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Directorate of Distance Education

M.Sc. [Home Science - Nutrition and Dietetics]

I - Semester

365 13

ADVANCED FOOD SCIENCE

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Advanced Food Science

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INTRODUCTION

Food science is defined by the Institute of Food Technologists as, 'the discipline in which the engineering, biological, and physical sciences are used to study the nature of foods, the causes of deterioration, the principles underlying food processing, and the improvement of foods for the consuming public'. The activities in food science encompass the development of new food products, design of processes to produce these foods, selection of packaging materials, shelf-life studies, sensory evaluation of products employing survey panels or potential clients, as well as microbiological and chemical testing.

Some of the sub disciplines of food science include food chemistry, food engineering, food preservation, food technology, food microbiology, etc. Food scientists also examine more fundamental phenomenon that are directly connected to the production of food products and their properties.

This book, *Advanced Food Science*, is divided into fourteen units that follow the self-instruction mode with each unit beginning with an Introduction to the unit, followed by an outline of the Objectives. The detailed content is then presented in a simple but structured manner interspersed with Check Your Progress Questions to test the student's understanding of the topic. A Summary along with a list of Key Words and a set of Self-Assessment Questions and Exercises is also provided at the end of each unit for recapitulation.

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BLOCK - I
FOOD PREPARATION, PROPERTIES OF
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UNIT 1 FOOD IN RELATION TO
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1.0 INTRODUCTION

Food is a mixture of many different chemical components. Food is that which nourishes the body. It can be defined as anything eaten or drunk, which can be absorbed by the body to be used as an energy source, building, regulating or protective material. In short, food is the raw material form which our bodies are made. Intake of the right kinds and amounts of food can ensure good health, which may be evident in our appearance, efficiency and emotional well-being.

In this unit, you will study about food in relation to health. It provides an introduction to food science as a discipline and discusses the modern developments in this field. Different methods of cooking and functions of cooking food are also discussed in this unit.

1.1 OBJECTIVES

After going through this unit, you will be able to:

- Define and discuss the scope of food science
- Discuss the relationship of food science with other sciences
- Assess the concept of health, nutrition and disease

- Explain the role of water in health
- Describe the basic concept of cooking methods and functions of food

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1.2 INTRODUCTION TO FOOD SCIENCE AS A DISCIPLINE AND MODERN DEVELOPMENTS

Food science can be defined as an application of basic sciences and engineering to study the fundamental physical, chemical and biochemical nature of food with respect to food processing. The study of food science involves understanding the changes that occur in these components during food preparation. These reactions may be a result of interaction between components with the medium of cooking, environmental condition such as heat, cold, light and air to which they are subjected during cooking. The study of food science also includes understanding the nutritive value of different foods and changes in the nutritive values of food during cooking, processing, preservation and consumption of food. Thus, food science is a broad discipline which contains within it many specializations such as food microbiology, food engineering and food chemistry, food psychology, food biochemistry; thus, it becomes a chain that there is close relation between food science and nutrition.

1.2.1 Food Science and its Inter-relationship with Food Chemistry, Food Microbiology and Food Processing

Nutritive foods are very important for an individual. Study of food science also includes the understanding of the nutritive value of foods and methods of preserving their nutritive value during cooking. The different fields of food science are as follows:

- 1. Food Chemistry:** It covers the basic composition, structure and properties of food and the chemistry of changes that occur during processing and utilization.
- 2. Food Analysis:** It deals with principles, methods and techniques, necessary for quantitative, physical and chemical analysis of food products and ingredients.
- 3. Food Microbiology:** It is the study of microbial ecology related to food, effect of environment on food spoilage and food manufacture; the physical, chemical and biological destruction of microorganisms in foods along with the biological examination of food stuff.
- 4. Food Processing:** It covers general characteristics of raw materials, principle of food preservation, processing factor, which influence quality, package, water and waste management, good manufacturing practices and sanitation procedure.
- 5. Food Engineering:** It involves the study of engineering concepts and unit operations used in food processing. Engineering principles should include energy balance, thermodynamics, heat and mass transfer.

Inter-relationship of food science:

1. With Food Chemistry: Food science is important in biochemistry as it includes the study of raw, cooked and processed foods and factors affecting the nutritive value. The use of *artificial sweetener* instead of sugar involves the importance of chemistry with food science. Some of the applications of food chemistry are as follows:

- *Development of palatable, nutritious, low cost food* for eg., development of fish flour which is a cheaper source of protein, development of milk powder (although the cost of milk powders is very high, but it is very effective in areas where there is limited supply of fresh milk).
- *Improvement of existing and developing new food products:* This is the largest single activity of the food scientist working in industrial organization. As consumers like to have new products available so creative ways to meet the demands of the consumer must be worked out. A successful product development requires a blend of science and creativity.
- *Altering the nutritive content of the food:* Food scientists are often involved in increasing or decreasing the particular nutrient content of a particular food (fortified hydrogenated fats, development of low sodium salt, fortified Calcium jam, cholesterol free butter, diet Pepsi/coke by replacing sugar with saccharine / aspartame etc.)
- *Adding desirable vitamins and minerals to food, that is, fortification:* Food scientists are involved in improving the vitamin and mineral content of some food for e.g., breakfast cereal, fortified bread, iodized salt etc. These nutrients are added in such a way as to be evenly dispersed and to remain in that nutritive property for fixed period of time.

2. With Food Microbiology: One of the most important role of food science is to make the food as safe as possible.

- *Prevention of outbreak of food poisoning:* The judicious application of food processing, storage and preservation method help to prevent food poisoning.
- *Use of new techniques and products emerging from the field of genetic engineering and biotechnology:* The advances in recombinant DNA technology and related methods providing improved microbial strains to increase yield and cut cost supports the fermentation industry up to a great extent.

3. With Food Processing

- *Optimization of different processing operations to maximize nutrient retention and development of new food products keeping in view the food laws and food standards.*
- *Adaptation and development of preservation methods:* Food scientists are involved in adapting and developing preservation methods, appropriate

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and affordable to various regions of the world (especially for developing and poor countries).

- *Proper storage of fruits and vegetables to make them available for considerable time:* For different fruits and vegetables, different atmospheric conditions are required, which are produced commercially by automatic control and thus storing and preserving the fruits and vegetables for a long time.
- *Quick freezing of delicate fruits:* It is done by liquid nitrogen or by carbon-di-oxide. When fruits and vegetables are frozen, ice crystals form within and between the cells which retard the growth of microorganisms and prevent the cell rupture.

4. Other Important Contributions

- Food scientists are now developing systems which recycle foods for space voyage.
- Prevention of foods by toxic substances produced by pathogenic contaminants such as chemicals like pesticides.
- Food scientists are also investigating the removal of ions from liquid foods through the combined use of selective membranes and electric current, a process known as electro dialysis.
- Food scientists are also involved in establishing International Food Standards to promote and facilitate world trade of food and at the same time to assure the wholesomeness and value of foods purchased between nations.
- Food scientists work in conjunction with nutritionists to develop standards for optimal nutritional content of the list. They are also involved in investigating how food formulations affect the bio-availability of nutrients.
- Food scientists are also involved in developing **nutraceuticals** (These are nutrient medicines which reduce disease symptoms or help in improving the nutritional status of the individual).

Check Your Progress

1. What does food chemistry cover?
2. State one important role of food science.
3. What are nutraceuticals?

1.3 HEALTH, NUTRITION AND NUTRIENTS: MEANING AND RELATION

Health is defined by the WHO as the “state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.

Food is that which nourishes the body. It can be defined as anything eaten or drunk, which can be absorbed by the body to be used as an energy source, building, regulating or protective material. In short, food is the raw material form which our bodies are made. Intake of the right kinds and amounts of food can ensure good health, which may be evident in our appearance, efficiency and emotional well-being.

Food is a prerequisite of nutrition. *Nutrition* is “the science of foods, the nutrients and other substances therein; their action, interaction, and balance in relationship to health and disease; the processes by which the organism ingests, digests, absorbs, transports, and utilizes nutrients and disposes off the end products”. In addition, nutrition must be concerned with social, economic, cultural and psychological implications of food and eating.

Nutrients are components of food that must be supplied to the body. These are needed by the body in adequate amounts in order to grow, reproduce and lead a normal, healthy life. Nutrients include water, protein, fats, carbohydrates, minerals and vitamins.

The science of nutrition deals with what nutrients we need, why we need these and where we can get them. Nutrition is the result of the kinds of foods supplied to the body and how the body uses the foods supplied.

Nutritional classification of foods

Since foods vary widely in their contents of various nutrients, they have been broadly classified under three heads from the nutritional point of view:

- **Energy yielding foods:** Foods rich in carbohydrates and fats are called energy yielding foods. Cereals, roots and tubers, dried fruits, sugars and fats are included in this group. Cereals contain, in addition fair amounts of proteins, minerals and certain vitamins and form the important sources of the above nutrients in poor dietary sources.
- **Body building foods:** Foods rich in proteins are called body building foods. Milk, meat, fish, eggs, pulses oilseeds and nuts and low-fat oilseed flours are included in the group of body building foods.
- **Protective foods:** Foods rich in proteins, vitamins and minerals are termed protective foods. Milk, eggs, liver, green leafy vegetables and fruits are included in this group. Protective foods are broadly classified in two broad categories:
 - o Foods rich in vitamin, minerals, and proteins of high biological value, for e.g., milk, eggs and liver.
 - o Foods rich in certain vitamins and minerals only, e.g., green leafy vegetables and fruits.

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Classification of food depending on their shelf life**NOTES**

- 1. Perishable Food:** “Perishable food” means any food having a significant risk of spoilage, loss of value, or loss of palatability within approximately 60 days of the date of packaging.
- 2. Semi-perishable Food:** “Semi-perishable food” means any food for which a significant risk of spoilage, loss of value, or loss of palatability occurs only after a minimum of 60 days, but within 6 months, after the date of packaging.
- 3. Non-perishable Food or Long Shelf-life Food:** “Long shelf-life food” means any food for which a significant risk of spoilage, loss of value, or loss of palatability does not occur sooner than 6 months after the date of packaging, including foods preserved by freezing, dehydrating, or being placed in a hermetically sealed container.

1.4 WATER IN RELATION TO HEALTH

Water, next to oxygen, is the most important constituents of life. It is an integral part of animal and vegetable tissues. Water is the medium through which all cellular reactions occur. Water is the most widely distributed compound in the world as liquid, solid and vapour. It is one of the most important chemicals in food.

The necessity of water in maintaining life was demonstrated by the German physiologist, *Rubner*, who found that during starvation an animal can live if he loses all of his glycogen and fat as well as one-half of his body protein, but a loss of 20 per cent water results in death.

Physical properties of water

1. The physical constants of water are very different when compared with molecules of similar molecular weight and atomic composition, such as hydrogen sulphide, hydrogen, fluoride, ammonia etc.
2. Water has unusually large values for melting point, boiling point, surface tension, specific heat and dielectric constant. Its heats of fusion, vaporization and sublimation are also very high.
3. Water has maximum density at 4 °C and not at 0 °C, its freezing point.
4. The thermal conductivity of water is 0 °C is approximately four times that of water at the same temperature, indicating that ice has much faster rate than immobilized water.
5. In a given environment, thermal diffusion of the ice greater than that of water. These differences account for the more rapid freezing of tissues than their thawing.

Structure of water molecule

1. The properties of water are closely related to its structure. Its unusual properties suggest the existence of strong attractive forces among water molecules.
2. The observed differences between the properties of water and ice are not common.
3. A molecule of water is formed by two hydrogen atoms forming covalent bonds with an oxygen atom.
4. The bond angle is 104.5° .
5. When water freezes into ice, a regular hexagonal pattern of molecules results. This structure of ice accounts for its properties.
6. In most substances solid form is denser than liquid. This is not true of water. The crystal structure of ice contains a large proportion of empty space; so, ice at 0°C is actually less dense than liquid water at 0°C .

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Dietary sources of water

The source of water for the body comes from the fluids of the diet, the “solid” foods of the diet (*comprising the **visible sources***) and the water produced by the metabolism of the energy nutrients within the tissues (*comprising the **invisible sources***).

- The **largest amount of the body water** comes from the ingested fluids (beverages as water, coffee, tea, soup, and other liquids each day). The amount of fluid will vary from one individual to another. Infants consume more per unit body weight than do adults. Persons living in tropics, where there is greater evaporation from the skin, consume more than those in temperate climates, and the persons engaged in strenuous physical activity consume more than sedentary individuals. The amounts consumed by adults as fluid varies from 900 to 1500 ml, with an average intake of 1100 ml under normal circumstances.
- The **solid foods, the second most important source of water**, contain 0% to 96% water. On an average, the “solid” foods contain 70% water.
- The end products of combustion of carbohydrate, fat and protein include water, referred to as **water of metabolism**, in addition to carbon-di-oxide and energy. A constant amount water is released during the oxidation or burning of these –

Carbohydrates (1 g)	0.6 g of water
Proteins (1 g)	0.42 g of water
Fats (1 g)	1.07 g of water

Bound water**NOTES**

Food and living systems contain bound water molecules due to their biological structures or the presence of solutes. The intensity of binding varies but only those molecules of water that are mobile and bound least firmly determine the observed activity. Bound water behaves differently from that of pure water. The bound water is grouped into four types. Distinct boundaries do not, however, exist between the *four types of bound water*. These are intermediate stages of boundness.

Type IV water is one with full activity and does not exist in the free state. The other types of water are present in biological matter.

Type III activity is found in water physically entrapped in tissue matrix and in solutions. This type of water represents the majority of water in plant animal food tissues. The activity of this type of water is only slightly reduced than water in Free State. This type of bound water is available for the growth of microorganisms, enzymic activity (hydrolytic and oxidative) and non-enzymic browning. Type III water can easily be removed to a moisture content of 12 to 25 per cent.

Type II water is more firmly bound, and its activity is reduced substantially. It permits enzymic activity (only hydrolytic) and non-enzymic browning. Removal of this type of water reduces the water level to 3 to 7 % and eliminates the possibility of microbial growth and greatly reduces most kinds of chemical reactions.

Type I water is much more firmly bound than type II and the water activity is further reduced. Partial removal of this type of water can be accomplished by conventional dehydrations but not by freezing. The degree of binding is such that any reactions depending on solution are slow as to be immeasurable. At this stage, there is an acceleration of lipid phase reactions, such as oxidative rancidity.

During starvation or when carbohydrate-free diet is ingested an excessive loss of body water, potassium and sodium occurs through the urine. This accounts for the rapid initial weight loss and weakness often reported by persons on such reducing diets. In extreme cases the loss of potassium may result in heart failure. A small amount of carbohydrate prevents this undesirable change by preventing the accumulation of ketones.

Through skin: Loss of water through skin amounts to 300 to 700 ml each day. It has been reported as high as 2500ml/hr and 500 ml/hr is not uncommon at environmental temperature and low humidity. Infants experience a high rate of evaporation from the skin, which compensates for small urine losses.

Through lungs: water along with CO₂ is constantly being lost through the lungs. The amount released this way is 300 ml but will increase at high altitudes because of increased respiration rates. Where the atmosphere is unusually dry, the total cost through the lungs and akin equals urinary losses.

Through digestive juices: During a 24-hour period as much as 8 to 10 liters of water (with 3700 ml) may be considered as a minimum) may be secreted into the digestive tract as digestive juices. These secretions include the saliva, gastric juices, intestinal and pancreatic juices, bile and secretion of lymph glands. Practically all of this is reabsorbed as it passes down the GIT so that as little as 200ml will be excreted in the faeces.

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1.5 COOKING METHODS AND FUNCTIONS

The following illustration discusses the various methods of cooking.

Moist Heat Methods
Boiling
<ul style="list-style-type: none"> Boiling is a method of cooking foods by just immersing them in water at 100°C and maintaining the water at that temperature till the food is tender. Rice, egg, dhal, meat, roots and tubers are cooked by boiling. Simple method -It does not require special skill and equipment. • Uniform cooking can be achieved. Continuous excessive boiling leads to damage in the structure and texture of food. • Loss of heat labile nutrients such as Vitamins B and C if the water is discarded. • Time consuming – Boiling takes more time to cook food and fuel may be wasted. • Loss of colour – water soluble pigments may be lost.
Stewing
<ul style="list-style-type: none"> It refers to the simmering of food in a pan with a tight fitting lid using small quantities of liquid to cover only half the food. This is a slow method of cooking. The liquid is brought to boiling point and the heat is reduced to maintain simmering temperatures (82°C -90°C). The food above the liquid is cooked by the steam generated within the pan. Apple, meat along with roots, vegetables and legumes are usually stewed. Loss of nutrients is avoided as water used for cooking is not discarded. • Flavour is retained. • The process is time consuming and there is wastage of fuel.
Steaming
<ul style="list-style-type: none"> It is a method of cooking food in steam generated from vigorously boiling water in a pan. The food to be steamed is placed in a container and is not in direct contact with the water or liquid. Idli, custard and idliappam are made by steaming. Vegetables can also be steamed. • Less chance of burning and scorching. Texture of food is better as it becomes light and fluffy. Eg. Idli. • Cooking time is less and fuel wastage is less. • Steamed foods like idli and idliappam contain less fat and are easily digested and are good for children, aged and for therapeutic diets. • Nutrient loss is minimised. • Steaming equipment is required. This method is limited to the preparation of selected foods.
Pressure cooking
<ul style="list-style-type: none"> When steam under pressure is used the method is known as pressure cooking and the equipment used is the pressure cooker. In this method the temperature of boiling water can be raised above 100°C. Rice, dhal, meat, roots and tubers are usually pressure cooked. • Cooking time is less compared to other methods. Nutrient and flavour loss is minimised. • Conserves fuel and time as different items can be cooked at the same time. • Less chance for burning and scorching. • Constant attention is not necessary. • The initial investment may not be affordable to everybody. • Knowledge of the usage, care and maintenance of cooker is required to prevent accidents. • Careful watch on the cooking time is required to prevent over cooking.
Poaching
<ul style="list-style-type: none"> This involves cooking in the minimum amount of liquid at temperatures of 80°C- 85°C that is below the boiling point. Egg and fish can be poached. • No special equipment is needed. • Quick method of cooking and therefore saves fuel. • Poached foods are easily digested since no fat is added. • Poached foods may not appeal to everybody as they are bland in taste. • Food can be scorched if water evaporates due to careless monitoring. • Water soluble nutrients may be leached into the water.
Blanching
<ul style="list-style-type: none"> This can be achieved by blanching. In this method, food is dipped in boiling water for 5 seconds to 2 minutes depending on the texture of the food. This helps to remove the skin or peel without softening food. Blanching can also be done by pouring enough boiling water on the food to immerse it for short periods and then immediately immersing in cold water. The process causes the skin to become loose and can be peeled off easily. • Peels can easily be removed to improve digestibility. • Destroys enzymes that bring about spoilage. • Texture can be maintained while improving the colour and flavour of food. • Loss of nutrients if cooking water is discarded.

