his hunger with foods of animal origin since earliest times. The term meat refers to muscle of warm-blooded terrestrial four legged animals such as cattle, sheep and pigs. Meat also includes the glands and organs of these animals. Meat products include many of the by-products from animal slaughter such as animal gut used for sausage casings, the fat from the meat used in the manufacture of lard, gelatin etc.

### STRUCTURE OF MUSCLE

**Muscle tissue:** Muscle is composed of long, cylindrical, multinucleated cells called fibres varying in length from few millimetres to several centimetres and an average diameter of 60 µm. The fibres are arranged in a parallel fashion to form bundles. These bundles are called fasiculi.

**Connective tissue:** The bundles called fasiculi are held together by connective tissue. The connective tissue merges at the end of the muscle to form a tendon which in turn connects the muscle to bone. Collagen and elastin are two types of connective tissues. During cooking collagen is softened and converted to gelatine. Elastin does not become soft during cooking.

**Fatty tissues:** These are connective tissues with embedded fat cells. Fat is deposited under the skin, around the glands, organs and between and within the muscle fibres. Fat distribution in lean parts of meat is called marbling.

**Bones:** Bones are either long or short. Long bones are hollow and contain yellow marrow. Other bones which contain red marrow are spongy inside.

**Pigments:** Myoglobin is the pigment in meat that gives the characteristic red colour to the meat. The greater the amount of myoglobin the darker the colour of meat. As the animal ages the amount of myoglobin increases. Raw meat when allowed to stand in the refrigerator changes its colour from red to brownish red. If myoglobin is heated the colour changes from red to brown.

According to food industry the body of a livestock animal from which the head, hide, legs, tail and viscera have been removed before rendering it into cuts of meat.

### MARBLING

When the animal is fed well, fat deposits subcutaneously as a protective layer around the organs and in between muscles. Fat penetrates between the muscle bundles and this is known as marbling. Marbling is desirable with some meats (like beef) because of the amount of fat and water holding capacity of the meat, which influences juiciness during cooking.

## COMPOSITION OF MEAT

Meat contains 15 to 20% of proteins. The amino acid make up of meat proteins is very good for the maintenance and growth of human tissue.

The fat content of meat varies from 5% to 40% with the type, breed, feed and age of the animal. Meat fats are rich in saturated fatty acids which may produce certain forms of atherosclerosis. The cholesterol content of meat is about 75 mg for 100 g. The lean portion of meat contains greater proportions of phospholipids (0.5 to 1.0 %) and these are located in the membranes of the cell. The fatty acids in the lean portion of meat have a higher proportion of unsaturated fatty acids than tissue fats.

Carbohydrates are found only in very small quantities in meat. Two of them found in meat are glycogen and glucose.

Meat is an excellent source of some of the B complex vitamins and a good source of iron and phosphorus. Meat also contains sodium and potassium. Liver is rich in vitamin B12 and vitamin A and iron.

Meat contains protein hydrolyzing enzymes cathepsins. These are responsible for the increased tenderness of meat during ageing. The colour of the meat is primarily due to myoglobin. Variations in colour of meat depend on the chemical state of myoglobin. Haemoglobin also contributes to the colour of meat to some extent.

## POST-MORTEM CHANGES IN MEAT

The changes taking place in meat after slaughter may be grouped under two heads

1. Onset of rigor mortis and
2. Development of tenderness in muscle

**Rigor mortis** - The first biochemical change occurring in muscle is rapid glycolysis of the glycogen represented by the presence of enhanced lactic acid content in muscle. The lactic acid content of muscle after rigor mortis is as high as 0.9 per cent. The muscle becomes stiff due to rigor mortis. Rigor mortis was correlated with the disappearance of ATP. In the absence of ATP, actin and myosin combine to form rigid chains of actinomyosin. Just before an animal is slaughtered, the muscles are soft and pliable. But immediately upon death, stiffening of the carcass known as rigor mortis occurs. It is 24-48 hours in beef.

**Tenderization of meat -** When meat is stored at $0^{\circ}$C biochemical changes take place in meat leading to the development of tenderness in meat. This process is called conditioning of meat. The tenderness is due to

- Denaturation of the meat proteins and
- Mild hydrolysis of denaturated meat proteins by the enzyme cathepsin present in meat.

  The increase in tenderness is followed by an increase in water soluble amino nitrogen indicating mild proteolysis of the muscle proteins. Contrary to the general belief, there is practically no change in the connective tissues and collagen. There is no increase in water soluble hydroxyl proline peptides indicating collagen has not been acted upon by proteolytic enzymes.

## AGEING OF MEAT

- If meat is held cold for sometime for 1 or 2 days after it has completed rigor mortis, the muscles again becomes soft and pliable with improved flavour and juiciness which is called resolution of rigor. Some changes that take place during this period are known as ageing or ripening.
- During ageing there is progressive tenderisation of meat owing to the denaturation of the muscle proteins by the intracellular proteolytic enzymes, the cathepsins.
- Ageing or ripening is done by holding meat at 0.50 to 200C temperature in a cold room. Aging may take 1-4 weeks. The best flavour and the greatest tenderness develop in meat aged from 2 to 4 weeks.
- During ageing, humidity of the cold room is to be controlled and meat may also be affected by holding it at a higher temperature for a shorter time usually 200 C for 48 hours.
- Ageing with even higher temperature for lesser time is practised commercially. In such cases, ultraviolet light is used to keep down surface bacterial growth.
- Beef is usually the only kind of meat that is commercially aged. Lamb and mutton are occasionally aged. Pork is never aged because of its high fat content.