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Dry Heat Methods
Roasting
<ul style="list-style-type: none"> In this method food is cooked in a heated metal or frying pan without covering it. Eg. Groundnut. *Quick method of cooking. *It improves the appearance, flavour and texture of the food. *Spices are easily powdered if they are first roasted. *Food can be scorched due to carelessness. *Roasting denatures proteins reducing their availability.
Grilling
<ul style="list-style-type: none"> Grilling or broiling refers to the cooking of food by exposing it to direct heat. In this method food is placed above or in between a red hot surface. Papads, corn, phulkas, chicken can be prepared by this method. *Enhances flavour, appearance and taste of the product. *It requires less time to cook. *Minimum fat is used. *Constant attention is required to prevent charring.
Toasting
<ul style="list-style-type: none"> This is a method where food is kept between two heated elements to facilitate browning on both sides. Bread slices are cooked by toasting. *Easy and quick method. *Flavour improved. *Special equipment required. *Careful monitoring is needed to prevent charring.
Baking
<ul style="list-style-type: none"> In this method, the food gets cooked in an oven or oven-like appliance by dry heat. The temperature range maintained in an oven is 1200C – 2600C. The food is usually kept uncovered in a container greased with a fat coated paper. Bread, cake, biscuits, pastries and meat are prepared by this method. *Baking lends a unique baked flavour to foods. *Foods become light and fluffy – cakes, custards, bread. *Uniform and bulk cooking can be achieved. Eg. bun, bread. *Flavour and texture are improved. *Variety of dishes can be made. *Special equipment like oven is required. *Baking skills are necessary to obtain a product with ideal texture, flavour and colour characteristics. *Careful monitoring needed to prevent scorching.
Sauteing
<ul style="list-style-type: none"> Sauteing is a method in which food is lightly tossed in little oil just enough to cover the base of the pan. The pan is covered with a lid and the flame or intensity of heat is reduced. The product obtained is slightly moist and tender but without any liquid or gravy. Foods cooked by sauteing are generally vegetables. *Takes less time. *Simple technique. *Minimum oil is used. *Constant attention is needed as there is chance of scorching or burning.
Frying
<ul style="list-style-type: none"> In this method, the food to be cooked is brought into contact with larger amount of hot fat. When food is totally immersed in hot oil, it is called deep fat frying. Samosa, chips, pakoda are examples of deep fat fried foods. In shallow fat frying, only a little fat is used and the food is turned in order that both sides are browned. Eg. Omelette, cutlets, parathas. *Very quick method of cooking. *The calorific value of food is increased since fat is used as the cooking media. *Frying lends a delicious flavour and attractive appearance to foods. *Taste and texture are improved. *Careful monitoring is required as food easily gets charred when the smoking temperature is not properly maintained. *The food may become soggy due to too much oil absorption. *Fried foods are not easily digested. *Repeated use of heated oils will have ill effects on health.

Combination of Cooking Methods
Braising
<ul style="list-style-type: none"> Braising is a combined method of roasting and stewing in a pan with a tight fitting lid. Flavourings and seasonings are added and food is allowed to cook gently. Food preparations prepared by combination methods are: Uppuma -Roasting and boiling. Cutlet -Boiling and deep frying. Vermicilli payasam - Roasting and simmering.
Microwave cooking
<ul style="list-style-type: none"> Microwaves are electromagnetic waves of radiant energy. Food placed in the oven is heated by microwaves from all directions. Moist foods and liquid foods can be rapidly heated in such ovens. Food should be kept in containers made of plastic, glass or china ware which do not contain metallic substances. These containers are used because they transmit the microwaves but do not absorb or reflect them. *Quick method – 10 times faster than conventional method. So loss of nutrients can be minimised. *Only the food gets heated and the oven does not get heated. *Food gets cooked uniformly. *Leftovers can be reheated without changing the flavour and texture of the product. *Microwave cooking enhances the flavour of food because it cooks quickly with little or no water. *Baked products do not get a brown surface. *Microwave cooking cannot be used for simmering, stewing or deep frying. *Flavour of all ingredients does not blend well as the cooking time is too short.
Solar Cooking
<ul style="list-style-type: none"> Solar cooking is a very simple technique that makes use of sunlight or solar energy which is a nonconventional source of energy. The temperature up to 1400C can be obtained which is adequate for cooking. *Simple technique – requires no special skill. *Cost effective as natural sunlight is the form of energy. *Original flavour of food is retained. *There is no danger of scorching or burning. *Loss of nutrients is minimum as only little amounts of water is used in cooking. *Special equipment is needed Slow cooking process. *Cannot be used in the absence of sunlight.

NOTES**Check Your Progress**

4. What does perishable food mean?
5. How many types does bound water have?
6. Name any two moist heat cooking methods.
7. Grilling is grouped under which type of cooking method?

1.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Food Chemistry covers the basic composition, structure and properties of food and the chemistry of changes that occur during processing and utilization.
2. One of the most important role of food science is to make the food as safe as possible.
3. Nutraceuticals are nutrient medicines which reduces disease symptoms or help in improving the nutritional status of the individual.
4. “Perishable food” means any food having a significant risk of spoilage, loss of value, or loss of palatability within approximately 60 days of the date of packaging.
5. The bound water is grouped into four types.
6. Two moist heat cooking methods are boiling and stewing.
7. Grilling is a type of dry heat method.

1.7 SUMMARY

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- Food science can be defined as an application of basic sciences and engineering to study the fundamental physical, chemical and biochemical nature of food with respect to food processing.
- The study of food science involves understanding the changes that occur in these components during food preparation.
- The study of food science also includes understanding the nutritive value of different foods and changes in the nutritive values of food during cooking, processing, preservation and consumption of food.
- Thus, food science is a broad discipline which contains within it many specializations such as food microbiology, food engineering and food chemistry, food psychology, food biochemistry; thus, it becomes a chain that there is close relation between food science and nutrition.
- Food Chemistry covers the basic composition, structure and properties of food and the chemistry of changes that occur during processing and utilization.
- Food Processing covers general characteristics of raw materials, principle of food preservation, processing factor, which influence quality, package, water and waste management, good manufacturing practices and sanitation procedure.
- Food Engineering involves the study of engineering concepts and unit operations used in food processing. Engineering principles should include energy balance, thermodynamics, heat and mass transfer.
- Food science is important in biochemistry as it includes the study of raw, cooked and processed foods and factors affecting the nutritive value.
- One of the most important role of food science is to make the food as safe as possible.
- Food scientists are now developing systems which recycle foods for space voyage.
- *Health* is defined by the WHO as the “state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.
- *Food* is that which nourishes the body. It can be defined as anything eaten or drunk, which can be absorbed by the body to be used as an energy source, building, regulating or protective material.
- Food is a prerequisite of nutrition.
- The science of nutrition deals with what nutrients we need, why we need these and where we can get them. Nutrition is the result of the kinds of foods supplied to the body and how the body uses the foods supplied.
- The source of water for the body comes from the fluids of the diet, the “solid” foods of the diet (comprising the visible sources) and the water produced by the metabolism of the energy nutrients within the tissues (comprising the invisible sources).

1.8 KEY WORDS

- **Nutrition:** It is the process of providing or obtaining the food necessary for health and growth.
- **Semi-Perishable Food:** These commodities are those that do not require refrigeration, but still have a limited shelf life.

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1.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. Write short notes:
 - Dehydration
 - Water and health
 - Nutrition and health
2. What are the various combinations of cooking methods?
3. State the four types of bound water.

Long Answer Questions

1. What do you understand by food science? What scope does it have in the near future? Explain in terms of your understanding of the unit.
2. Write an essay on food science and its relation to various other sciences.
3. Differentiate between dry heat methods and moist heat methods of cooking.

1.10 FURTHER READINGS

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UNIT 2 FUNCTIONAL PROPERTIES OF FOOD

NOTES

Structure

- 2.0 Introduction
- 2.1 Objectives
- 2.2 Definition, Structure and Properties of Food Hydrocolloids:
Gelling, Emulsifying, Thickening, Stabilizing and Coating Agents
 - 2.2.1 Modern Concept of Colloids
 - 2.2.2 Properties of a Colloidal System
- 2.3 Carbohydrates (caramelization and crystallization)
- 2.4 Important Roles of Fats and Proteins
 - 2.4.1 Important Roles of Proteins (Denaturation and Browning)
- 2.5 Answers to Check Your Progress Questions
- 2.6 Summary
- 2.7 Key Words
- 2.8 Self Assessment Questions and Exercises
- 2.9 Further Readings

2.0 INTRODUCTION

Foods have a very complex structure and are made of various components. These components are responsible for the physical as well as chemical properties of the food. These are present in the food in the following forms:

- As Solids
- As Solution
- As Colloid

Thomas Graham (1861) divided the soluble substances into two types:

- 1) **Crystalloids:** Their solution readily diffuses through the parchment membrane. Examples are sugar, urea, sodium chloride, glucose, fructose etc.
- 2) **Colloids:** The substances, whose solutions do not diffuse or diffuse very slowly through parchment membrane, are called colloids. Examples are glue, gelatin, albumin, starch, gum, proteins etc.

We will discuss the functional properties of foods in the unit.

2.1 OBJECTIVES

After going through this unit, you will be able to:

- Explain the meaning of food colloids
- Discuss the reactions of carbohydrates

- Analyse the reactions of fats and oils
- Describe the reactions of proteins

2.2 DEFINITION, STRUCTURE AND PROPERTIES OF FOOD HYDROCOLLOIDS: GELLING, EMULSIFYING, THICKENING, STABILIZING AND COATING AGENTS

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Hydrocolloids are widely used in many food formulations to improve quality attributes and shelf-life. The two main uses are as thickening and gelling agents. As thickening agents, they find uses in soups, gravies, salad dressings, sauces and toppings while as gelling agents, they are extensively used in products like jam, jelly, marmalade, restructured foods and low sugar/calorie gels.

Hydrocolloids are a heterogeneous group of long chain polymers (polysaccharides and proteins) characterised by their property of forming viscous dispersions and/or gels when dispersed in water. Presence of a large number of hydroxyl (-OH) groups markedly increases their affinity for binding water molecules rendering them hydrophilic compounds. Further, they produce a dispersion, which is intermediate between a true solution and a suspension, and exhibits the properties of a colloid. Considering these two properties, they are aptly termed as 'hydrophilic colloids' or 'hydrocolloids'.

The foremost reason behind the ample use of hydrocolloids in foods is their ability to modify the rheology of food system. This includes two basic properties of food system namely, flow behaviour (viscosity) and mechanical solid property (texture). The modification of texture and/or viscosity of food system helps to modify its sensory properties, and hence, hydrocolloids are used as important food additives to perform specific purposes. It is obvious that several hydrocolloids belong to the category of permitted food additive in many countries throughout the world. Various food formulations like soups, gravies, salad dressings, sauces and toppings use hydrocolloids as additives to attain the desired viscosity and mouth feel. They are also used in many food products like ice-cremes, jams, jellies, gelled desserts, cakes and candies, to create the desired texture. Considering their role in the adjustment of viscosity and texture of food formulations, several studies have been conducted in various food systems employing different hydrocolloids either singly or in combination.

Hydrocolloids have a wide array of functional properties in foods. These include thickening, gelling, emulsifying, stabilisation, and controlling the crystal growth of ice and sugar though the basic properties for which hydrocolloids find extensive use are thickening and gelling. Hydrocolloids disperse in water to give a thickening or viscosity producing effect. This water-thickening property is common to all hydrocolloids and is the prime reason for their overall use. The extent of thickening varies with the type and nature of hydrocolloids, with a few giving low

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viscosities at a fairly high concentration but most of them giving high viscosities at concentration, below 1% (Glicksman 1982).

While all hydrocolloids thicken and impart stickiness to aqueous dispersions, a few biopolymers also have another major property of being able to form gels. Gel formation is the phenomenon involving the association or cross-linking of the polymer chains to form a three dimensional network that traps or immobilises the water within it to form a rigid structure that is resistant to flow. In other words, it becomes viscoelastic exhibiting both characteristics of a liquid and a solid. The textural properties (e.g., elastic or brittle, long or spreadable, chewy or creamy) of a gel vary widely with the type of hydrocolloid used. The other sensory properties such as opacity, mouth feel and taste also depend on the hydrocolloid employed. Hydrocolloids that are commonly used as thickening are starch, xanthan, guar gum, locust bean gum, gum karaya, gum tragacanth, gum Arabic and cellulose derivatives. The gelling type hydrocolloids are alginate, pectin, carrageenan, gelatin, gellan and agar.

2.2.1 Modern Concept of Colloids

Colloid is a state of system that depends on the particle size of matter. In colloidal state the particles of the 50 to 2000 Å. particles are known as **colloidal particles**. Colloidal solution is an intermediate state between true solution and a suspension.

A colloidal solution is **heterogeneous** and consists of following two phases:

- 1) **Dispersed phase:** This phase exists as colloidal particles. The particle size ranges from 50 Å. to 2000 Å.. Thus, the dispersed phase makes the system colloidal system when its particles are of above size.
- 2) **Dispersion medium, outer phase or continuous phase:** This is the medium in which the particles of the dispersed phase are distributed in the colloidal form.

Characteristics of colloids

- The particle size ranges from 50 Å. to 2000 Å.
- Particles themselves are invisible, light scattered can be seen by ultra-microscope.
- They are generally transparent.
- Diffuses slowly through the parchment membrane.
- Ordinary filtration is not possible whereas ultra-filtration is possible.
- Settles only on centrifugation.
- Shows Tyndall effect
- Shows Brownian movement.

2.3 CARBOHYDRATES (CAMELIZATION AND CRYSTALLIZATION)

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It has been observed that an increased carbohydrate intake, corresponding to at least 55% of total energy. The carbohydrate content in diets typical for developing countries should be maintained at a high level.

The nutritional quality of the carbohydrates and the effects of processing on that quality then becomes a concern, because both the content and the nutritional quality of food carbohydrates can be altered by processing in a number of ways.

Carbohydrates and leaching

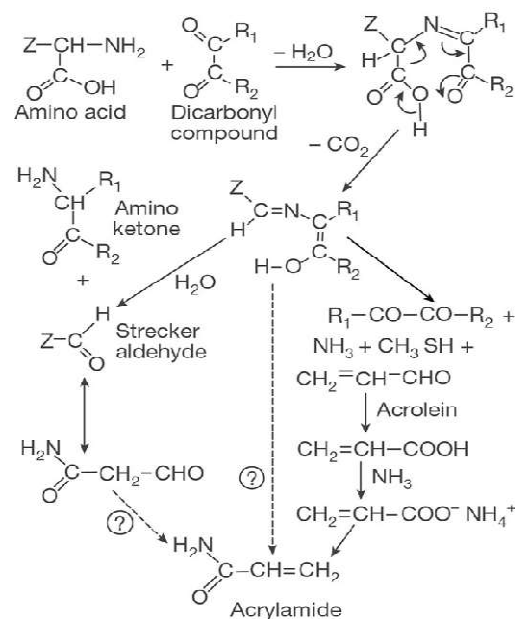
During wet heat treatment, as in blanching, boiling and canning of vegetables and fruits, there is a considerable loss of monosaccharides and disaccharides as well as micronutrients, into the processing water. The loss of glucose and fructose at boiling is higher than that of sucrose. The losses of low molecular weight carbohydrates in carrots have also been shown to differ between various cultivars, and also to be different at harvest and in storage. After storage the loss of low molecular weight carbohydrates increases following boiling, most probably due to the higher water content and therefore also a higher diffusivity. On the contrary, no leaching of dietary fibre into the processing water has been reported with blanching, boiling and canning of carrots, green peas, green beans and Brussels sprouts.

Effect on low molecular carbohydrates:

- Fructo-oligosaccharides can be synthesized from sucrose and by hydrolysis of inulin.
- The galacto-oligosaccharides can be synthesized from lactose.

Maillard reactions (Non-enzymic browning)

- Non-enzymatic browning reactions (Maillard reactions) occur between reducing sugars and amino groups in foods at processing and in storage.
- These reactions are temperature dependent and observed mostly at intermediate water activities.
- They may diminish the bioavailability of amino acids, especially lysine, thus diminishing the protein nutritional value. The carbohydrate content and availability is influenced only marginally
- When a non-reducing disaccharide such as sucrose is replaced by, for example, high fructose corn syrup containing glucose and fructose, Maillard reactions occur much more rapidly and extensively. This has to be kept in mind in selecting processing procedures and storage conditions.