## FISH

## CLASSIFICATION OF FISH

Seafoods may be classified into two major categories. Scaly fish (vertebrate) and shell fish (invertebrate). The former are covered with scales and the latter with some type of shell. Shell fish are of two groups – the molluscs and the crustaceans. The molluscs are of soft structure and are either partially or wholly enclosed in a hard shell that is of largely mineral composition. Molluscs include oysters, clams and mussels of crustaceans and lobster, crabs, shrimp and cray fish.

The kinds of scaly fish available for food vary widely in different localities. They include both salt water and fresh water varieties and differ in flavour and quality depending partly on the water in which they are grown. Fish from cold, clear and deep waters are superior in quality and in flavour to fish from warm muddy and shallow waters. Salt water fish usually have a more distinctive flavour than fresh water one and oily fish have more flavour than the lean varieties.

Fish are often classified on the basis of their fat content. Lean fish have less than 2% fat in their edible flesh, whereas medium fat fish 2-5%fat.

## COMPOSITION OF FISH

The fat content of fish varies from 1% to about 25%. Season, sex and the stage of maturity determines the fat content of fish. Liver and viscera are the locations of fat deposits. Fat is also present in muscle tissue, skin, mutt and roes (eggs of fish).

The fish oils are glycerides of fatty acids. These oils are made up of unsaturated fatty acids. It also contains cholesterol, lecithin, waxes and fatty alcohols. The fat from fish eggs is especially high in lecithin.

Fish is an excellent source of proteins. The protein content of fish is about 20%. The protein content of shellfish is lower than that of finfish. Fish proteins are also easily digested. The amino acid pattern of fish protein is similar to that of animal proteins. Fish meat has lysine and methionine at a high level hence it has supplementary value with cereals and pulses.

Finfish contains some glycogen, shellfish contains more glycogen. The sweet taste of some shellfish is due to glucose formed from the glycogen by enzymatic action.

Fish is a good source of minerals. It is a good source of copper, sulphur and phosphorus. Salt-water fish contain more iron than the fresh water fish. Marine fish is a dependable source of iodine. The iodine content of marine fish is nearly 30 times that of fresh water fish. Iodine content of marine fish varies from 0.01 to 0.5 mg per 100 g of fish meat.

Fish oils are the richest known sources of vitamin A and D. Fish flesh is a fair source of thiamine. It also contains riboflavin. Red fish has higher riboflavin content. Both sea water and fresh water fish are good sources of niacin. The vitamin C content of the fish is very low.

**CHARACTERISTICS OF FRESH FISH**

- Eyes. Yes: Crystal clear, plump, moist. No: sunken or cloudy.
- Gills. Yes: Clean, cold and bright color. No: Slimy and dark color.
- Fins. Yes: wet and whole. ...
- Flesh. Yes: cold, wet, slippery and resilient when poked. ...
- Smell. Yes: Clean, fresh. ...

**FISH SPOILAGE**

Fishes are highly perishable. Fish tissue is generally more perishable than animal tissue. The reasons for the spoilage of fish are microbiological, physiological and chemical in origin. Flesh of healthy live fish is bacteriologically sterile. Many types of bacteria are found on the surface of the skin, gills and in digestive tract of living fish. Spoilage takes place shortly after the death of the fish due to the bacteria present in it; these bacteria continue to grow even under common refrigeration conditions.

Bacterial spoilage of fish will not begin until the fish has gone into rigor mortis and passed out of it. Rigor mortis in fish is comparatively shorter. When fish is killed, there is little glycogen left to be converted into lactic acid to slow down bacterial growth.

Fish when taken out of water have virtually little or no odour. The fishy odour is due to the production of trimethyl amine by the action of bacteria on phospholipids and choline present in fish. Unsaturated fish fats undergo oxidation and become rancid which also contributes to the smell of deteriorated fish.

**POULTRY**

**STRUCTURE OF HEN'S EGG**

A fully formed egg has a shell, two shell membranes, albumen or white of the egg, yolk or the yellow of the egg and germinal disc.