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Effect of heat on carbohydrates

a. Gelatinization

Gelatinization refers to the irreversible loss of the crystalline regions in starch granules that occur upon heating in the presence of water. The temperature range during which the crystalline structure of the starch granule is lost is dependent on the water content, and on the type of starch. The gelatinization dramatically increases the availability of starch for digestion by amylolytic enzymes.

Usually, the starch granules are not completely dissolved during food processing, and a food can be regarded as a dispersion in which starch granules and/or granular remnants constitute the dispersed phase. The degree of gelatinization achieved by most commonly used food processes, however, is sufficient to permit the starch to be rapidly digested.

b. Retrogradation

Gelatinized starch is not in thermodynamic equilibrium. There is, therefore, a progressive re-association of the starch molecules upon ageing. This recrystallization is referred to as retrogradation. Retrogradation reduces the digestibility of the starch. The crystallinity of retrograded amylopectin is lost following re-heating to approximately 70°C, whereas temperatures above 145°C are required to remove crystallinity of retrograded amylose. This is a temperature well above the range used for processing of starchy foods. This implies that retrograded amylose, once formed, will retain its crystallinity following re-heating of the food.

c. Par-boiling

During par-boiling of rice, the kernels are subjected to a pre-treatment involving heating and drying. This process reduces the stickiness of the rice, possibly by allowing leached amylose to retrograde and form inclusion complexes with polar

lipids on the kernel surface. Parboiling also affects the final cooking properties of the rice.

Effect of processing on dietary fibre

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a. Milling and peeling

During milling of cereal grains to refined flours the outer fibre-rich layers are removed, resulting in a lower content of total dietary fibre because of the decrease of insoluble fibre.

The dietary fibre composition in both whole-grain and refined flours is different. Refined flours of oats, barley, rice and sorghum contain mainly glucans, while arabinoxylans dominate in refined flours of wheat, rye and maize.

Whole-grain flours all contain considerable amounts of cellulose.

The husk which surrounds barley, rice and oats also contains considerable amounts of xylans. This fraction is generally removed before consumption, but oat and rice husks are used for fibre preparation to enrich foods.

b. Heat-treatment

An increased temperature leads to a breakage of weak bonds between polysaccharide chains followed by breaking of glycosidic linkages in the dietary fibre polysaccharides.

A decreased association between fibre molecules, and a depolymerization of the fibre, results in a solubilization.

If the depolymerization is extensive, alcohol soluble fragments can be formed, resulting in a decreased content of dietary fibre.

Moderate depolymerization and decreased association between fibre molecules, may have only minor influence on the dietary fibre content, but functional (e.g. viscosity and hydration) and physiological properties of the fibre will be changed.

Other reactions during processing that may affect the dietary fibre content and its properties are leakage into the processing water, formation of Maillard reaction products thus adding to the lignin content, and formation of resistant starch fractions.

The architecture of the fibre matrix in the cell wall differs between various types of plant material. The cross-linking of constituent polysaccharides and phenolics within the cell wall is important in determining the properties of the fibre matrix, as the solubility of the fibre is highly dependent on the type and amount of cross-links present.

During heat-treatment the cell-wall matrix is modified and the structural alterations that occur may be important not only for the nutritional properties of the product but also for its palatability.

With extrusion-cooking of wheat-flour, even at mild conditions, the solubility of the dietary fibre increases. The solubilization seems to be dependent on the water content used in the process, and the lower the content of water, the higher the solubilization of the fibre, at least for whole-grain wheat flour and wheat bran.

Hydration properties (swelling, water-holding and water-binding capacity) are changed by heat-treatment.

The kinetics of water uptake is different for steam-cooking and roasting. Thus, both products exposed to steam-cooking had a very rapid water-uptake, whereas the roasted sample had a slow uptake.

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2.4 IMPORTANT ROLES OF FATS AND PROTEINS

As we know that fats are the primary constituents of margarines, butterfat, shortenings, and oils for salad and cooking. In addition to the visible fat contained in food, fats and oils are found in high quantities in many bakery goods, infant formulas, and dairy products and some sweets. Oils, butter or margarine are sometimes used directly on food.

According to PFA (1955), the package, label or the advertisement of edible oils and fats shall not use the expressions “Super-Refined”, “Extra-Refined”, “Micro-Refined”, “Double Refined”, “Ultra-Refined”, “Anti-Cholesterol”, “Cholesterol Fighter”, “Soothing to Heart”, “Cholesterol Friendly”, “Saturated Fat Free” or such other expressions which are an exaggeration of the quality of the Product.

Cooking oils

- The major use of cooking oil is in frying, where it functions as a heat transfer medium and contributes flavour and texture to foods.
- The cooking oil should be stable under high temperatures and moisture during deep-fat frying. For satisfactory results, oil should be kept at a maximum temperature of 180°C during frying.
- Frying food at a temperature which is too low results in increased fat uptake.
- Water present in the foods enhances the breakdown of fatty acids which occurs during heating.
- Hydrolysis results in a poor-quality oil that has a reduced smokepoint, darkened colour and altered flavour.
- During heating, oils also polymerize, creating a viscous oil that is readily absorbed by foods and that produces a greasy product.
- The more saturated (solid) the oil, the more stable it is to oxidative and hydrolytic breakdown, and the less likely it is to polymerize.

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- It is important to note that oils rich in linolenic acid, such as soybean and canola oils, are particularly susceptible to these undesirable changes.
- Stable oil is required when foods that are fried are stored before eating, for example, snack products.
- Stability can be improved by saturated oils, however, if the frying fat is solid at room temperature it will produce a dry dull surface that is undesirable on some fried products.
- When oils are used continuously, as in restaurants, a frying fat which can withstand very heavy use is needed. In these cases, more solid shortenings are used to maximize the stability of the fat for many hours of frying.
- Frying oils made from sunflower and safflower has lower stability because of their high polyunsaturated fatty acids and low tocopherol content.
- For optimal use of cooking oils, it is necessary to distinguish between different frying conditions. The most important parameters to be monitored are duration of use and nature of the foods to be fried. If food fats enter the frying oil, food components could destabilize the oil and the water content of the material could influence the frying operation. Finally, temperature must be considered.

Margarines

- Margarines must have some crystalline structure to maintain a semisolid consistency at refrigerator and room temperatures.
- Sharp melting at body temperature is needed so that the margarine will melt rapidly in the mouth leaving no waxy feeling.
- Oleic acid melts at 16°C, whereas elaidic acid melts at 44°C, so that the presence of some trans isomers may vastly raise the melting point and stability of a product.
- In addition to partial hydrogenation, the correct consistency of a margarine can be obtained by blending soft and hard fats. Lower fat spreads, for example, 40 percent or 60 percent fat, contain less trans fatty acids.
- Another important feature in solidifying oil for margarines is the type of crystal formed. Fats are polymorphic, that is, they are capable of forming several different types of crystals. Some crystals are the tiny, forming a smooth but unstable crystal while some are medium in size, still they are generally desirable in margarines because they impart a smooth texture, are fairly stable, and ensure plasticity of the product. It has been found that the largest crystals are stable and grainy, and generally undesirable.
- The lengths of fatty acids and their positions on the glycerol backbone determine the type of crystal formed.

- The triacylglycerols in a certain fat or solidified oil always form the same type of crystals unless other ingredients are added to alter crystal formation.
- According to PFA (1955), margarines should have following properties:

1. Fat	Not less than 80 per cent mass/mass
2. Moisture	Not less than 12 per cent and not more than 16 per cent mass/mass.
3. Vitamin A	Not less than 30 I.U. per gram of the product at the time of sale.
4. Melting point of extracted fat	31 degree C to 37 degree C (Capillary Slip method).
5. Unsaponifiable matter of	Not more than 1.5 per cent by weight extracted fat.
6. Free fatty acids (as oleic acid)	Not more than 0.25 per cent weight acid) of extracted fat
7. Acid value	Not more than 0.5

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Shortenings

- Shortenings are semisolid fats that impart a “short” or tender quality to baked goods, enhance the aeration of leavened products, and promote a desirable grain and flavour.
- They coat the gluten proteins of flour which prevents toughness. In contrast, toughness is desirable in yeast-raised products to give a chewy texture. For products with characteristics between breads and cakes such as doughnuts, shortening modifies the gluten and adds richness to the product. In baked goods, shortenings are used specifically to leaven, cream and lubricate. In icings and fillings, the fats help to form tiny air bubbles that create a light and fluffy structure. Shortenings used as stable frying fats provide a heating medium, and their crystalline structures are not important.
- The melting behavior of bakery shortenings remains constant over a wide range of temperature and have a wide plastic range. This quality allows the fat to be easily manipulated without melting at room temperature and enhances its mixing ability.

Fat spread

- Fat spread means a product in the form of water in oil emulsion, or an aqueous phase and a fat phase of edible oils and fats excluding animal body fats.
- Fat spread shall be classified into the following three groups:-
 1. Milk fat spread: Fat content will be exclusively milk fat.
 2. Mixed fat spread: Fat content will be a mixture of milk fat with any one or more of hydrogenated, unhydrogenated refined edible vegetable oils or interesterified fat.

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3. Vegetable fat spread: Fat content will be a mixture of any two or more of hydrogenated, non-hydrogenated, refined vegetable oils or unesterified fat.

- In mixed fat spread, the milk fat content shall also be declared on the label along with the total fat content.
- It may contain edible common salt not exceeding 2 percent by weight in aqueous phase; milk solids-not-fat; lactic acid, butyric acid, valeric acid, cinnamon oil, and Ethyl butyrate may also be added as flavouring agent upto 0.08 percent m/ml, Diacetyl may be added as flavouring agents not exceeding 4.0 p.p.m., permitted emulsifiers and stabilizers' permitted antioxidants (BHA or TBHQ) not exceeding 0.02 percent of the fat content of the spread; permitted Class II preservatives namely sorbic acid including its sodium, potassium and calcium salts (calculated as sorbic acid) or benzoic acid and its sodium and potassium salts (calculated as benzoic acid) singly or in combination not exceeding 1000 parts per million by weight; and sequestering agents.
- It may contain annatto and/or carotene as colouring agents.
- It shall be free from animal body fat, mineral oil and wax.
- Vegetable fat spread shall contain raw or refined Sesame oil (Til oil) in sufficient quantity so that when separated fat is mixed with refined groundnut oil in the proportion of 20:80 the red colour produced by Baudouin test shall not be lighter than 2.5 red units in 1 cm. Cell on a Lovibond scale.
- According to PFA (1955), it shall also conform to the following standards, namely:
 1. Fat: Not more than 80 percent and not less than 40 percent by weight.
 2. Moisture: Not more than 56 percent and not less than 16 percent by weight.
 3. Melting point of Extracted: Not more than 37 deg C fat (capacity slip method) in case of vegetable fat spread.
 4. Unsaponifiable matter of extracted fat –
 - a. In case of milk fat and mixed fat spread: Not more than 1 percent by weight.
 - b. In case of vegetable fat spread: Not more than 1.5 percent
 - c. Acid value of extracted fat: Not more than 0.5%
- The vegetable fat spread shall contain not less than 25 IU synthetic vitamin 'A' per gram at the time of packing and shall show a positive test for vitamin 'A' when tested by Antimony Trichloride (Carr-Price) reagents.
- It shall contain starch not less than 100 PPM and not more than 150 PPM.

Salad oils

- Salad oils are used in salad dressings.
- Traditional salad dressings, some of which are emulsified, consist of a two-phase system of oil and water with 55-65 percent oil.
- A salad oil coats the salad ingredients, spreading the flavour of the dressing that improves the palatability of the salad.
- The other major use of salad oils is in mayonnaise and thick salad dressings, which contain 80 and 35-50 percent oil, respectively.
- The oil in mayonnaise is responsible for viscosity, whereas the oils in thick salad dressings help to modify the mouthfeel of the starch paste that thickens the product.
- It is important to note that a salad oil must not contain solid crystals. Solid crystals when refrigerated, impart a waxy, tallowy texture. They may even break the emulsion formed between water and oil, or would give the product a cloudy appearance. Oils can be winterized, a process that removes solid crystals formed at refrigerator temperatures.
- For industrial purposes, unhydrogenated or partially hydrogenated soybean, canola, winterized cottonseed, safflower, sunflower, and corn oils are used as salad oils. Olive oil has a unique flavour, although it forms crystals at refrigerator temperature, it is often served at room temperature as a salad oil.

Antifoaming agents in edible oils and fats: According to PFA (1955), “Antifoaming agent” means substance which retards deteriorative changes and foaming height during heating.

Dimethyl and Polysiloxane, food grade, may be used as an antifoaming agent in edible oils and fats for deep fat frying up to a maximum limit of 10 parts per million. Provided that mono and diglycerides of fatty acids of edible oil may be used as antifoaming agent in jam, jellies and marmalade.

Medium-chain triglycerides (MCT)

- In addition to the common dietary fats, lipid fractions such as medium-chain triglycerides (MCT oil) are used in specialized therapeutic preparations.
- MCT oil is a fraction of coconut oil containing fatty acids of 8-10 carbon atoms in triacylglycerols.
- MCT oil is used in formulas for enteral feeding and in diets for patients with malabsorption syndromes.

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2.4.1 Important Roles of Proteins (Denaturation and Browning)

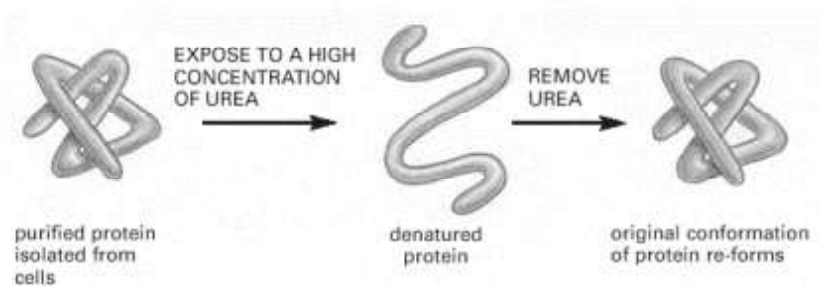
Colloidal nature

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- Show many colloidal properties because of their large shape and size
- Extremely slow diffusion rates
- Produce scattering of light in solution

Denaturation

The proteins have a three-dimensional structure. This structure though very complicated, is delicate. That is, it undergoes alternations even if subjected to some physical or chemical agents. It is important to note that the alterations in the protein structure does not breaks the peptide bonds. The loss of native conformation of proteins that subsequently alters its characterizing properties is known as “denaturation”.



Changes brought about on denaturation of proteins:

- 1) The hydrolysis of the peptide bonds becomes easier.
- 2) The solubility of the proteins decreases.
- 3) The proteins loses their catalytic properties
- 4) The proteins lose their hormonal properties.
- 5) The viscosity of the proteins increases

Causes of denaturation

- 1) Modification in the structures of the proteins
- 2) Breaking of hydrogen bonds
- 3) Breaking of hydrophobic bonds
- 4) Breaking of salt linkages.

It is important to note that the covalent bonds and the peptide bonds are not broken. The proteins unfold and assume a random coil structure. This is followed by the coagulation of the proteins.

Physical and chemical agents that cause denaturation of proteins

- 1) Heat (physical agent) is one of the most important causative factors for denaturation.
- 2) The rate of denaturation increases in the increase in temperature of the medium.
- 3) Denaturation of proteins due to heat is observed in stirring, shaking, high pressure treatment and subjecting the proteins to ultra-violet radiations.
- 4) The pH of the medium acts as a chemical agent in denaturing the proteins.
- 5) The rate of denaturation increases with increase in the pH of the medium.
- 6) The other chemical agents are urea, guanine hydrochloride, sodium dodecyl sulphate (SDS)

During processing of food, most of the proteins undergo coagulation or denaturation. However, this property of proteins is of great concern during the processing of milk.

Renaturation

The proteins of high molecular weight can resume their structure again if they are subjected to only mild treatments. This process is known as reversible denaturation or renaturation.

Amphoteric nature of proteins

Two-dimensional gel electrophoresis (2DE) separates proteins by molecular charge and molecular size. Proteins are first solubilised in a denaturing buffer containing a neutral chaotrope, a zwitterionic or neutral detergent, and a reducing agent. First-dimension isoelectric focusing, then subjects proteins to a high voltage within a pH gradient. The amphoteric nature of proteins means each migrates to the pH where the net molecular charge is zero. After equilibration, to ensure complete protein unfolding, the second dimension separates by molecular size. Each protein is therefore resolved at a unique isoelectric point/molecular size coordinate. After visualization by staining proteome changes are revealed by gel image analysis, and protein spots of interest excised and identified by mass spectrometry sequence analysis combined with database comparison. Variations to this procedure include staining or radio-labelling prior to electrophoresis. Although 2DE does have limitations, the most significant being the resolution of membrane and/or hydrophobic proteins, the potential solutions offered by pre-fractionation or adjustments to the electrophoresis regimen mean this technique is likely to remain central to proteomic research.

Ion binding capacity

A research was carried out by US department of agriculture to study the ion binding capacity of proteins. This preliminary investigation tests the premise that

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biologically relevant (1) peptide-metal ion interactions, and (2) metal ion-dependent macromolecular recognition events (e.g., peptide-peptide interactions) may be modeled by biomimetic affinity chromatography. Divinylsulfone-activated agarose (6%) was used to immobilize three different synthetic peptides representing metal-binding protein surface domains from the human plasma metal transport protein histidine-rich glycoprotein (HRG). The synthetic peptides represented 1-3 multiple repeat units of the 5-residue sequence (Gly-His-His-Pro-His) found in the C-terminal of HRG. By frontal analyses, immobilized HRG peptides of the type (GHHPH)_nG, where n = 1-3, were each found to have a similar binding capacity for both Cu(II) ions and Zn(II) ions (31-38 μmol/ml gel). The metal ion-dependent interaction of a variety of model peptides with each of the immobilized HRG peptide affinity columns demonstrated differences in selectivity despite the similar internal sequence homology and metal ion binding capacity. The immobilized 11-residue HRG peptide was loaded with Cu(II) ions and used to demonstrate selective adsorption and isolation of proteins from human plasma. These results suggest that immobilized metal-binding peptides selected from known solvent-exposed protein surface metal-binding domains may be useful model systems to evaluate the specificity of biologically relevant metal ion-dependent interaction and transfer events in vitro.