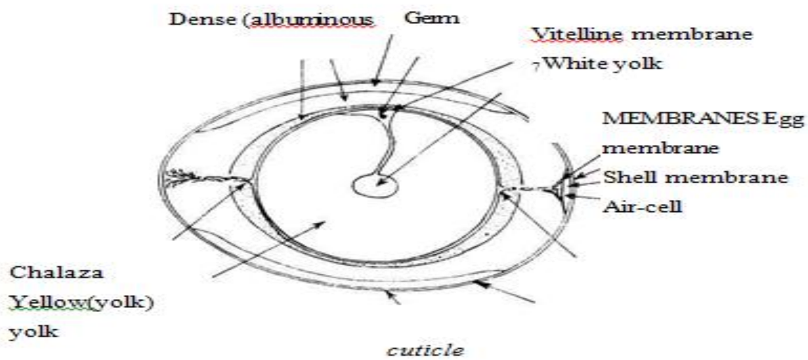
The shell of the egg is made of calcium carbonate and protein-polysaccharide complex. It is porous and contains thousands of small holes (7000-17000 per egg) which allow the gases to pass in and out of the egg for the developing embryo in the case of fertilized egg. The holes are covered with a thin layer of gelatinous mucoprotein called cuticle. The cuticle seals off the pores of the shell to some extent and helps to avoid excessive evaporation from the inner contents of egg. It also restricts the entry of microorganisms into the egg and thus protects its inner contents from various infections. The cuticle is soluble in water and easily removed by washing which results in hastening the deterioration of quality.

Within the shell there are inner and outer membranes that also protect the quality of the egg. Both the membranes are porous and composed of fibres. The outer membrane is thicker (48µm) than the inner one (22µm). Outer layer is firmly attached to the shell. These membranes are composed of protein-polysaccharide complex.

The egg contains little or no air-cell when it is laid. After being laid, due to lower surrounding temperature than hen's body, contraction of the inner contents of the egg occurs. This results in air being drawn into the shell resulting in a small air-cell formation between the two shell membranes at the broad end of the egg.

The white of egg consists of three layers. The yolk is enclosed in a sac called the *'vitelline membrane'*. Immediately beyond this is another membranous layer known as the *chalaziferous layer*. The yolk is connected to thick albumen by twisted rope-like extensions of the chalaziferous layer called *chalazae*. The chalazae anchor the yolk in the white and it is centred in the egg.

The yolk carries an indistinct germinal disc which develops into the embryo after fertilization. Below the germinal disc a white column called the latebra extends up to the centre. The yolk is in layers of white and yellow yolk which are not readily demarkable. Poultry eggs are infertile.




**COMPOSITION AND NUTRITIVE VALUE**

The shell of egg contributes to 8-11% of its weight. The composition of egg white and yolk differ considerably. Egg white constitutes upto 56-61% whereas yolk constitutes upto 27-32% of its weight.

Eggs are rich sources of all nutrients except ascorbic acid. Eggs contain 12-14% proteins which are well balanced with respect to all essential amino acids. Hence, it is used as standard against which the chemical score of other proteins is compared. Fat in the egg is confined to the yolk portion. It is a source of essential fatty acids, linoleic acid and arachidonic fatty acids. Vitamins A, D and E are present in the yolk and egg fat also acts as the vehicle for these fat soluble vitamins. Egg fat is in highly emulsified form hence it is easily digested and absorbed. On an average each egg contains 250mg of cholesterol. Calcium is the most abundant mineral in the whole egg but it is concentrated in the shell. Important minerals such as phosphorus, iron, zinc and other trace elements are present in the egg. Except for vitamin C which is totally absent in the egg, other water soluble as well as fat soluble vitamins are present in the egg in appreciable amounts. Egg is particularly rich in vitamin A, riboflavin, folic acid and B12.

**CHARACTERISTICS OF FRESH EGG**

The factors constituting egg quality are both external and internal ones. Size, shape of the egg and condition of the shell are examples of external factors. Internal factors are the size of air-cell and condition of albumen, yolk and the germ spot.

Condition of the egg shell is an important factor. It affects shell strength, porosity, soundness, texture, colour and cleanliness. The strength of the shell depends upon its thickness. A high porosity of the egg shell will hasten the deterioration in the quality of egg contents. A porous shell is graded lower than the one with fine pores. Eggs must be clean; any dirt on the egg shell means the presence of a large number of contaminants like microorganisms.

The quality of the internal contents of the egg is determined by the size of the air-cell. As the age of the egg increases the size of the air-cell also increases and the white becomes thinner. The yolk position tends to drift off from centre when the egg becomes stale.

Evaluation of egg quality: 1. The quality of the egg in the shell is evaluated by candling: The egg is held against a source of strong light. Candling will reveal

1. a crack in the shell

2. the size of the air cell

3. the firmness of albumin

4. the position and mobility of yolk

5. the possible presence of foreign substances like blood spots, moulds and developing embryo.

As the egg deteriorates, the chalaza weakens and the yolk tends to settle towards the shell rather than remain suspended in the firm white.

2. Floating in water: If the egg sinks, it is considered as good. Poor quality eggs float due to increase in size of the air cell and due to loss of moisture.

**DETERIORATION OF EGG QUALITY**

After laying, changes begin to lower the quality of eggs. There is no known method by which this quality can be improved subsequently. Eggs are to be maintained in fresh condition as far as possible.

If the shell gets cracked, the inner contents of the egg get exposed to unfavourable environmental conditions, resulting in loss of moisture and carbon dioxide, invasion of microorganisms and development of objectionable odours. Weak shells and rough handling are the causes of breakage.

Evaporation of moisture from the inner contents of egg takes place through the shell pores. The loss of water from the egg results in the decrease in the weight of the egg, increase in the size of the air-cell and decrease in the specific gravity of the egg.

In a freshly laid egg, the albumen of the egg contains $CO_2$ that begins to escape through the pores of the shell. The pH of egg white increases from 7.9 to 9.3 in the first three days. With an increase in alkalinity the white becomes thinner and may become yellow and cloudy. The thinner white will not be able to keep the yolk at the centre of the egg. Changes in pH influence its functional properties. The changes in pH of white results from the rupture of the vitelline membrane and mixture of the yolk and white, resulting in disintegration and decomposition of egg contents.

During storage microbial spoilage may take place. These organisms may pass through the porous shell. The chances of microbial invasion will increase if the shell is dirty. The microorganisms penetrate through the shell and shell membranes. Alkaline pH of the egg, iron containing albumen and avidin resists the growth of microorganisms. Heavy contamination overcomes the defence mechanisms and causes spoilage during storage.

If the egg is exposed to a temperature of $20^0$C or above, the embryo starts growing. The development of the embryo deteriorates the quality of the egg contents. At a temperature below $38^0$C the growth of embryo is defective and usually dies after some time. If the death of the embryo takes place before blood has been formed a red spot appears at germinal disc. This lowers the edible quality of the egg. If the death of embryo occurs shortly after blood has been formed small red ring is produced at the surface of the yolk. Eggs having such red ring or dead embryo are inedible.

## DIFFERENCE BETWEEN BROILER AND LAYERS

An egg laying poultry is called egger or layer whereas broilers are reared for obtaining meat. Layers produce more numbers of large sized eggs and boilers yield more for meat and they grow well.

## MILK AND MILK PRODUCTS

### Definition of milk

Milk is one of the most complete single foods available in nature for health and promotion of growth. The purpose in nature is to provide good nourishment for young ones of that particular species producing it. The cow is the principle source of milk for human consumption in many parts of the world. Other animals as source of milk for human beings are the buffalo, goat, sheep, camel etc. In India, more milk is obtained from buffalo than cow.

The first food that an infant takes after birth is milk and milk is perhaps the only food that is relished by persons of all ages. Even sick people are given milk and preparations involving milk are relished by everybody.

### NUTRITIVE COMPOSITION OF MILK

Milk contains 4-5 percent carbohydrate**.** The chief carbohydrate present in milk is lactose, a disaccharide, although trace amounts of\glucose, galactose and other sugars are also present. Lactose on hydrolysis gives glucose and galactose. Milk is only substance that contains lactose, which has galactose which is essential for the synthesis of myelin sheath. Lactose, not being easily soluble, favours the growth of lactic acid bacilli in the intestine, which decreases the pH. The drop in pH favour calcium absorption. Lactose also increase the permeability of the small intestine for calcium ions. When milk is heated**,**lactose reacts with protein and develops a brown colour. The development of brown colour is due to nonenzymatic browning. It is called Millard reaction.

Milk contains 3-4% protein which is a good quality protein. Lysine is one of the essential amino acid which is abundant in milk proteins. Casein constitutes 80% of the total nitrogen in milk. It is precipitated on the acidification of milk to pH 4.6 at 20C. The remaining whey protein constitutes lactoglobulin and lactalbumin. Casein can also be separated from milk by the addition of rennin, an enzyme secreted by the young calves.

Buffalo milk contains 6.5% fat. Cow's milk contain 4.1% fat. Milk fat is of great nutritive value. The flavour of milk is due to milk fat. The fat of milk is easily digestible. Milk contains saturated, unsaturated and polyunsaturated fattyacids. It contains linoleic acid, linolenic acid and arachidonic acid.

Milk is main source of calcium, magnesium, sodium and potassium. Milk is poor of iron. Milk contains trace elements like zinc, molybdenum and iodine.

Milk is good source of vitamins A and D. Riboflavin is present in a higher concentration in milk, than the other B vitamins. Milk is not a good source of thiamine and niacin. It is a poor source of vitamin C.

**TYPES OF MARKET MILK AND MILK PRODUCTS**

**Full cream milk -** In full cream milk, the fat content is maintained at 7% and SNF(Solids Not Fat) at 9% from whole milk.

**Recombined milk -** Recombined milk is a homogenized product prepared from milk fat, non-fat milk solids and water. It should be pasteurized and show a negative phosphate test. Its fat content should be less than 6% and SNF 8.5%.

**Standardized milk -** In standardized milk, the fat content is maintained at 4.5% and SNF 8.5%. It is prepared from the mixture of buffalo milk and skim milk.

**Toned milk -** Toned milk is prepared with a fat content of 3% and SNF 8.5%.

**Double toned milk -** It is prepared with fat not less than 1.5% and SNF 9%.

**Skimmed milk -** Fat content is reduced to 0.1%. By removing fat from the milk not only taste or flavour is reduced but also fat soluble vitamins like vitamin A and D are reduced. Usually this milk is fortified with vitamin A and D. Skim milk is used for low calorie diets and for children who need high protein.