Solubility of proteins

The surface of a protein has a **net charge** that depends on the number and identities of the charged amino acids, and on pH. At a specific pH the positive and negative charges will balance, and the net charge will be zero. This pH is called the isoelectric point, and for most proteins it occurs in the pH range of 5.5 to 8. A protein has its lowest solubility at its isoelectric point. If there is a charge at the protein surface, the protein prefers to interact with water, rather than with other protein molecules. This charge makes it more soluble. Without a net charge, protein-protein interactions and precipitation are more likely.

The solubility of proteins in blood requires a pH in the range of 7.35 to 7.45. The bicarbonate-carbonic acid buffer system of blood ($\text{HCO}_3^- + \text{H}^+ \rightleftharpoons \text{H}_2\text{CO}_3$), in which the bicarbonate is in excess of the carbonic acid, helps to maintain the correct pH. Exhalation of carbon dioxide from the lungs causes some of the bicarbonate ions in blood to combine with protons, and this would raise the pH. However, because there is an excess of bicarbonate ions and protons, the loss of a small number of protons does not influence the pH significantly.

The proteins of protein mixtures can be separated using a technique known as isoelectric focusing. A mixture is placed in a polyacrylamide gel that has a pH gradient. An anode (positive electrode) and a cathode (negative electrode) are positioned at the low and high ends of the pH gradient, respectively. If a protein is located in the high pH region, it will be negatively charged and will move toward the anode. As the protein moves to a lower pH region, its surface charge will become less negative, and a pH region will be reached at which the protein net

charge is zero (the isoelectric point). The protein will stop moving and, because different proteins have different isoelectric points, separation can be achieved.

Optical activity:

The polarized light is rotated to the left by all protein solutions. This concludes that they are levorotatory.

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Check Your Progress

3. What is gelatinization?
4. What is the major use of cooking oil?
5. What is an antifoaming agent?

2.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Colloid is a state of system that depends on the particle size of matter.
2. Colloids may be of two types depending upon the affinity of dispersed phase for the dispersion medium.
3. Gelatinization refers to the irreversible loss of the crystalline regions in starch granules that occur upon heating in the presence of water.
4. The major use of cooking oil is in frying, where it functions as a heat transfer medium and contributes flavour and texture to foods.
5. According to PFA (1955), “Antifoaming agent” means substance which retards deteriorative changes and foaming height during heating.

2.6 SUMMARY

- **Colloid** is a state of system that depends on the particle size of matter.
- In colloidal state the particles of the 50 to 2000 Å. particles are known as colloidal particles.
- Colloidal solution is an intermediate state between true solution and a suspension.
- Colloids may be of two types depending upon the affinity of dispersed phase for the dispersion medium.
- They are lyophilic or reversible and lyophobic or irreversible (‘lyo’ means dispersion medium).
- It has been observed that an increased carbohydrate intake, corresponding to at least 55% of total energy.
- The nutritional quality of the carbohydrates and the effects of processing on that quality then becomes a concern, because both the content and the

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nutritional quality of food carbohydrates can be altered by processing in a number of ways.

- Fructo-oligosaccharides can be synthesized from sucrose and by hydrolysis of inulin.
- Non-enzymatic browning reactions (Maillard reactions) occur between reducing sugars and amino groups in foods at processing and in storage.
- Gelatinization refers to the irreversible loss of the crystalline regions in starch granules that occur upon heating in the presence of water.
- The temperature range during which the crystalline structure of the starch granule is lost is dependent on the water content, and on the type of starch.
- Fat spread means a product in the form of water in oil emulsion, or an aqueous phase and a fat phase of edible oils and fats excluding animal body fats.
- According to PFA (1955), “Antifoaming agent” means substance which retards deteriorative changes and foaming height during heating.
- Dimethyl and Polysiloxane, food grade, may be used as an antifoaming agent in edible oils and fats for deep fat frying up to a maximum limit of 10 parts per million.
- The proteins have a three-dimensional structure.
- The loss of native conformation of proteins that subsequently alters its characterizing properties is known as “denaturation”.
- The proteins of protein mixtures can be separated using a technique known as isoelectric focusing.

2.7 KEY WORDS

- **Membrane:** It is a microscopic double layer of lipids and proteins forming the boundary of cells or organelles.
- **Tyndall Effect:** It is the scattering of light as a light beam passes through a colloid.
- **Isomer:** It refers to each of two or more compounds with the same formula but a different arrangement of atoms in the molecule and different properties.

2.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. State the properties and characteristics of colloids.

2. Write a short note on carbohydrates and leaching.
3. What is a Maillard reaction?
4. State the uses of cooking oils.
5. State the role of following fats and oils in cookery:
 - a) Margarines
 - b) Shortenings
 - c) Fat Spread and Salad Oils
6. What is the effect of processing on dietary fiber?
7. What do you understand by MCT?

Long Answer Questions

1. What happens when carbohydrates are subjected to heat treatment? Discuss
2. Explain solubility of proteins in detail.
3. Give a detailed description of denaturation of proteins and its causes. What are the physical and chemical agents that cause denaturation of proteins? What is renaturation?
4. Describe the Amphoteric nature of proteins and their ion binding capacity.

2.9 FURTHER READINGS

- Jain, J.L., Jain, Sunjay & Nitin Jain. 2004. *Fundamentals of Biochemistry*. New Delhi: S. Chand.
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UNIT 3 EVALUATION OF FOOD QUALITY

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Structure

- 3.0 Introduction
- 3.1 Objectives
- 3.2 Sensory Properties of Food: Quality Attributes
 - 3.2.1 Appearance and Colour
 - 3.2.2 Texture
 - 3.2.3 Flavour
- 3.3 Physical Properties
 - 3.3.1 Chemical Composition
 - 3.3.2 Moisture Content
 - 3.3.3 Types of Sensory Evaluation Tests
 - 3.3.4 Discrimination (Difference) Tests
- 3.4 Objective Evaluation
- 3.5 Procedures for Determination and Monitoring of Shelf Life
- 3.6 Answers to Check Your Progress Questions
- 3.7 Summary
- 3.8 Key Words
- 3.9 Self Assessment Questions and Exercises
- 3.10 Further Readings

3.0 INTRODUCTION

Sensory evaluation is a discipline that measures, analyzes, and interprets the response of people to products as perceived by the senses. It is a means of determining whether product differences are perceived, the basis for the differences, and whether one product is preferred more than another. The value of the science lies in its use of limited numbers of consumers to achieve decisions that can be extrapolated to larger populations with assurance. This means that the panelists are representative of the consumer population for whom the product is proposed and have the essential sensory skills. In practical terms, it enables one to assess products in a relatively short time and at low cost. Sensory Analysis is a scientific discipline used to inducing measure, analyze and construe reactions to those characteristics of foods as they are recognized by the senses of sight, smell, taste, touch and hearing.

3.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the sensory properties of food
- Describe the various methods of sensory evaluation

- Explain the various methods of objective evaluation
- Analyse the concepts of objective evaluation

3.2 SENSORY PROPERTIES OF FOOD: QUALITY ATTRIBUTES

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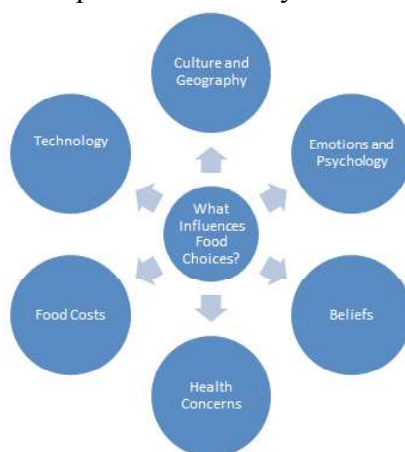
The sensory properties of foods are related to three major attributes:



The consumer integrates all of those sensory inputs— appearance, aroma, flavor, hand-feel, mouth-feel and chewing sounds—into a final judgment of the acceptability of that fruit or vegetable.

Significance of sensory evaluation

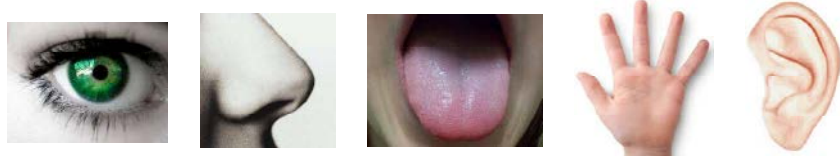
- Evaluate a range of existing food products
- Analyse a test sample for improvement
- Estimate consumer response to a product
- Check that a final product meets its original specifications
- Evaluate differences in similar products
- Analyse specific attributes e.g. Crunchiness of carrots
- Explain how various influences affect food choices
- Describe sensory characteristics that affect food preferences
- Plan a setting for successful sensory evaluation
- Explain the role of sensory evaluation in the food industry
- Explain the relationship between sensory characteristics and nutrition



Sensory Evaluation: A Scientific Approach

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- **Sensory evaluation** – it involves scientifically testing of food properties, using the human senses of sight, smell, taste, touch and hearing.
- **Sensory characteristics** – the qualities of a food identified by the human senses- appearance, tastes, smells, sounds, mouthfeel and so on.



In the process of perception, most or all of the attributes overlap, i.e., we receive a jumble of near-simultaneous sensory impressions, and without training we will not be able to provide an independent evaluation of each

Sensory Evaluation

Sensory evaluation panels – groups of people who evaluate food samples

Three main groups

- Highly trained experts
- Laboratory panels
- Consumer panels

Uniform Evaluations

Minimize distractions – testing takes place in a controlled atmosphere. Light and temperature are kept constant.

Minimize bias – researchers may mask irrelevant characteristics.

Objective Evaluations – offer a greater degree of control and consistency.

Appearance	Odor/ Aroma/ Fragrance	Flavour	Texture/mouthfeel
<ul style="list-style-type: none"> ✓ Color, gloss, translucency ✓ Size & shape ✓ Surface characteristics ✓ Interior appearance ✓ Clarity ✓ Discoloration ✓ Mode of presentation 	<p>Odor of a product is detected when food volatiles enter the nasal passage and are perceived by the olfactory system</p> <p>Volatility – related to the temperature of the food and the nature of the compounds</p> <p><u>Aroma</u> – perceptions caused by volatile substances released from a product in the mouth (lemon, mint, buttery)</p>	<p>Flavor, is the combined impression perceived via the chemical senses from a product in the mouth, i.e., it does not include appearance and texture.</p> <p>It includes</p> <p><u>aromatics</u></p> <p><u>taste</u> and</p> <p><u>chemical feeling factors</u> – compounds that stimulate nerve ends in the soft membranes of the mouth and nasal cavity (spicy hot, cool, metallic).</p>	<p>Sensory manifestation of the structure or inner make up of a food product (solids or semi-solids)</p> <p>Sounds produced by a food during mastication (chewing) or physical handling.</p> <p>Includes</p> <p><u>pitch</u> – frequency of sound</p> <p><u>loudness</u> – intensity of the sound</p> <p><u>persistence</u> – endurance of sound over time</p>

<ul style="list-style-type: none"> ✓ Factors to be considered are for presentation: ✓ • Product description - name, price, ingredient, etc; ✓ • Packaging - shape, design, colour; ✓ • Contrast - phenomena of adjacent colours; and ✓ • Illumination - affects apparent product colour. 			
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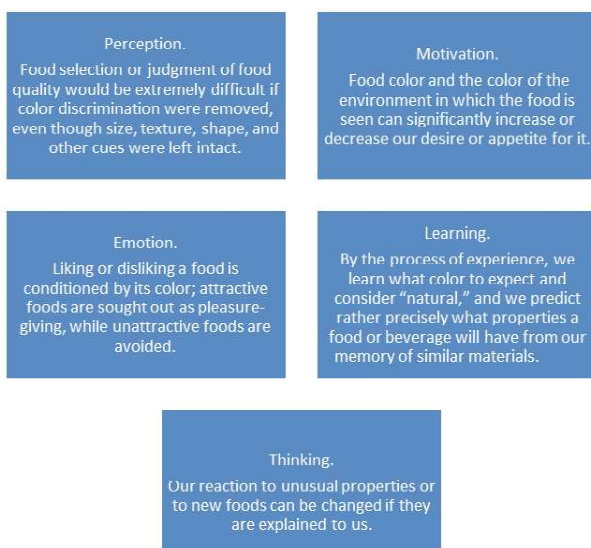
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3.2.1 Appearance and Colour

Colour and other characteristics of appearance influence food’s positive reception and quality, particularly by the consumer. Human being has subjective standards for the satisfactory range and preferred parameters for these qualities for nearly each food.

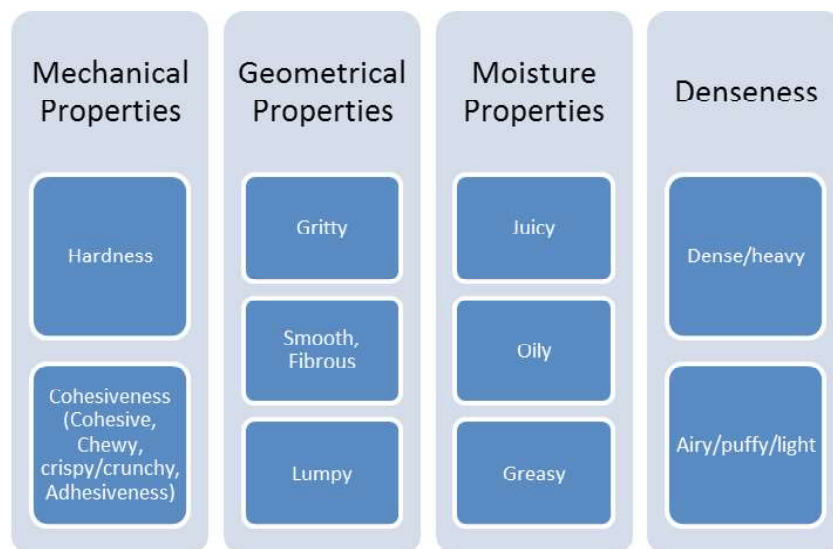
The significance of the color of food commodities and processed foods cannot be exaggerated. A significant problem is discoloration or the vanishing of the colors of different raw and processed fruits and vegetables. In a number of cases, color changes are come with undesirable changes in texture, taste, or odor. The maturity of many fruits and vegetables is strongly connected with color development or changes in color. Colour change may not be actually disadvantageous, nevertheless reduces consumer acceptance. Consumers anticipate certain foods to have certain colors, and variation from those colors may cause resistance. Many of these intolerances are on the whole illogical.

Parameters of acceptance of food



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Texture can be described as the properties of a food picked up both by the eyes and by the skin and muscle senses in the mouth, taking on coarseness, softness, etc. The texture or mouth feel of liquid foods, is strongly correlated to their viscosity. The instruments determine compression, resistance to penetration, or force required shearing texture of fruits and vegetables, meat and meat products etc. for e.g. penetrometers are used for objective evaluation of the texture of cooked, canned, and frozen foods.



3.2.3 Flavour

When food is consumed, the interaction of taste, odor, and textural feeling generally provides sense that is best defined by the English word “flavor.” Flavor results from compounds that are divided into two classes: 1) responsible for taste and 2) responsible for odors or aroma.

Flavor is the most important sensory property of many food products. Flavor, as a characteristic of food products, is defined as the summation of perceptions resulting from stimulus of the senses. Taste, gustatory perceptions (salty, sweet, sour, bitter) caused by soluble substances in the mouth

Chemical feeling factors that stimulate nerve endings in the soft membranes of the oral and nasal cavities (astringency, spicy taste etc).

Compounds responsible for taste are usually non-volatile in nature at room temperature. They interact merely with taste receptors positioned in the taste buds of the tongue. Aroma substances are volatile compounds that are distinguished by the odor receptor sites of the nasal cavity.

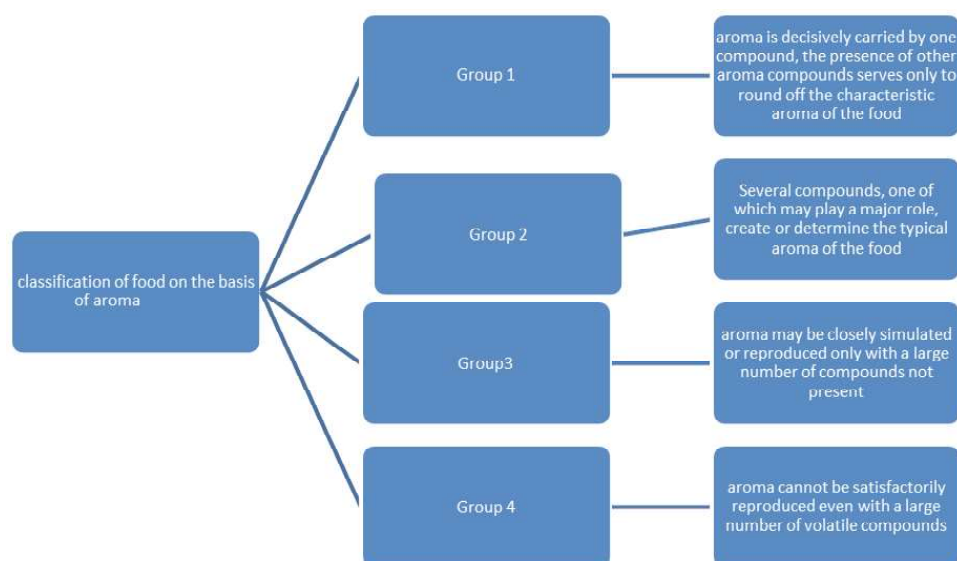
Aroma

The lowest concentration of a compound that can still be directly recognized by its odor is called as an odor threshold. Threshold concentration data permits comparison of the strength or effectiveness of odorous substances.