**Condensed milk -** The product is made from pasteurized milk that is concentrated and sweetened with sugar. Sugar concentration is 65%. This milk cannot be substituted for the ordinary fresh milk for children. SNF should be 31% and fat 9%.

**Ultra high temperature (UTH) -** Milk is heated at temperatures higher than those used for pasteurization, 138-150C for 2-6 sec. Then, under sterile conditions it is packaged into pre-sterilized containers, which are aseptically sealed so that spoilage organisms cannot enter. Hydrogen peroxide may be used to sterilize the milk packaging material. UTH milk can be stored unrefrigerated for at least 3 months.

**UNIT – V**

**FOOD MICROBIOLOGY**

## FOOD SPOILAGE

## FACRORS RESPONSIBLE FOR SPOILAGE:

Contamination of food results in its spoilage. Food spoilage can be broadly classified into six groups. Foods spoil mainly because of any one or more of the following reasons.

1. **Microbiological action:** Microorganisms are present everywhere and in all the sources of contamination. These organisms can contaminate food and spoil it. Milk turns sour because of bacterial action, yeasts ferment fruit juices and mold grows on bread which has to be discarded. Microbial growth in foods may be obvious like the examples listed above. Some bacteria which cause food poisoning or food infection may contaminate food which is unhygienically handled. In such cases, microbial growth may not be obvious. Not all microorganisms can cause disease, in fact some are useful to the food industry. Foods having a high protein, moisture, vitamin and mineral content are an ideal media for bacterial growth.
2. **Presence of contaminants:** If any unwanted inedible matter is added to or is present in food, the food is said to be spoiled and should be rejected. Radiation used for preserving spices and those emitted by microwave ovens, although invisible, may also prove hazardous to health if used in excess. This kind of contamination occurs at any stage right from harvesting to food service.
3. **Action of insects:** Foods are spoilt because of the presence of worms, weevils, fruit flies months, etc. These may damage the food and reduce its nutrient content. Food spoilt by insects is not fit for human consumption.
4. **Natural enzymes:** Foods spoil by autolysis or the action of various enzymes naturally present in them. Signs of spoilage seen in fruits and vegetables include over maturing, softening, browning and sprouting. After picking or harvesting, fruits and vegetables remain alive for some time. They respire and ripen, and if they are not consumed or processed soon, they become over-pipe and ultimately spoil.
   Enzymes naturally present in meat act on mutton fibres and bring about autolysis. If these natural changes are not controlled, foods may spoil.
5. **Physical changes:** These changes occur in food by freezing, desiccation, evaporation and absorption of moisture. Freezer burn is a physical change seen in deep frozen foods.
   Mechanical damage during harvesting and transporting foods, like bruising and crushing of fruits and vegetables, broken eggs and cracked shells, can accelerate spoilage by microorganisms because of easy access. It also results in greater susceptibility to decay and discolouration by enzyme action. This can be prevented by proper storage and transport facilities.
6. **Chemical reactions:** Chemical changes, which are not catalysed by natural enzymes or action or microorganisms, can also results in chemical spoilage of foods. A reaction between acidic food and iron from the can causes hydrogen swell in canned foods. Development of oxidative rancidity in fats and the fatty phases of foods results

in spoilage of fried snacks and oil-based pickles. Other changes include oxidative discolouration, flavour changes and nutritive loss.

## MICROORGANISMS THAT BRING ABOUT USEFUL CHANGES IN FOOD

The beneficial role of microorganisms is in the production fermented foods, dairy products, bakery products, alcoholic beverages and vinegar.

Fermentation is a chemical process that breaks down organic materials. This process is carried out by microbes such as bacteria, yeasts and moulds. The microbes such as bacteria, yeast and moulds, is useful in the production of bread, cheese any yoghurt, and alcoholic beverages like wine and beer etc. The microbes that bring about food fermentations may be added to the food in the form of a pure culture or mixed culture or very often no culture added as the desired microbes are naturally present in adequate numbers in the food. For example, while making Idli the bacteria Leuconostoc, streptococcus and pediococcus that bring about fermentation of the rice and black gram paste are already present in sufficient numbers on the grains.

Some Important Microbial Reactions

Bakery Products In bread dough, sugars are fermented by the yeast Saccharomyces cerevisiae to ethanol (alcohol) and $CO_2$.

Sugar from grape juice $\xrightarrow[fermentation]{YEAST} Wine + CO_2$

Sugar from malted grains of barley $\xrightarrow[fermentation]{YEAST} Beer + CO_2$

Yeast for beer making – saccharomyces carlsbergensis

Other fermented beverages are:

Ale - made from malted barley

Cider - made from apples

Sake - Japanese rice wine

Distilled spirits contain higher percentages of ethyl alcohol, e.g., whiskey, vodka, rum, etc. Rum is produced by distillation of alcoholically fermented sugar juice or molasses. Whiskeys are produced from saccharfied and fermented grains such as rye, wheat and corn.

Saacharmyces cererisiae var. ellipsoideus that gives a high percentage of alcohol is used for fermentation.