Compound	Threshold value (mg/l)
Pyrazine	300.00
Ethanol	100.00
Maltol	35.00
Hexanol	0.7
Butyric acid	0.2
Vanillin	0.02
Limonene	0.01
Linalool	0.006
Hexanal	0.0045
2-Phenylethanal	0.004
α -Ionone	0.004
2-Methylpropanal	0.001
Ethylbutyrate	0.001
(+)-Nootkatone	0.001

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The amount of volatile substances in food is exceptionally low, generally only 1 mg/kg to 50 mg/kg. Nonetheless, their number reaches several hundreds. Not all of these are significant to food aroma. For an aroma compound to be perceived, a part of the unstable fraction must be present in food in higher concentration than its threshold value. The inequity of the aroma ingredients from the other volatile compounds is frequently tricky, and generally provides only estimated values at the most. With regard to the incident of such key compounds, food can be divided into four groups:



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A strange, extraneous type of aroma, normally not present in a food, may arise through loss of “impact compounds,” or a shift in aroma concentration, or a change in composition of the individual components of the aroma. This is designated as an aroma defect, or simply as an off-flavor. Some common off-flavors that can arise during food processing and/or storage are listed in the table below.

Food product	Off-flavor
Milk	Sunlight flavor
Milk	Bean-like, gluey, glutinous
Milk fat	Metallic
Milk products	Malty
Mutton-meat	Sweet, acidic
Peas, deep frozen	Hay-like
Orange juice	Grapefruit note Terpene note
Beer	Sunlight flavor Phenolic note

The application of modern analytical instruments to problems of food science has been rapid and extensive, primarily because of the sensitivity of the instruments to small amounts of volatile material. Although they will probably be used more in investigations of the composition of foods, we can also expect application in detecting off-odors, and of the correlation between the amounts of specific compounds and sensory quality. It has been noted that, in some cases, it appears that compounds present in subthreshold concentrations exhibit a synergistic effect, and thus contribute to the odor of the food.

Check Your Progress

1. What is sensory evaluation?
2. What is texture?

3.3 PHYSICAL PROPERTIES

Among physical properties playing a role in the determination of food quality, the appearance, color, and texture are primary.

Appearance. The size and shape of food products, together with defects and color, are appearance factors that greatly influence initial consumer impressions. Unfortunately, these sensory attributes are often taken for granted or even

overlooked. Appearance factors are also useful in sizing and grading, which ensure uniformity and facilitate the process of buying and selling. During food manufacture, grading according to size shortens the succeeding processing operations and improves the quality of the end product.

Color is a quality factor that greatly influences the appearance of a product. Associated with it are several desirable and undesirable changes in food, such as those occurring during ripening, storage, curing, spoilage, and so on. Color is a character of light, measurable in terms of intensity and wavelength. It is a general term for all sensations arising from the activity of the human eye. When light reaches the retina it sensitizes the nerve mechanisms.

The physical tests commonly used for color measurement are the spectrophotometric and the Munsell systems. Each is a tri-stimulus system in which color is specified by three attributes; dominant wavelength, purity, and lightness in the spectrophotometric systems; hue, chroma, and value in the Munsell system. Of the two, the latter is more popular because of its simplicity and low cost.

Some other physical properties may be also of importance in quality evaluation of specific foods. Volume is interesting for baked products; textural properties for meat products. Tenderness of meat is an important quality index. Specific gravity measurement is used for the detection of watered milk.

3.3.1 Chemical Composition

The nature and amount of compounds in a specified food product determine the nutritive value and other properties. As the development and enforcement of standards of identity and purity, the control of food safety is based on the determination of chemical processes. Therefore, removal of water from or binding it by increasing the concentration of common salt or sugar retards many reactions and inhibits the growth of composition, including chemical contaminants. Analysis of the molecular composition of food substances is known as proximate analysis. It is used to study the protein, fat, carbohydrate, ash, and water content of foods

3.3.2 Moisture Content

Water (moisture) is the predominant constituent in many food products. As a medium, water supports chemical reactions, and it is a direct reactant in hydrolytic microorganisms, thus improving the shelf life of a number of foods. Through physical interaction with proteins, polysaccharides, lipids, and salts, water contributes significantly to the texture of food.

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<p>Sensory evaluation panels – groups of people who evaluate food samples Three main groups</p> <ul style="list-style-type: none"> • Highly trained experts • Laboratory panels • Consumer panels 	<p>Parameter for Evaluations</p> <ul style="list-style-type: none"> • Minimize distractions – testing takes place in a controlled atmosphere. Light and temperature are kept constant. • Minimize bias – researchers may mask irrelevant characteristics. • Objective Evaluations – offer a greater degree of control and consistency
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Sensory Evaluation Panels consists of groups of people who evaluate food samples. There are 3 main groups:

<p>Trained panels</p> <ul style="list-style-type: none"> • Judge the quality based on standards set by the food industry. • May be 5 to 8 in number. 	<p>Laboratory Panels</p> <ul style="list-style-type: none"> • Small groups that work at a company's lab. • Help develop new products and determine how to change existing products. • Usually 10-15 in number. 	<p>Consumer Panels</p> <ul style="list-style-type: none"> • Used to test foods outside the laboratory (grocery stores, malls, market research forms) using scientific terms to tell how much they like or dislike the product. • May be 80-120 in number.
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Descriptive methods are used to present more-comprehensive profiles of a product by inquiring panelists to recognize the special characteristics within the product and quantify characteristics. Trained panelists must be used for descriptive methods.

3.3.4 Discrimination (Difference) Tests

Difference testing is used to determine if different processing techniques or operations have a sensory affect. As such, difference testing methods usually provide the realistic information needed to improve and assess the product. They are the most practicable for use, simple and robust.

Difference testing is a method to establish if a sensory difference actually exists between samples. The degree or nature of the difference cannot be computed, though. Descriptive tests are, in general, required to accurately describe differences. There are four types of difference tests which can be used to counter a number of practical questions.

Difference tests are occasionally applied in a simple manner in the food industry where only one or two panelists perform the evaluation. While superior

than no testing at all, to attain a statistically-significant sensory result, a little more advanced course of action should be carried out using the minimum number of panelists. Usually, the bigger the number of panelists, the better is the evaluation. However, still a small panel of 5-7 will offer highly-valuable feedback that will significantly augment consistency and uniformity of production decisions based on sensory assessment.

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Test	Number of panelists	Use	Samples	Basic method	Results: are the wines significantly different?
<i>Triangle</i>	5	Multi-purpose	Three coded test samples. Two are the same wine (A) (but are coded differently). One is a different wine (B).	Tasters assess all three samples, and then pick the sample which is different from the other two, or the odd one out. Serving orders ³ : AAB, ABA, BAA, BBA, BAB, ABB	Correct response - taster picks the odd one out. Significance - Required no. of correct/total responses: Single tasting 4/5 5/6 5/7 6/8 Repeated tasting 7/10 8/12 9/14 9/16
<i>Duo-trio</i>	7	Comparison to a reference food product	One reference sample (Ref). Two coded test samples (A,B). A is the same food product as the reference (control food product). B is the food product to test.	Tasters assess the reference (Ref), then the two test samples (A,B). Tasters are asked to indicate which test sample is the same as the reference. Serving orders: Ref AB, Ref BA	Correct response - taster picks A as the same as the reference. Significance - Required no. of correct/total responses ² : Single tasting 7/7 7/8 8/9 9/10 Repeated tasting 10/12 11/14 12/16 13/18
<i>Paired comparison</i>	7	When a difference is known	Two coded test samples (A,B). One is known to be chemically higher in an attribute (e.g., bitterness).	Tasters are asked to identify which sample is higher in an attribute (e.g., identify which sample is sweeter). Serving orders: AB, BA	Correct response - taster picks the sample that is higher (e.g., the presumed sweeter sample). Significance - Required no. of correct/total responses ² : As for <i>Duo-trio</i>

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Same/ different	7	When a difference is unknown	Two coded test samples (A,B).	Tasters assess both samples and indicate whether they think samples are the same or are different. Serving orders: AB, AA, BA, BB (usually two serving orders are presented to each taster)	Correct response - taster correctly picks the two samples as being the same or different, depending on the serving order. Significance - Required no. of correct/total responses: As for <i>Duo- trio</i>
Paired preference	7	Which food product is preferred	Two coded test samples (A,B).	Panelists assess both samples and indicate which one they prefer. A choice must be made; the taster can't say they prefer neither. Serving orders: AB, BA	Count the number of people who prefer one wine over another (e.g., A over B). Significance - Required no. preferred A/total 4: Single tasting 7/7 8/8 8/9 9/10 Repeated tasting 12/14 13/16 14/18 15/20

Selection of the appropriate difference test depends on many factors such as the objectives defined, number of panelists and the quantity of the food product available for testing.

These tests are relatively simple for the panelists if the panelists are well-informed about the product and characteristics to be taken into consideration. In each method, the panelist is forced to make a decision or choice among the products. The amount of information drawn from these tests is limited to a detection of difference. It is not possible to know the degree of differences that exist among products, or if the change in the characteristic affects acceptability of, or preference for, the product.

Triangle Test. Triangle tests are helpful as a multi-purpose test. The panelists are required to select the sample which is dissimilar. Triangle tests are often have a preference over other tests, as they require fewer panelists, and there is a superior probability that an outcome will be legitimate and not attributable to a chance effect.

The triangle test uses three samples to determine if an overall difference exists between two products. The three samples include two that are identical, and one that is different. The samples must be coded with individual three-digit numbers which is usually obtained from a random numbers table and presented at one time to the panelists. The panelist is asked to recognize the code on the scorecard representative of the odd sample.

This method requires the panelist to make a choice among the samples; the panelist has a 33% chance of presumption, appropriately. This test method has good quality applications in ascertaining if a process change affects the overall product attributes. Fatigue is a reason, as panelists frequently must re-taste several times. Adaptation may also occur as a result of re-tasting. It is recommended that no more than two sets (six samples) be evaluated at one testing session. Interpretation is based on the minimum number of accurate responses required for significance at a predetermined significance level, given the total number of responses received.

Duo-Trio Test. Duo-trio tests are sometimes used instead of triangle tests to compare unknown differences between food samples. The panelists are presented with a reference food product, and then two test food products; one food product is the same as the reference, and the other is the sample food product to be tested. The panelists are asked to recognize the sample that is the same as the reference food product.

This test might have a preference, as the panelists have a reference food product to compare. Generally, people find it simpler to assess with a reference standard.

Paired Comparison Test. Paired comparison tests can be used when there is a known difference in chemical composition of the wines (a simple difference test), which requires a sensory assessment. The test requires the same quantity of food product and panelists as the duo-trio test. Products are compared such that every sample is placed in the first tasting position an equal number of times. This test causes less fatigue and is repeatedly used for strongly flavored or complex products.

Whereas the triangle test provides only a 33% chance of supposition correctly, there is a 50% chance with the paired comparison test. Therefore, more panelists (at least 20) are required to complete this test.

Descriptive Tests

Often, it is significant to assess the changes in the characteristics of the food product. Discrimination testing, which is simple to use, easy to understand, and easy for panelists to complete, is initially used to decide that a difference does exist. Such methods cannot provide information about the description of those differences, although. Descriptive evaluation methods are trickier to complete and understand,

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but provide much more information. They provide a quantitative measure of traits of food products that permit for comparison of strength between products, and a means of interpretation of these results.

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Descriptive analysis of food products requires products with comparatively similar traits. If feasible, 10 to 12 panelists are selected to partake based on ability to discriminate, communication skills, and task comprehension. The individual responses have a greater effect on the mean scores. A scorecard is developed by conformity of the panel that includes all characteristics of interest in the order in which they are to be evaluated. Each trait is rated on a scale with descriptors of “weak” and “strong” as endpoint indicators. After the training is completed, the panelists perform independently in the evaluation. No more than six or seven attributes should be evaluated at each session to avoid exhaustion. If strong aroma characteristics are evaluated, fewer than six samples should be evaluated in one testing. Products are evaluated for strength of the distinctiveness on the scorecard. Panelists rate the intensity of each attribute by marking a across the appropriate horizontal rating line. These marks are converted to numerical data by measuring the distance from the origin (“weak”) of the line to the vertical mark.






Data analysis is completed using a mixed model analysis of variance for treatment by subject, with replication. To determine individual panelists’ abilities to distinguish differences among products, a one-way analysis of variance is completed for each panelist.

3.4 OBJECTIVE EVALUATION

Using objective evaluation, we can test the following parameters:


- temperature,
- acidity (pH),
- water activity (a_w) and
- water binding capacity
- light intensity
- texture.

All routine physical testing can be carried out with portable instruments.




<p>Electronic thermometer</p>	<p>Temperature measurement with thermo-elements/thermocouples is based on the thermo-electrical effect.</p>	
<p>pH meters</p>	<p>Portable instruments are battery driven and have glass electrodes through which the pH is measured in food products by direct contact between the sensitive diaphragm of the electrode and the food tissue</p>	 <p>Monitoring unit Cable Tip of pH electrode with diaphragma</p>
<p>Hygrometers</p>	<p>Hygrometers measure the relative humidity and are used in production and storage rooms of the meat industry.</p>	<p>$\frac{\text{absolute water vapour}}{\text{water vapour at saturation}} \times 100$</p> 
<p>Water holding capacity (WHC)</p>	<p>The WHC can be measured using a glass compressorium</p>	
<p>texture measurement</p>	<p>It is used to test tenderness/toughness or homogenous/fibrous structure of meat and meat products.</p>	

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Chemical analysis

<p>moisture content</p>	<p>It is done by drying an appropriate amount of the sample. The difference in weight between the fresh and dried samples represents the water content</p>	
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<p>protein content</p>	<p>It is determined by using the Kjeldahl method, where meat products are digested by acid to obtain the nitrogen compounds and then distilled and titrated to determine nitrogen quantitatively, with which the protein component can be calculated</p>	
<p>fat content</p>	<p>Samples for fat analysis are semi-dried before being subjected to ether-extraction using the Soxhlet apparatus. After complete extraction, the fat is obtained by evaporating and recovering the ether.</p>	
<p>ash</p>	<p>The defatted samples are then used for ash analysis by subjecting it to a temperature of +600°C in a muffle furnace for two hours. The weight of the ash is used to calculate the minerals content in % (weight of ash, divided by total sample weight, multiplied by 100).</p>	

3.5 PROCEDURES FOR DETERMINATION AND MONITORING OF SHELF LIFE

a) Total Plate Count (using nutrient agar)

- For determination of the number of viable or living microorganisms in a sample.
- Food sample (10 grams meat + 90 ml sterile distilled water or 0.1% peptone water). Homogenize in stomacher. First dilution.
- Transfer 1 ml from first dilution (10^1) to second test tube (Test tube contains 9 ml. of sterile distilled water) (2^{nd} dilution or 10^2) then from second test tube transfer 1ml to the third tube (3^{rd} dilution or 10^3) and so on up to the 4^{th} or 6^{th} dilution.
- Inoculate sample.
- Pipette 1 ml from 3^{rd} dilution and transfer to the sterile petridish, also from the 4^{th} dilution to another sterile petridish depends upon how many dilutions are desired (see below and Fig. 445).
- The inoculation is usually done according to the spread plate method. The diluted sample is released from the pipette onto the solidified agar and spread on the surface by means of a sterile bent glass stick. The alternative is the pour plate method, where the sample is first put into the Petri dish and 15 ml agar (liquefied in a water bath at $44-46^{\circ}\text{C}$) are poured into the plate afterwards. Agar and sample are thoroughly mixed by rotating the Petri dish.
- Incubate for 12 to 24 hours at 35 to 37°C , alternatively 24-48 hours at 30°C .
- Results
 - Count all colony forming units (CFU), including those of pinpoint size (Fig. 446). Select spreader-free plate.
 - normal plates 25-250 counts
 - plates with more than 250 colonies for all dilution - too numerous to count
 - plates with no CFU. Report as less than 1 times the corresponding dilution used.

Selective Plate Count

- The practicable microbiological standards should, in addition to the total plate count, always include the number of hygienically sensitive microorganisms, which can be used as an indicator for specific hygienic risks. These microorganisms are selected out of the total number of bacteria.
- This can be done using selective bacterial culture media, which contain chemical additives that suppress the growth of all bacteria except the group of microorganisms that shall be detected and used as indicator bacteria.



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Conclusion

Sensory evaluation is a discipline that measures, analyzes, and interprets the response of people to products as perceived by the senses. It is a means of determining whether product differences are perceived, the basis for the differences, and whether one product is preferred more than another. Color and other characteristics of appearance influence food's positive reception and quality, particularly by the consumer. Texture can be described as the properties of a food picked up both by the eyes and by the skin and muscle senses in the mouth, taking on coarseness, softness, etc. When food is consumed, the interaction of taste, odor, and textural feeling generally provides sense that is best defined by the English word "flavor." Flavor results from compounds that are divided into two classes: 1) responsible for taste and 2) responsible for odors or aroma. The lowest concentration of a compound that can still be directly recognized by its odor is called as an odor threshold. Difference testing is a method to establish if a sensory difference actually exists between samples. The degree or nature of the difference cannot be computed, though. Descriptive tests are, in general, required to accurately describe differences. Discrimination testing, which is simple to use, easy to understand, and easy for panelists to complete, is initially used to decide that a difference does exist. Such methods cannot provide information about the description of those differences, although. Descriptive evaluation methods are trickier to complete and understand but provide much more information.

Check Your Progress

3. Name the primary physical properties that determine food quality.
4. Which tests are used for colour measurement?

3.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Sensory evaluation involves scientifically testing of food properties, using the human senses of sight, smell, taste, touch and hearing.
2. Texture can be described as the properties of a food picked up both by the eyes and by the skin and muscle senses in the mouth, taking on coarseness, softness, etc.

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3. The appearance, color, and texture are primary physical properties that determine food quality,
4. The physical tests commonly used for color measurement are the spectrophotometric and the Munsell systems.

3.7 SUMMARY

- Sensory evaluation is a discipline that measures, analyzes, and interprets the response of people to products as perceived by the senses.
- It is a means of determining whether product differences are perceived, the basis for the differences, and whether one product is preferred more than another.
- The consumer integrates all of those sensory inputs— appearance, aroma, flavor, hand-feel, mouth-feel and chewing sounds—into a final judgment of the acceptability of that fruit or vegetable.
- Sensory evaluation involves scientifically testing of food properties, using the human senses of sight, smell, taste, touch and hearing.
- Sensory characteristics are the qualities of a food identified by the human senses- appearance, tastes, smells, sounds, mouthfeel and so on.
- Color and other characteristics of appearance influence food's positive reception and quality, particularly by the consumer.
- Color is a quality factor that greatly influences the appearance of a product. Associated with it are several desirable and undesirable changes in food, such as those occurring during ripening, storage, curing, spoilage, and so on.
- The physical tests commonly used for color measurement are the spectrophotometric and the Munsell systems.
- The nature and number of compounds in a specified food product determine the nutritive value and other properties.
- Water (moisture) is the predominant constituent in many food products. As a medium, water supports chemical reactions, and it is a direct reactant in hydrolytic microorganisms, thus improving the shelf life of a number of foods.
- Descriptive methods are used to present more-comprehensive profiles of a product by inquiring panelists to recognize the special characteristics within the product and quantify characteristics.
- Difference testing is used to determine if different processing techniques or operations have a sensory affect.
- Triangle tests are helpful as a multi-purpose test. The panelists are required to select the sample which is dissimilar.

3.8 KEY WORDS

- **Flavour:** It is the sensory impression of food or other substance and is determined principally by the chemical senses of taste and smell.
- **Mouthfeel:** It refers to the physical sensations in the mouth caused by food or drink, as distinctive from taste.
- **Olfactory system:** It refers to the parts of the body involved in sensing smell, together with the nose and many parts of the brain.

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3.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. What is the significance of sensory evaluation?
2. What are the characteristics of food?
3. Write a note on flavor contributing attributes of food?

Long Answer Questions

1. With the help of suitable examples explain the various types of sensory evaluation.
2. Give a detailed description of objective evaluation.
3. What are the various methods of shelf life determination in foods? Discuss.

3.10 FURTHER READINGS

- Jain, J.L., Jain, Sunjay & Nitin Jain. 2004. *Fundamentals of Biochemistry*. New Delhi: S. Chand.
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NOTES

BLOCK - II
CEREALS, MILLETS, PULSES, NUTS, VEGETABLES,
FRUITS AND FLESH FOOD

UNIT 4 EVALUATION OF FOOD
QUALITY

Structure

- 4.0 Introduction
- 4.1 Objectives
- 4.2 Cereals and Millets: Classification and Properties
- 4.3 Polysaccharides
- 4.4 Starch
 - 4.4.1 Properties of Whole Granular Starches
 - 4.4.2 Fermentation of Carbohydrates
- 4.5 Nutritional Value of Cereals and Fermented Products
- 4.6 Answers to Check Your Progress Questions
- 4.7 Summary
- 4.8 Key Terms
- 4.9 Self Assessment Questions and Exercises
- 4.10 Further Readings

4.0 INTRODUCTION

Cereals belong to the gramineous family and considered simply to be the crops harvested for dry grain. Crops harvested green for feed, fodder or grazing are classified as fodder crops. There is also a category of industrial crops, which includes crops like sorghum. Cereals are classified according to their genus. Nevertheless, when two or more genera are sown and harvested as a mixture they should be classified and reported as “mixed grains”.

The dry weight of grains (12-14 percent moisture) in the form usually marketed. Rice, however, is reported in terms of paddy. Apart from moisture content and inedible components such as cellulose, cereal grains have, beside with traces of minerals and vitamins, carbohydrates - mainly starches - (comprising 65-75 percent of their total weight), as well as proteins (6-12 percent) and fat (1-5 percent). Cereal products derive either from the processing of grain through one or more mechanical or chemical operations, or from the processing of flour, meal or starch. Each cereal product is listed after the cereal from which it is derived.

Carbohydrate is the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake.

In research on macronutrients to date, the role of dietary carbohydrates in human nutrition has been less extensively studied than those of protein and fat. Carbohydrates represent a broad group of substances which include the sugars, starches, gums and celluloses. The common attributes of carbohydrates are that they contain only the elements carbon, hydrogen and oxygen, and that their combustion will yield carbon dioxide plus one or more molecules of water.

The simplest carbohydrates are the three-carbon sugars which figure importantly in intermediary metabolism and the most complex are the naturally occurring polysaccharides, primarily of plant, origin.

Carbohydrates make up three-fourths of the biomass of plants but are present only in small quantities in the animal body as glycogen, sugars and their derivatives. Glycogen is often referred to as animal starch because it is not present in plants. Derived mono-saccharides such as the sugar acids, amino sugars and the deoxy sugars are constituents of all living organisms.

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4.1 OBJECTIVES

After going through this unit, you will be able to:

- Describe the classification and properties of cereals
- Discuss the sources and classification of carbohydrates
- Explain polysaccharides and starch
- Assess fermentation of carbohydrates

4.2 CEREALS AND MILLETS: CLASSIFICATION AND PROPERTIES

Let us analyse the classification and properties of cereals and millets.

Wheat

WHEAT *Triticum*(*T. aestivum*)

- Common and durum wheat are the main types. Among common wheat, the main varieties are spring and winter, hard and soft, and red and white. At the national level, different varieties should be reported separately, reflecting their different uses. Used mainly for human food.

Flour of Wheat

- Defined broadly to include meal, groats and pellets. Strong flours from hard wheat are used for bread, while durum wheat flour is used primarily for pasta. Weaker flours from soft wheat are mainly used in cakes, pastries, biscuits and certain noodles.

Macaroni

- Pasta made from semolina, or flour, that is mixed with water and kneaded into a dough. Other ingredients may be included as well. The dough is then shaped into various forms. This heading is limited to macaroni that is not cooked, stuffed or otherwise prepared.

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Germ of Wheat

- The seed embryo. Whole or rolled germ is used for oil extraction by solvents. Flaked or ground germ is used in bakers' wares, dietetic preparations, feed supplements and in pharmaceutical preparations.

Bread

- A baked product of flour or meal of cereals, especially wheat. Includes ordinary, unleavened, crackers, rusks, etc.

Bulgur

- Whole wheat grains that are boiled, dried and cracked, either between stones or in a hand mill. Very popular in the Near East.

Pastry

- All baked products excluding those listed under bread. Pastry products may contain ingredients other than wheat flour, such as milk, eggs, sugar, honey, starch, fats, fruit, seeds, etc.

Starch of Wheat

- Starch is the carbohydrate component in many plant cells. A white, odourless powder that is insoluble in cold water, it forms a paste in hot water. Wheat starch is used for human consumption and animal feed, and is processed into glucose and dextrine for industrial use. It is usually obtained from low-quality flour.

Wheat Gluten

- A by-product of the industrial production of starch, wheat gluten is the preferred cereal gluten for food purposes. Uses include enriching protein in flours for bread, pasta, etc.

Rice

RICE PADDY *Oryza* spp., mainly *oryza sativa*

- Rice grain after threshing and winnowing. Also known as rice in the husk and rough rice. Used mainly for human food.

Rice, Husked

- Rice grain without hulls or husks. Also known as brown or cargo rice.

Rice, Milled (Husked)

- White rice milled from imported husked rice. Includes semi-milled, whole-milled and parboiled rice.

Rice, Milled

- White rice milled from locally grown paddy. Includes semi-milled, whole-milled and parboiled rice.

Rice, Broken

- Residues from the selection of whole-grain, milled rice.

Rice, Gluten

- A by-product of the industrial production of starch. Not suitable for food use.

Starch of Rice

- Rice starch is usually obtained from broken rice. Use primarily in the photographic industry to prepare "matt" paper.

Flour of Rice

- Produced by milling broken or milled rice. Finely ground rice flour is widely used in infant foods and in noodles. It is not used in bread because it lacks the necessary gluten-forming protein.

BARLEY *Hordeum* spp.:
 two-row barley (*H. disticum*)
 six-row barley (*H. hexastichum*)
 four-row barley (*H. vulgare*)

- Tolerates poorer soils and lower temperatures better than does wheat. Varieties include with husk and without (naked).
- Used as a livestock feed, for malt and for preparing foods.

Pot Barley

- Whole-seed barley with the husks, hulls and bran removed.

Barley, Pearled

- Small, round pellets obtained by the further milling of pot barley. This definition also includes kibbled, rolled or flaked grains.

Barley Flour and Grits

- Fine flour and coarse meal obtained as milling by-products of pearled barley.

Malt

- A grain - usually barley - that has been germinated through a soaking process and then dried. Malt is used in brewing and distilling, and as a nutrient additive.

Malt Extract

- A concentrated solution from water-macerated malt, which is used in infant and dietetic foods and in bread baking.

Maize

MAIZE

- Zea mays Corn, Indian corn, mealies A grain with a high germ content. At the national level, hybrid and ordinary maize should be reported separately owing to widely different yields and uses. Used largely for animal feed and commercial starch production.

Germ of Maize

- The seed embryo that is separated during processing and is valued mainly for its oil.

Flour of Maize

- Broadly defined to include meal, groats and pellets.

Maize Gluten

- Maize protein is often called gluten, although it lacks the quality characteristics of wheat gluten. It is separated from maize during commercial wet milling and used to enrich animal feeds.

Starch of Maize

- The primary product of the large-scale industrial wet-milling process. Used mainly for the production of glucose, dextrin and alcohol.

WHITE MAIZE

- Although separate data are reported for white maize production owing to its regional importance, its production is also included in 0056.

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PopCorn

- POPCORN *Zea mays* var. *everta* A variety of maize that is eaten after the kernels have been heated and have "popped".

Rye

- RYE *Secale cereale* A grain that is tolerant of poor soils, high latitudes and altitudes. Mainly used in making bread, whisky and beer. When fed to livestock, it is generally mixed with other grains.

Flour of Rye

- Broadly defined to include meal, groats and pellets. In northern countries, rye flour is used primarily in bread.

Oats

- OATS *Avena* spp., mainly *Avena sativa* A plant with open, spreading panicle-bearing large spikelets. Used primarily in breakfast foods. Makes excellent fodder for horses.

Oats, Rolled

- Obtained by crushing or rolling the whole or broken grain; includes grains flaked, hulled or otherwise worked for human consumption.

Millet

- MILLETS Including inter alia: barnyard or Japanese millet (*Echinochloa frumentacea*); ragi, finger or African millet (*Eleusine coracana*); teff (*Eragrostis abyssinica*); common, golden or proso millet (*Panicum miliaceum*); koda or ditch millet (*Paspalum scrobiculatum*); pearl or cattail millet (*Pennisetum glaucum*); foxtail millet (*Setaria italica*) Small-grained cereals that include a large number of different botanical species. Originated by the domestication of wild African grasses in the Nile valley and the Sahel zone, millets were subsequently taken to China and India. These cereals tolerate arid conditions and possess a small, highly nutritious grain that stores well. Used locally, both as a food and as a livestock feed. In all areas where they are cultivated, millets are used in traditional beer brewing. Also used as a feed for birds.

Flour of Millet

- Broadly defined to include meal, groats and pellets.

Sorghum

- SORGHUM** Sorghum spp.: guinea corn (*S. guineense*); common, milo, feterita, kaffir corn (*S. vulgare*); durra, jowar, kaoliang (*S. dura*) A cereal that has both food and feed uses. Sorghum is a major food grain in most of Africa, where it is also used in traditional beer brewing. It is desirable to report hybrid and other varieties separately.

Flour of Sorghum

- Broadly defined to include meal, groats and pellets.

Buckwheat

- BUCKWHEAT** *Fagopyrum esculentum* (Polygonaceae) A minor cereal cultivated primarily in northern regions. Buckwheat is considered a cereal, although it does not belong to the gramineous family.

Flour of Buckwheat

- Broadly defined to include meal, groats and pellets. The flour is normally used in bread and crackers, and is also mixed with wheat flour. Meal and groats are normally used for soups.

Quinoa

- QUINOA** *Chenopodium quinoa* (Chenopodiaceae) A minor cereal, which tolerates high altitudes, quinoa is cultivated primarily in Andean countries. Used for food and to make chicha, a fermented beverage.

Fonio

- FONIO** *Digitaria* spp.: fonio or findi (*D. exilis*); black fonio or hungry rice (*D. iburua*) A minor cereal of importance only in West Africa where it is eaten in place of rice during famines. The seeds are cooked by steaming the whole grain.

Flour of Fonio

- Broadly defined to include meal, groats and pellets.

Triticale

- TRITICALE** A minor cereal that is a cross between wheat and rye, combining the quality and yield of wheat with the hardiness of rye.

Flour of Triticale

- Broadly defined to include meal, groats and pellets.

Canary Seed

- CANARY SEED** *Phalaris canariensis* Minor cereal normally used as bird feed.

Mixed Grain

- MIXED GRAIN** A mixture of cereal species that are sown and harvested together. The mixture wheat/rye is known as meslin, but in trade is usually classified with wheat.

Flour of Mixed Grain

- Broadly defined to include meal, groats and pellets.

Cereal Preparations

- Cereal grains, excluding barley and oats, that are either rolled, flaked, pearled, sliced or kibbled.

Mixes and Doughs

- Used in the preparation of bakers' wares.

Food Preparations of Flour, Meal or Malt Extract

- Food preparations of flour, meal, starch or malt extracts, that either do not contain, or contain less than 50%, cocoa powder. Also, food preparations of milk that either do not contain, or contain less than 10%, cocoa powder.

NOTES

Sources of carbohydrates

The major carbohydrate-containing foods in the human diet are:

- a) Cereals
- b) Sweeteners
- c) Root crops
- d) Pulses
- e) Vegetables
- f) Fruit
- g) Milk products

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Classification of carbohydrates

- Carbohydrates are classified generally according to their degree of complexity.
- The free sugars such as glucose and fructose are termed monosaccharides; sucrose and maltose, disaccharides; and the starches and celluloses, polysaccharides. Carbohydrates of short chain lengths such as raffinose, stachyose and verbascose, which are three, four and five sugar polymers respectively, are classified as oligosaccharides.
- While a formal definition of a carbohydrate can be considered somewhat difficult, one commonly accepted by chemists is that carbohydrates are “polyhydroxy aldehydes, ketones, alcohols, acids, their simple derivatives and their polymers having polymeric linkages of the acetal type”.
- Carbohydrates are further classified according to their degree of polymerization (DP) as: sugars (mono- and disaccharides), oligosaccharides (contain three to nine monosaccharide units), and polysaccharides (contain ten or more monosaccharide units).
- Carbohydrates play a major role in human diets, comprising some 40-75% of energy intake.
- Their most important nutritional property is digestibility in the small intestine.
- In terms of their physiological or nutritional role, they are often classified as available and unavailable carbohydrates.
- Available carbohydrates are those that are hydrolyzed by enzymes of the human gastrointestinal system to monosaccharides that are absorbed in the small intestine and enter the pathways of carbohydrate metabolism.
- Unavailable carbohydrates are not hydrolyzed by endogenous human enzymes, although they may be fermented in the large intestine to varying extents.
- Small amounts of other carbohydrates can be detected in some foods but these are of little overall significance. These include maltose, commonly

formed from hydrolysis of starch and found in starch hydrolyzates used as food ingredients; galactose from fermented dairy products; and pentoses, such as xylose and arabinose, from fruits.