**Fermentation of Milk**

$$C_{12}H_{22} + H_2O \xrightarrow{\text{Lactase enzyme}} \underset{\text{Glucose + Galactose}}{2C_6H_{12}O_6} \xrightarrow[\text{enzymes}]{\text{System of}} \underset{\text{Lactic acid}}{2CH_3CHOHCOOH}$$

Microorganisms used in making yoghurt

Lactobacillus bulgaricus

Streprococcus thermophilus

Cheese is ripened by bateria or mold

Hard cheese - Lactobacillus casei

Lactobacillus bulgaricus

Swiss cheese - Propionibacterium

Normal Flora of Curds is species of

Lactobacilli

Leuconostoc

Streptococci and Yeast

**Manufacture of vinegar:** Manufacture of vinegar involves two steps:

Step 1

$$\underset{Sugar}{C_6H_{12}O_6} \xrightarrow[\text{Fermentation}]{\text{YEAST}} \underset{Ethyl\ alcohol\ carbon-di-oxide}{2C_2H_5OHCOOH}$$

The yeast that brings about fermentation of any carbohydrate rich substrate such as sugarcane juice fruit juice etc. is Saccharomyces cerevisiae

Step 2

$$\underset{Pthyl\ alcohol}{2CH_3\,CH_2OH} + 2O_2 \xrightarrow[action]{Bacterial} \underset{Acetic\ acid}{2C_3\,COOHO} + 2H_2O$$

Bacterial which are used to oxidise the alcohol formed in the first step to acetic acid or vinegar are:

1. Acetobacter aceti and

2. Gluconobacter

Beneficial role of Microorganisms in Some food products

| S.No. | Food product | Raw material | Microorganisms involved |
|---|---|---|---|
| 1. | Idli | Rice + black gram | Leuconostoc mesenteroides<br>Streptococcus faecalis<br>Pediococcus cerecisiae |
| 2. | Soy sauce | Soyabeans and wheat bran | Aspergillus oryzae, Streptococci, Lactoba |
| 3. | Tamari Sauce | Soybeans + rice | Aspergillus tamari |
| 4. | Tempeh | Soybeans | Rhizopus stolonifera |
| 5. | Poi | Corms of taro plant | Lactic acid bacteria, yeasts, molds |
| 6. | Coffee | Coffee berries | Pectinolytic bateria, Leuconostoc mesenteroides, lactobacillus bra |

| | | | |
|---|---|---|---|
| | | | Lactobacillusplantarum, streptococci faecalis |
| 7. | Cocoa | Cocoa beans | Candida yeast enzymes |
| 8. | Vinegar | Starchy vegetables, malted grains, sugars and fruit juice | Saccharomyces cerevisiae var.elliposoideus alcoholic fermentation; Acetobacter and gluconobacter acidic fermentation |
| 9. | Sauerkraut | Cabbage | Enterobacter, Leuconostoc mesenteroides Lactobacillus plantarum |
| 10. | Pickles | Cucumber, Dill, Olives | Pediococcus cerevisiae |
| 11. | Curds | Milk | Streptococcus lactis<br>Streptococcus cremoris<br>Leuconostoc cremoris |
| 12. | Cheese<br>Hard<br>Swiss<br>Roquefort<br>Camembert<br>Cheddar<br><br>Yougurt | Milk<br>Flavour and eye<br>Formation | Streptococcus lactis,<br>Lactobacillus casei<br>Propoionibacterium freudenrcichii<br>Penicillium roqueforti<br>Penicillium camemberti<br>Stereptococcus thermophilius<br>Stereptococcus faecalis<br>Stereptococcus thermophilus<br>Lactobacillus bulgaricus |

**FOOD SANITATION AND HYGIENE**

**Preparing Food**

**Procedures in Food Preparation:** The procedure to be followed will depend to a large extent on the food being prepared. Some common procedures which affect the microbial count are as follows:

**Cleaning:** Cereals and pulses are picked before they are milled or cooked, to remove frit, mud, stones, husk, mouldy and insect-infested grains. Green leaves are separated from the inedible roots and tough stalks.

**Washing:** Most foods need to be washed before preparation with potable cold water. Washing removes extraneous matter like surface dirt, soil and preservative and pesticide residue.

**Thawing:** Frozen foods should be thawed completely before cooking, unless the manufacturers instructions are otherwise. Thawing large portions of food, joints and poultry takes time. Freezing only prevents bacteria from multiplying, it does not kill them. When a food is thawed, these dormant microorganisms start multiplying rapidly once again.

If food is cooked while it is partially or totally frozen, a large amount of heat will have to travel to the centre of the food to melt the ice. The food may get cooked on the surface, but internal temperatures will not be high enough to kill bacteria. The food is thus likely to reach a temperature within the danger zone which is favourable for bacterial growth.

Meat may be thawed in a special thawing cabinet at a temperature of 10 to 15°C. The advantage of such a cabinet is that cross contamination is prevented and thawing is faster and safer at a cool temperature of 15°C.

A refrigerator may be used instead of a thawing cabinet. Care should be taken to prevent any liquid from raw meat dripping in the refrigerator and contaminating other foods. Raw meat can contaminate any and everything it comes in contact with in the kitchen, like hands, work table, chopping board, meat block, knives, cutters, utensils, dish cloth and dusters. These articles can further contaminate other foods.