- The most important carbohydrates in foods are:

Monosaccharides	Glucose, Fructose
Disaccharides	Sucrose, Lactose
Oligosaccharides	Raffinose, Stachyose, Fructo-oligosaccharides
Polysaccharides	Cellulose, Hemicelluloses, Pectins, Glucans, Fructans, Gums, Mucilages, Algal polysaccharides
Sugar alcohols	Sorbitol, Mannitol, Xylitol, Lactitol, Maltitol

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4.3 POLYSACCHARIDES

- The polysaccharides represent a large group of complex carbohydrates which are condensation products of undetermined numbers of sugar molecules. The various subgroups are rather ill-defined and there is a lack of agreement on their classification.
- Most polysaccharides are insoluble in water. Upon hydrolysis with acids or enzymes they eventually yield their constituent monosaccharides.
- Starch is a high molecular weight polymer of D-glucose and is the principal reserve carbohydrate in plants.
- Most starches consist of a mixture of two types of polymers, namely; amylose and amylopectin. The proportion of amylose and amylopectin is generally one part of amylose and three parts of amylopectin.
- Enzymes capable of catalyzing the hydrolysis of starch are present in the digestive secretions of animals within their cells. The α -amylases which are found virtually in all living cells cleave the α - linkages at random and bring about an eventual total conversion of the starch molecule into the reducing sugars.
- The principal α -amylases of animal origin are those produced in the salivary gland and the pancreas.
- Starch is insoluble in water and is stained blue by iodine.
- Glycogen is the only complex carbohydrate of animal origin. It exists in limited quantities in liver and muscle tissues and acts as a readily available energy source.
- Dextrins are intermediate compounds resulting from incomplete hydrolysis or digestion of starch.
- The presence of α -D-(1, 6) linkages in amylopectin and the inability of α -amylase to cleave these bonds give rise to low molecular weight carbohydrate

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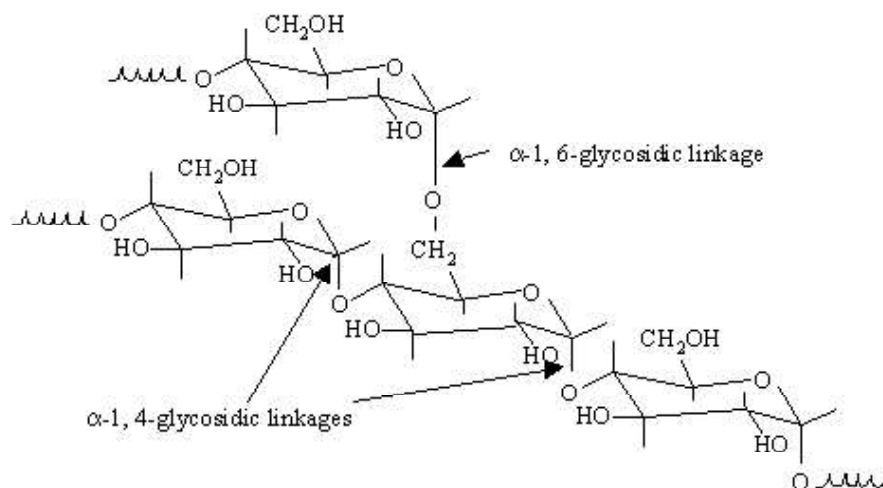
segments called limit dextrins. These residues are acted upon primarily by acidophilic bacteria in the digestive tract.

- Cellulose is made up of long chains of glucose units held together by α -D-(1, 4) linkages. The enzymes which cleave these linkages are not ordinarily present in the digestive secretions of animals and fish although some species of shellfish are believed to elaborate cellulase, the enzyme which catalyzes the hydrolysis of cellulose. Cellulase producing micro-organisms present in the gut of herbivorous animals and fish impart to their host animals the ability to utilize as food the otherwise indigestible cellulose.
- Other complex polysaccharides in common occurrence are the hemicelluloses and pentosans.
- Hemicellulose represents a group of carbohydrates including araban, xylan, certain hexosans and polyuronides.
- These substances are generally less resistant to chemical treatment and undergo some degree of enzymatic hydrolysis during normal digestive processes.
- Pentosans are polymers of either xylose or arabinose as constituents of plant structural material and vegetable gums, respectively.

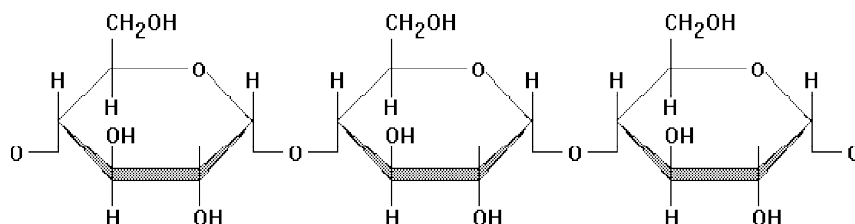
Check Your Progress

1. Name any two carbohydrate-containing foods in the human diet.
2. What are oligosaccharides?
3. State the most important nutritional property of carbohydrates.
4. State any property of polysaccharides.

4.4 STARCH



- Starch is the most important, abundant, digestible food polysaccharide.
- It occurs as the reserve polysaccharide in the leaf, stem (pith), root (tuber), seed, fruit and pollen of many higher plants.
- It occurs as discrete, partially-crystalline granules whose size, shape, and gelatinization temperature depend on the botanical source of the starch. Common food starches are derived from seed (wheat, maize, rice, barley) and root (potato, cassava/tapioca) sources.
- Starches have been modified to improve desired functional characteristics and are added in relatively small amounts to foods as food additives.
- Starch is a homopolysaccharide composed only of glucose units and consists of a mixture of two polymers, amylose and amylopectin, whose glucopyranosyl units are linked almost entirely through α -D-(1 \rightarrow 4)-glucosidic bonds.
- **Amylose** shows many of the properties of a linear polymer and has historically been considered to be a linear polymer with a degree of polymerization of approximately 1000 or less. However, it is now known that amylose contains a limited amount of branching involving α -D-(1 \rightarrow 6)-glucosidic linkages at the branch points. **Amylopectin** is a high molecular weight, highly branched polymer containing about 5-6% of α -D-(1 \rightarrow 6)-glucosidic linkages as the branch points. The average chain length is 20 to 25 units with an average degree of polymerization in the thousands, and molecular weight in the millions.



- While the manner in which amylose and amylopectin are organized to form the starch, granule is not clearly understood, the granule is partially crystalline exhibiting an x-ray diffraction pattern and birefringence.
- Most common cereal starches contain 20-30% amylose. Waxy starches (maize, rice, sorghum, barley) have no amylose and contain essentially 100% amylopectin. The first example of a waxy wheat starch has recently been reported from Japan. High-amylose starches (maize, barley) having 50-70% amylose are available.
- Waxy and high-amylose starches differ from normal starches in some properties that make them of use in certain food products.
- A number of double and triple maize starch mutants are being investigated to determine whether they have unique or desirable physicochemical and/or functional properties that would make them of use in selected food products.

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Source	Gelatinization Temperature Range, °C	Granule Shape	Granule Size (mm)	Iodine Binding Capacity (g I2/100g)	Amylose Content (%)
Barley	51-60	Round or lenticular	20-25 2-6	4.3	22
Triticale	55-62	Round	19 (2-35)	-	23-24
Wheat	58-64	Lenticular or Round	20-35 2-10	5.0	26 (23-27)
Rye	57-70	Round or lenticular	28 (12-40)	5.5	27
Oats	53-59	Polyhedral	5-10	5.1	23-24
Potato	59-68	Oval	40(15-100)	4.5	23
Maize	62-72	Round or polyhedral	15 (5-25)	5.3	28
Waxy maize	63-72	Round	15 (5-25)	0.1	1
Broad bean	64-67	Oval	30	4.5	24
Sorghum	68-78	Round	15-35	-	25 (23-28)
Rice	68-78	Polygonal	3-8		17-19* 21-22**
High amylose Maize	67-80	Round	25	ca. 10.5	52
Maize		Irregular sausage shaped			
Peas smooth	55/70	Reniform*** (simple)	5-10	6.7	33-36
wrinkled	>99	Reniform*** (cmpd)	30-40	14.7	71-76

* japonica; ** indica; *** kidney-shaped

- Starch granules are not water soluble but easily hydrate in aqueous solution, swelling about 10% in volume.
- When an aqueous suspension of granules is heated, additional swelling occurs until a temperature is reached where there is a transition from organization to disorganization. This is known as the gelatinization temperature and normally occurs over a range of about 10°C.
- The digestion of starch by α -amylase is greatly enhanced by **gelatinization**. Upon further heating (pasting or cooking), swelling continues and the amylose and portions of the amylopectin leach from the granule producing a viscous suspension.
- Cooling of this suspension leads to the formation of a gel.
- With further time, realignment of the linear chains of amylose and the short chains of amylopectin can occur in the process known as **retrogradation**. In food products based on starch gels, this can lead to liquid being expressed from the gel in the phenomenon known as **syneresis**, which is generally an undesirable occurrence. Retrogradation is most rapid with amylose and much slower and more incomplete with amylopectin due to the short chain length of its branches.

Modified starches

- Many starches do not have the functional properties needed to impart or maintain desired qualities in food products. As a result, some starches have been modified to obtain the functional properties required.
- The starches most commonly modified for commercial use are those from normal maize, tapioca, potato, and waxy maize.
- Modified starches are used to improve viscosity, shelf stability, particulate integrity, processing parameters, textures, appearance and emulsification.
- While virtually all of the different types of modified starches find use in the food industry, substituted and cross-linked starches are particularly important.
- These two types of modified starches are produced by reactions in which a small number of hydroxyl groups on the glucose units of amylose and amylopectin, mostly in amorphous regions and on the surface of the granule, are modified without destroying the granular nature of the starch.
- Substituted starches are produced by etherification or esterification. This reduces the tendency of chains to realign (retrograde) following gelatinization of starch during heat processing. Substitution lowers the gelatinization temperature, gives freeze-thaw stability, increases viscosity, increases clarity, inhibits gel formation, and reduces syneresis.
- Cross-linked starches are produced by introducing a limited number of linkages between the chains of amylose and amylopectin using difunctional reagents.
- Cross-linking essentially reinforces the hydrogen bonding occurring within the granule.
- It increases gelatinization temperature; improves acid stability, heat stability and shear stability; inhibits gel formation; and controls viscosity during processing.

Dietary fibre

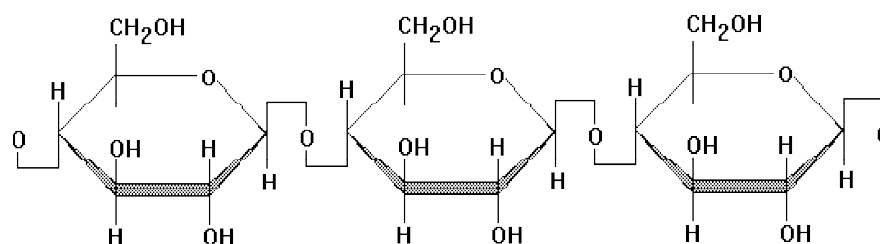
- Dietary fibre has been considered to be composed of non-starch polysaccharides plus lignin plus resistant oligosaccharides plus resistant starch.
- Lignin is not a carbohydrate.
- Dietary fibre occurring in foods and food products can be considered to consist of cellulose, hemicelluloses, pectic substances, hydrocolloids (gums and mucilages), resistant starches, and resistant oligosaccharides.

Cellulose

- **Cellulose**, the major cell wall structural component in plants, is an unbranched linear chain of several thousand glucose units with α -D-(1->4)-glucosidic linkages.

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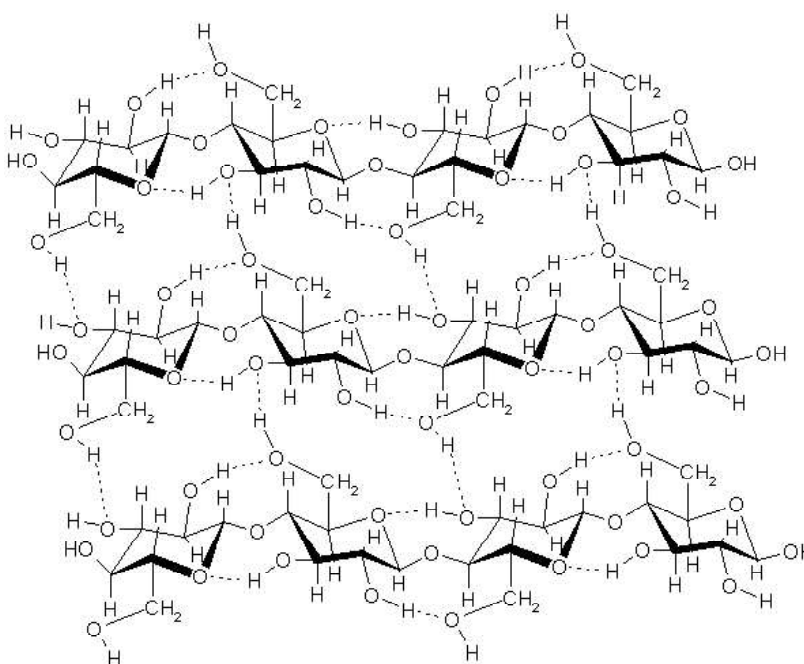
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- Cellulose’s mechanical strength, resistance to biological degradation, low aqueous solubility, and resistance to acid hydrolysis result from hydrogen bonding within the microfibrils.
- There is a portion (10-15%) of the total cellulose, referred to as “amorphous,” that is more readily acid hydrolyzed.
- Controlled acid hydrolysis of the amorphous fraction yields microcrystalline cellulose.
- Cellulose has been used as a bulking agent in food due to its water-absorbing ability and low solubility.
- Some of the early dietary fibre ingredient sources were based on cellulose powders or microcrystalline cellulose.
- Cellulose is not digested to any extent by the enzymes of the human gastrointestinal system.

Hemicelluloses

- **Hemicelluloses** may be present in soluble and insoluble forms and are comprised of a number of branched and linear pentose- and hexose-containing polysaccharides.

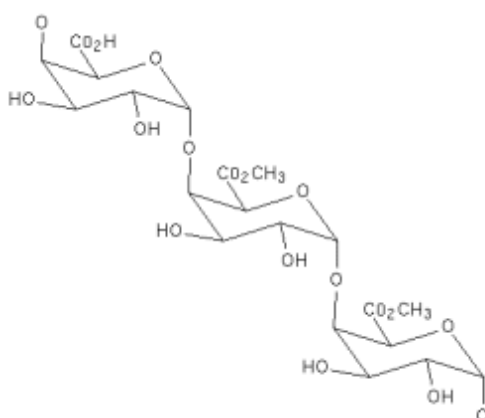


- In cereal grains, soluble hemicelluloses are termed “pentosans.” Hemicelluloses are of much lower molecular weight than cellulose. Component monosaccharide units may include xylose, arabinose, galactose, mannose, glucose, glucuronic acid, and galacturonic acid.
- Both soluble and insoluble **hemicelluloses** play important roles in food products, the former functioning as soluble and the latter as insoluble fibre.
- They are characterized by their ability to bind water and hence serve as bulking agents.
- The presence of acidic components in some hemicelluloses imparts the capacity to bind cations.
- Hemicelluloses are fermented to a greater extent than cellulose in the colon.

NOTES

Pectins

- **Pectins** find widespread use in foods such as jams and jellies because of their ability to form stable gels.



- Completely esterified pectins do not require the addition of acid or electrolyte to form gels.
- The presence of calcium salts enhances the gelling capacity and decreases the dependence on pH and sugar concentration.
- Pectic substances are of importance as a component of dietary fibre because of their ion-exchange properties, due to the presence of the galacturonic acid units, and gelling (viscosity enhancing) properties.

Hydrocolloids

- **Hydrocolloids** (gums, mucilages) are used in small amounts in food products for their thickening (viscosity increasing), gelling, stabilizing, or emulsifying ability.
- They are derived from seaweed extracts, plant exudes, seeds, and microbial sources.

NOTES

- While starch was long thought to be completely digested, it is now recognized that there is a portion (resistant starch) which resists digestion, passes into the lower intestine, and is fermented there.
- Resistant starch has been defined as “the sum of starch and products of starch degradation not absorbed in the small intestine of healthy individuals”.

Three types of resistant starch have been identified:

- o **RS1 - Physically trapped starch:** These starch granules are physically trapped within a food matrix so that digestive enzymes are prevented or delayed from having access to them. This can occur in whole or partly ground grains, seeds, cereals, and legumes. The amount of type 1 resistant starch will be affected by food processing and can be decreased or eliminated by milling.
 - o **RS2 - Resistant starch granules:** Certain raw (native) starch granules, such as potato and green banana, are known to resist attack by α -amylase. This is probably related to the crystalline nature of the starch (i.e., crystalline regions of the starch granule are less susceptible to attack by acid and enzymes than the amorphous regions). Gelatinization normally occurs during cooking and food processing, although the extent is dependent on the moisture content of the food product and may not be complete in water-limited systems (e.g. sugar cookies). Gelatinized starch is much more rapidly digested by enzymes than is raw starch. Gelatinized potato and green banana starch are digested by α -amylases. High-amylose maize starches have high gelatinization temperatures, requiring temperatures that are often not reached in conventional cooking practices (154-171 °C) before the granules are completely disrupted. As a result, undigested starch granules have been observed in the effluent from ileostomates fed a meal containing high amylose maize. These starches offer an opportunity to manipulate the amount of resistant starch present in food products.
 - o **RS3 - Retrograded starch:** The amylose and amylopectin components of starch undergo the process of retrogradation in a time dependent process after starch has been gelatinized/cooked. The rate at which amylose retrogrades is much higher than that for amylopectin which has much shorter chain lengths. Amylose can be retrograded to a form that resists dispersion in water and digestion with α -amylase. This form of resistant starch can be generated during food processing.
- There is currently great interest in resistant starch because of its potential use as a food ingredient to increase the dietary fibre content of foods and also because it may be possible to manipulate the amount of resistant starch in food products through processing conditions.

Glucose and insulin

- The digestion of dietary carbohydrates starts in the mouth, where salivary α -amylase initiates starch degradation resulting in the formation of maltose, some glucose and dextrans containing the 1,6- α -glycosidic branching points of amylopectin.
- The α -amylase degradation of starch is completed by the pancreatic amylase active in the small intestine.
- The dietary disaccharides and the degradation products of starch are broken down to monosaccharides for better absorption. This final hydrolysis is accomplished by hydrolases (“disaccharidases”) present in the intestinal brush-border membrane. Disaccharidase deficiencies occur as rare genetic defects, causing malabsorption and intolerance of the corresponding disaccharide.
- Glucose and galactose are transported actively against a concentration gradient into the intestinal mucosal cells by a sodium dependent transporter (SGLT 1).
- Fructose undergoes facilitated transport by another mechanism (GLUT 5). Fructose is better absorbed when consumed with other naturally occurring sugars.
- The absorbed carbohydrates cause an elevation of the blood glucose concentration.
- Fructose and galactose are converted to glucose mainly in the liver. That is why; they produce less pronounced blood glucose elevation.
- The extent and duration of the blood glucose rise after a meal is dependent upon the following factors:
 - o Rate of absorption,
 - o Rate of absorption depends upon:
 - Gastric emptying rate
 - Rate of hydrolysis and
 - Diffusion of hydrolysis products in the small intestine.
- Insulin that is secreted is dependent on following factors:
 - o Blood glucose elevation
 - o Secretion is modified by many neural and endocrine stimuli
 - o Amount and the amino acid composition of dietary proteins.
- Insulin has important regulatory functions in both carbohydrate and lipid metabolism and is necessary for glucose uptake by most body cells.