Never thaw meat by immersion in warm water or near heat as the microorganisms on the surface will grow rapidly while the centre is still defrosting. Thawed meat should be cooked immediately or kept in the refrigerator for maximum 24 hours before cooking. Never refreeze meat which has once thawed. If it has to be refrozen, then cook and freeze.

***Rules for Thawing Food*:** Thaw or defrost food in any one of the following ways:

1. In the refrigerator below 4°C (39°F)
2. In a thawing cabinet at temperatures between 10-15°C
3. In potable running water at 21°C or below while it is still in the packet.
4. In a microwave oven, only when it has to be cooked immediately.
5. As part of conventional cooking, for example, certain frozen foods like frozen vegetables and ready-to-eat chicken preparations are cooked in the frozen state and quickly that when they are cooked.

**BASIC RULES TO BE OBSERVED DURING FOOD SERVICE:**

A number of diseases can be spread due to unsanitary practices while serving food. These diseases can be avoided by following certain basic rules of sanitation.
Protecting food during service is very important. Food should be protected at all times from contamination by people, dust, flies as well as changes in temperature.

1. Practice personal hygiene.
2. Avoid handling food with your bare hands. Bread rolls, chapatis, papad, sugar cubes, salads, cold cuts, cheese, ice and even garnishes should not be touched. Always use a pair of tongs, spoon or plastic glove to pick up these foods.
3. Maintain temperature control. Food which is to be held during a long lunch hour should be kept at temperatures outside the danger zone. Potentially hazardous or high risk foods may remain in the danger zone for a maximum period of four hours, after which they should be held outside the danger zone.

   The temperature of food in the bain-marie or hot cupboard should be above 63 C and the temperature of food held in the refrigerated case should be 5 to ***8***°C or lower, depending on the nature of the food.
4. Foods held on buffet tables must be kept at proper hot or cold holding temperatures. Check the temperature of all foods with a probe thermometer.
5. Do not re-serve leftovers that have been displayed on buffets. Foods on buffets remain on the table for several hours and are exposed to contamination by customers who may have coughed, sneezed or touched the food during the meal hour. The top portion of cold foods may get warmed by air and spoilage may begin. Therefore, after a buffet closes, consider all food articles on display contaminated and discard them.

   However, in a poor country like India this rule is not practical and, therefore, the food handier should follow proper temperature control.
6. Food which has once been served to a customer should never be reserved, for example, breadrolls, leftover butter, etc. only foods that are not potentially hazardous and are packed or wrapped may be served again.
7. Handle dishes and utensils in a sanitary manner. Plates should be held by the bottom or edge, cups by handles or bottoms, silverware by handles. Avoid touching the eating surface of crockery and cutlery.
8. Single service items should be dispensed in such a way that customers remove one item at a time without touching other items.
9. Before food service begins, all service personnel should check serving dishes for any signs of soil or improper cleaning.
10. Do not serve food in chipped or cracked dishes.

**FOOD STORAGE**

All catering establishments, irrespective of the volume of business handled, should have adequate, temperature-controlled storage facilities to protect food from any kind of spoilage.

Temperature- controlled storage facilities include a dry food store, refrigerated stores and deep freezers. Storage space required depends on quantity purchased.
These facilities will prevent the entry and multiplication of microorganisms and preserve the quality and palatability of food. Food will thus remain wholesome till it is consumed.

However, food cannot be completely free from microorganisms because of their ubiquitous nature. Complete sterilization of food is therefore, neither practical nor necessary. What is needed is control over the duration and temperature of storage to prevent growth of microorganisms. This can be achieved by ensuring that food is not left in warm and moist places for indefinite periods of time. The golden rule for storing any kind of food is to keep it clean, covered, cool and whenever applicable, dry.
The three major storage areas to hold large stocks or for bulk supplies are:

1. the dry food store for non-perishables (short-term holding) 10 to 21°C
2. the refrigerated store for perishables (short-term holding) 1 to 4°C
3. the freezer store for perishables (long-term holding) -6 to -25°C

The stores should ideally be located in the north-east part of the building. This will prevent it from getting heated by the sun and will help in keeping it cool and well lit. It should be near the goods receiving area. The kind of storage facilities and amount of storage space required depends on many factors like the menu, the number of covers served daily, purchasing policies and frequency of deliveries.

The stores should not be humid or damp and should be pestproof.

## GENERAL GUIDELINES FOR FOOD STORAGE

1. Wash items that need washing and prepare food for storage. Wipe cans.
2. Check frozen items to ensure that they are in a solidly frozen state before putting them in the freezer.
3. Rotate food supplies using the ‘first-in, first-out’ (FIFO) method. Goods should be placed in the order received. Date goods on receipt and place new deliveries in the rear of the store. The ‘Best before’ or ‘Use by’ date should be marked on products.
4. Store foods in areas designed for storage only and not in the kitchen and larder. Each storage area should be separate.
5. Keep all goods in clean wrappers or containers. Dirty wrappers attract pests and contaminate food. Use water proof and airtight material. Check packets before storing them.
6. Keep storage areas clean and maintain a regular cleaning schedule.

7. Keep vehicles used for transporting food with in the establishment clean.
8. Access to the food store should be restricted to prevent pilferage and to control stocks.
9. Periodic inspection and turnover of foods is necessary to check their condition.
10. Maintain appropriate temperature depending on the type of storage.
11. Avoid overcrowding of stored food and overstocking. Adequate air circulation and ventilation is necessary.
12. Food should be stored in the appropriate storage area to remain in a sound state, for example, if bananas are refrigerated, their skin darkens and they become unacceptable.
13. Food should be used as soon as possible because even under ideal conditions of storage there is loss in nutritive value, flavour and freshness.
14. Goods must be stored as soon as they are purchased. Potentially hazardous food items should not be left in the open yard or receiving area. They should be refrigerated or frozen immediately.
15. Separate areas should be made available for storage of equipment, cleaning materials and empty cartons/packaging materials.

**Microbiology of Different Foods**

We have already read that microbes are ubiquitous (present everywhere) and the microbial flora on food depends largely on the source of contamination. There are some microbes that are generally present in different food items. The food handler should understand that more the number of times a food is handled the greater are the chances of further contamination. The normal flora o microbes present in various categories of food is listed below.

**Cereals:** Microbes present on the outer surface of harvested grains include those from the soil, from insects and from other sources. Washing, milling and bleaching of cereals and their products helps in reducing the microbial load. Coliform bacteria and spores of Bacillus, along with other bacteria, may be present in cereals such as rice along with spores of the mold Aspergillus and Penicillium. The number of bacteria present per gramme of cereal may vary from a few hundred to millions. The surface of a freshly baked loaf of bread or freshly made chapatis is practically devoid of viable microbes. Bread can get contaminated by microbes from the air, the hands of the baker, the blades of the slicing machine or from the wrapper. The spores of the bacteria, which cause the defect ropiness in bread, are not destroyed during baking.

**Sweeteners:** Sugarcane juice has a high microbial count from the sugarcanes, the soil, and from the extracting equipment and containers used. Bacteria of the species Leuconostoc and Bacillus, a variety of other bacteria, yeasts and some molds are present. Raw sugar contains osmophilic yeasts, molds and bacteria of the species Bacillus, Clostridium and Desulfotomacalum. Honey contains the microbes yeast and bacteria from the nectar of flowers and the intestinal contents of honey bee. Clostridium botulinum spores from honey have been implicated as a cause of infant botulism.

**Eggs:** The white and yolk of freshly laid eggs is generally free from microbes but the shells soon get contaminated by faecal matter from the hen, the contents of the poultry farm, the water used to wash the eggs and the boxes in which eggs are packed. Salmonellae may be found in eggs as well as the shell and in dried or frozen egg powders. These Salmonellae may enter the eggs through contaminated poultry feed.

**Poultry:** The organisms from feet, feathers and droppings are added to the normal flora of the skin. Microorganisms found on the feet and the cut surfaces include Pseudomonas, Achromobactcr Micrococcus, Proteus, Bacillus, etc.

**Milk:** Milk from healthy cattle contains relatively few bacteria. It gets contaminated from the exterior of the animal. Bacteria from manure, soil and water are also found in milk. If dairy utensils are not cleaned and sanitised, they can be the most important source of contamination and may add considerable numbers of bacteria of the most undesirable kinds. Species of Streptococci Lactobacilli, Leuconostoc and yeasts constitute the normal flora of milk.

**Fish:** Fish flesh is highly perishable. The flora present on living fish will depend on the microbial load and the temperatures of water in which they breed. Psychrophiles like Psedomonas are seen in colder Northern waters, while mesophiles and found in larger numbers in tropical waters. Microbes are present in the slime layer that covers the outer surface of fish and in the intestinal contents. Bacteria of the genera Pseudomonas, Micrococcus, Lacaligenes, Escherichia, Vibro, Clostridium and Bacillus, are some of the bacteria on fish that contaminate trawlers, boxes and everything they come in contact with.

**Meat:** Like fish, meat is also an excellent medium for the growth of many microorganisms because it has adequate, it is rich in proteins and contains ample growth factors or vitamins and is at a favourable pH for most organisms. While the healthy inner flesh of meat generally has little or no microorganisms, it gets quickly contaminated during the normal slaughtering process. The exterior of the animal, i.e., the hide, hooves and hair harbour many different microorganisms from the dung, soil, water and fodder. These may be found in meat and bring about spoilage and disease.

**Vegetables and Fruit:** Fruits and vegetables are subjected to contamination from containers during transportation to the market or to the processing plants. Adequate washing of fruits and vegetables reduces the number of bacteria, especially in the case of root vegetables and salad vegetables. Microorganisms on the surface of fruits and vegetables include normal surface flora and also those from soil and water, and some plant pathogens, Genera of bacteria usually present are Achromobacter, Aerobacter, Psedomonas, and Lactobacillus. The natural flora on the surface of fresh grapes is mainly yeast.