NOTES

4.4.2 Fermentation of Carbohydrates

NOTES

- Fermentation is the breakdown of carbohydrates that is not digested and absorbed and occurs in the large intestine.
- This process involves gut microflora (anaerobic) and it occurs in the colon of the human beings, resulting in the formation of the gases hydrogen, methane and carbon dioxide, as well as short chain fatty acids (SCFA) (acetate, propionate and butyrate).
- It increases the bacterial growth.
- The gases are either absorbed and excreted in breath or passed out via the rectum.
- The major products of such fermentation are as follows:
 - o SCFA: rapidly absorbed and metabolized by the body.
 - o Acetate: passes into the blood and is taken up by liver, muscle and other tissues.
 - o Propionate: major glucose precursor in ruminant animals but not in humans.
 - o Butyrate: metabolized primarily by colonocytes; regulates cell growth and induces differentiation and apoptosis.

4.5 NUTRITIONAL VALUE OF CEREALS AND FERMENTED PRODUCTS

Across the world, cereals are considered to be a staple food. They provide major important nutrients and are a source of carbohydrate, protein, vitamin B and minerals. Cereals also contain a range of phytochemicals which do provide some health benefits seen among populations consuming diets based on plant foods.

Having a nutritious breakfast in the morning is extremely beneficial as it provides the energy that lasts throughout the morning and can also help control weight. Cereals which are a good source of protein, fiber and are least processed are considered to be the best cereals. Despite being laced with good nutrients, cereals are also deficient in some basic components such as essential amino acids. The most simple and economical way of improving their nutritional value, sensory properties, and functional qualities is fermentation. It has been observed that an increased carbohydrate intake, corresponds to at least 55 per cent of total energy. The carbohydrate content in diets should be maintained at a high level.

The nutritional quality of carbohydrates and the effects of processing on that quality has to be kept in mind as both the content and the nutritional quality of food carbohydrates can be altered by processing in a number of ways.

Processing

To produce a variety of different products, cereals undergo a range of processes. Milling is the main process associated with cereals, especially the bread cereals wheat and rye. Different milling techniques are used for different cereals. Other processes such as extrusion and fermentation may also be used in the production of cereal products. In addition to having technical consequences, processing also changes the nutritional content of cereals.

Milling

The process of milling is described as grinding, sifting, separation and regrinding. These steps are repeated to extract a particular part of the grain, the endosperm. Before the process begins, the cereals are first cleaned. Modern technology is used to separate foreign material from the grains. Prior to grinding, water may be added to the cereal, which is allowed to rest before milling (tempering). This allows absorption of water by the grains, toughening the pericarp and germ so they do not splinter during milling. To make sure that the product produced is uniform, different grains may be blended prior to milling and this is referred to as gristing.

Fermentation

Fermentation is a process used in the production of a number of cereal products including bread, and alcoholic beverages such as beer, vodka and whiskey. Examples of fermented cereal foods include kenkey, made from a fermented maize dough in Ghana and tapé ketan, a rice dessert in Indonesia (Macrae et al. 1993). During bread making, fermentation produces carbon dioxide making the dough rise and increasing its volume. During the proving stage, mechanically damaged starch grains are broken down by amylase to produce maltose, which is important for maintaining yeast activity (and therefore gas production). In addition to yeast, lactic acid bacteria are used in the production of sourdough bread to provide an acidic flavour to the final product. Some of the bioactive substances in rye increase in sourdough baking (Liukkonen et al. 2003). The bacteria also affect the dough proteins, making the dough stronger. In alcohol production, fermentation produces ethanol and carbon dioxide. In other fermented cereal products, the bioavailability of minerals may be higher than in similar non-fermented products due to the partial breakdown of the phytate. Fermentation may also improve protein quality because of bacterially produced lysine and by improving protein digestibility (Macrae et al. 1993).

NOTES

Check Your Progress

5. State one use of modified starches.
6. What are pentosans?
7. Why are pectins used in jams and jellies?

4.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

NOTES

1. Two major carbohydrate-containing foods in the human diet are cereals and pulses.
2. Carbohydrates of short chain lengths such as raffinose, stachyose and verbascose, which are three, four and five sugar polymers respectively, are classified as oligosaccharides.
3. Their most important nutritional property of carbohydrates is digestibility in the small intestine.
4. Most polysaccharides are insoluble in water. Upon hydrolysis with acids or enzymes they eventually yield their constituent monosaccharides.
5. Modified starches are used to improve viscosity, shelf stability, particulate integrity, processing parameters, textures, appearance and emulsification.
6. In cereal grains, soluble hemicelluloses are termed “pentosans”.
7. Pectins find widespread use in foods such as jams and jellies because of their ability to form stable gels.

4.7 SUMMARY

- Cereals belong to the gramineous family and considered simply to be the crops harvested for dry grain.
- Crops harvested green for feed, fodder or grazing are classified as fodder crops.
- There is also a category of industrial crops, which includes crops like sorghum.
- Cereals are classified according to their genus.
- Carbohydrate is the most important food energy provider among the macronutrients, accounting for between 40 and 80 percent of total energy intake.
- The simplest carbohydrates are the three-carbon sugars which figure importantly in intermediary metabolism and the most complex are the naturally occurring polysaccharides, primarily of plant, origin.
- Glycogen is often referred to as animal starch because it is not present in plants.
- Carbohydrates are classified generally according to their degree of complexity.

- The free sugars such as glucose and fructose are termed monosaccharides; sucrose and maltose, disaccharides; and the starches and celluloses, polysaccharides.
- While a formal definition of a carbohydrate can be considered somewhat difficult, one commonly accepted by chemists is that carbohydrates are “polyhydroxy aldehydes, ketones, alcohols, acids, their simple derivatives and their polymers having polymeric linkages of the acetal type”.
- Carbohydrates play a major role in human diets, comprising some 40-75% of energy intake.
- Their most important nutritional property is digestibility in the small intestine.
- The polysaccharides represent a large group of complex carbohydrates which are condensation products of undetermined numbers of sugar molecules.
- Most starches consist of a mixture of two types of polymers, namely; amylose and amylopectin.
- Glycogen is the only complex carbohydrate of animal origin. It exists in limited quantities in liver and muscle tissues and acts as a readily available energy source.
- Hemicellulose represents a group of carbohydrates including araban, xylan, certain hexosans and polyuronides.
- Starch is the most important, abundant, digestible food polysaccharide. It occurs as discrete, partially-crystalline granules whose size, shape, and gelatinization temperature depend on the botanical source of the starch.
- Starch granules are not water soluble but easily hydrate in aqueous solution, swelling about 10% in volume.
- Dietary fibre has been considered to be composed of non-starch polysaccharides plus lignin plus resistant oligosaccharides plus resistant starch.
- **Hemicelluloses** may be present in soluble and insoluble forms and are comprised of a number of branched and linear pentose- and hexose-containing polysaccharides.
- Fermentation is the breakdown of carbohydrates that is not digested and absorbed and occurs in the large intestine.

NOTES

4.8 KEY TERMS

- **Amylose:** It is a linear glucose polymer.
- **Cellulose:** It is the chief component of plant cell walls.
- **Hydrolysis:** It is the splitting of a large molecule of carbohydrates into simpler units involving addition of water.

4.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

NOTES

Short Answer Questions

1. What is dietary fiber? What is its significance?
2. State the properties of starch. What are modified starches?
3. What are hydrocolloids?
4. What do you know about the following terms:
 - (a) Syneresis
 - (b) Cellulose
 - (c) Hemicelluloses
 - (d) Pectins
5. Write a brief note on glucose and insulin.

Long Answer Questions

1. Classify carbohydrates giving example of each class.
2. What are polysaccharides? Explain in detail.
3. Explain the properties of whole granular starches.
4. What is resistant starch and what are the various forms of resistant starch?
5. Explain fermentation of carbohydrates.
6. What is the significance of carbohydrates in our diet? Discuss.

4.10 FURTHER READINGS

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UNIT 5 PULSES, NUTS AND SEEDS

Structure

- 5.0 Introduction
- 5.1 Objectives
- 5.2 Nutritive Value of Pulses
 - 5.2.1 Composition of Pulse Proteins
- 5.3 Protein Foods for Infants and Children
- 5.4 Soy Products
- 5.5 Protein Concentrates and Isolates
- 5.6 Texturized Vegetable Protein
- 5.7 Nutritional Value of Nuts and Oilseeds
- 5.8 Answers to Check Your Progress Questions
- 5.9 Summary
- 5.10 Key Words
- 5.11 Self Assessment Questions and Exercises
- 5.12 Further Readings

NOTES

5.0 INTRODUCTION

Pulses are a low fat source of protein with excessive stages of protein and fibre. Pulses additionally contain important nutritional vitamins and minerals like iron, potassium and folate. Pulses grant essential vitamins and are recommended as section of a healthy diet.

Most countrywide dietary guidelines recommend pulses as section of a healthy diet. Nuts and oilseeds are in truth prosperous in fat and for this reason are a targeted supply of calories. A handful of nuts can grant a giant amount of energy.

They are additionally remarkable sources of desirable pleasant proteins. Therefore they are advisable for all age- groups, from teens up to elderly. To render them digestible, they must be precise masticated and have to be consumed in small quantities. For too small children and aged people, it is always better to use nuts in powdered form.

5.1 OBJECTIVES

After going through this unit, you will be able to:

- Describe the nutritive value and processing of pulses, nuts and oilseeds
- Discuss protein foods for infants and children
- Explain soy products and their uses
- Describe the meaning of protein concentrates and isolates

- Discuss the significance of texturized vegetable proteins
- Analyse the methods of estimating protein quality

NOTES

5.2 NUTRITIVE VALUE OF PULSES

Pulses grant essential vitamins and are recommended as section of a healthy diet. Most countrywide dietary guidelines recommend pulses as section of a healthy diet. Studies have shown that human beings who eat at least ½ cup of pulses per day have greater intakes of fibre, protein, calcium, potassium, folate, zinc, iron, and magnesium as well as lower intakes of whole and saturated fat. Pulses are a necessary plant-based source of protein.

Many diets round the world depend on pulses as a supply of protein. The amount of protein in beans, lentils, chickpeas and peas is 2-3 instances the stages discovered in cereal grains like wheat, rice, quinoa, oats, barley, and corn. Compared to animal and many different plant-based sources of protein, pulses are an extra lower priced and sustainable protein source.

All proteins are created from twenty exceptional amino acid constructing blocks. Nine of these amino acids cannot be produced via the body and are known as “essential” because they need to come from foods we eat. Most plant proteins lack at least one quintessential amino acid. However, when two or greater plant-based sources of protein are combined, each meal can furnish the quintessential amino acid(s) that the complementary food(s) is missing. Eating protein from a range of sources, from both plant and animal sources, ensures the physique receives all of the quintessential amino acids crucial for desirable health.

Pulses have a notable supply of dietary fibre and other complicated carbohydrates. One cup of cooked pulses offers you more than half the amount of fibre you need for the whole day. Pulses also comprise each soluble and insoluble fibre. Soluble fibre can help control body weight, blood sugar levels and decrease cholesterol. Insoluble fibre on the other hand, assists with digestion and regularity. Pulses also include resistant starch, a kind of carbohydrate that behaves like fibre in the body; and has been shown have similar health benefits such as reduced circulating LDL cholesterol and blood sugar ranges as properly as improved intestine health. They are one of the essential meals plants globally due to higher protein content. Pulses are an essential group of plants in India, which is also responsible for yielding giant economic features via amounting for a massive phase of the exports.

Pulses are the most important sources of protein in the diet. Pulses form an indispensable phase of the Indian diet, offering plenty wanted protein to the carbohydrate wealthy diet. India is the biggest producer of pulses in the world. Pulses are 20 to 25 per cent protein with the aid of weight which is double the protein content of wheat and three times that of rice. Major pulses grown are

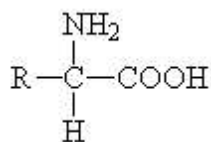
chickpeas (gram), pigeon pea (tur or arhar), moong beans, urad (black matpe), masur (lentil), peas and different sorts of beans.

The predominant areas with high productiveness are Punjab, Haryana, Western Uttar Pradesh, West Bengal delta region, coastal Andhra Pradesh, Tamil Nadu, Kerala, coastal and Japanese Karnataka and some parts of Maharashtra.

NOTES

5.2.1 Composition of Pulse Proteins

- Proteins are very complex organic compounds. They are made up of carbon, hydrogen, oxygen and nitrogen (16 per cent). Sometimes, presence of sulphur, phosphorus, iron and other minerals are also found associated.
- All the proteins are made up of amino acids. Thus, amino acids are the building blocks of proteins. The number, type, amount and arrangements of these amino acids cause variation in the types of proteins.
- There are twenty different types of amino acids found in nature. The amino acids form a linear chain to form proteins. This chain is known as polypeptide chain.
- Amino acids are a varied class of molecules with one defining property; i.e. they all possess a carboxylic acid group and an amino group, both linked to a single carbon atom called the α -carbon.
- Their chemical variety comes from the side chain that is also attached to the α -carbon. The importance of amino acids to the cell comes from their role in making proteins, which are polymers of amino acids joined head-to-tail in a long chain that is then folded into a three-dimensional structure unique to each type of protein.
- The covalent linkage between two adjacent amino acids in a protein chain is called a peptide bond; the chain of amino acids is also known as a polypeptide.
- As the name suggests, the word “amino” shows that the compound contains an amino group ($-\text{NH}_2$) and the “acid” shows the presence of carboxylic group ($-\text{COOH}$). In addition, they also contain a third group that is denoted by R. “R” can be a hydrogen atom or any other complex group depending on the type of amino acid. The structural formula of amino acids is:



- Regardless of the specific amino acids from which it is made, the polypeptide has an amino (NH_2) group at one end (its N-terminus) and a carboxyl (COOH) group at its other end (its C-terminus). This gives it a definite directionality, a structural (as opposed to an electrical) polarity.

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- All the twenty types of amino acids found commonly in proteins, possess a different side chain attached to the α -carbon atom.
- Like sugars, all amino acids, except glycine, exist as optical isomers in d- and l-forms. But only l-forms are ever found in proteins (although d-amino acids occur as part of bacterial cell walls and in some antibiotics). The origin of this exclusive use of l-amino acids to make proteins is another evolutionary mystery.
- The chemical versatility that the 20 standard amino acids provide is vitally important to the function of proteins.
- Five of the 20 amino acids have side chains that can form ions in solution and thereby can carry a charge. The others are uncharged; some are polar and hydrophilic, and some are non-polar and hydrophobic.

Classification of amino acids

In nature about 300 types of amino acids are found of which 20 amino acids are found in proteins. All the amino acids are required by the body but some are known as indispensable nutritionally essential amino acids, as these cannot be synthesized by the body. Their deficiency may disturb the nitrogen equilibrium, growth, and nutrition, maintenance of body and life span of the individual. The other amino acids are termed as dispensable or non-essential amino acids as they can be synthesized in the body. It is important to note that they are more important to the cell as compared to the essential amino acids.

There are ten essential amino acids for human beings. These include Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine. Of these, Arginine and Histidine are considered as semi-essential amino acids, since they are synthesized in the body but their quantities are not enough to meet the growth requirements. The amino acids, Cysteine and Tyrosine are also considered as essential amino acids as they are synthesized from Methionine and Phenylalanine.

5.3 PROTEIN FOODS FOR INFANTS AND CHILDREN

Both best and extent of protein consumption in infancy and childhood are of pastime with regard to later danger of non-communicable illnesses (NCDs) In the Nordic setting, the volume of protein intake is of utmost importance, as its first-rate hardly ever is a problem. The speculation that excessive protein in infants' diet stimulates growth and at the same time as increases the probability of obese and weight problems later in existence used to be first proposed in 1995 by way of Rolland-Cachera et al. Several Nordic researches have seeing that validated this association. The increase affiliation has been notion to rely on the stimulating impact

of excessive protein consumption on insulin-like growth factor 1 (IGF-I), which in flip may also end result in extra fast boom and increased muscle mass as nicely as fats mass.

Rapid boom at some stage in the first year of existence has been associated with an accelerated threat of overweight and obesity later in life in various epidemiological studies. Infants who are breastfed all through the first months of existence develop at a slower rate in infancy than these that are bottle-fed. It has been postulated that part of the clarification is associated to greater protein content material of child system in contrast with mother's milk.

Other destructive health outcomes of high protein intake early in existence have also been suggested. A systematic literature overview (SLR) used to be wanted to enhance the expertise about viable negative outcomes of a high protein intake. This is vital to enable formulating advice about splendid meals to give children and younger teenagers during the transition from breast milk to family foods, as well as for deciding protected levels for the composition of baby formulation and follow-on formulas. Further, it is important to explore the affiliation between older children's protein consumption and health.

According to the World Health Organization/Food and Agriculture Organization (WHO/FAO), reference values for protein consumption is 0.9 g/kg/day from three to 18 years of age for boys and from three to 15 years of age for girls. Between 15 and 18 years of age, the degree decreases slightly for female to 0.8 g/kg/day. Combining this reference value with the reference values for strength intake for age and sex, this equates to about 5 protein energy percentage (PE%) at three years of age steadily increasing to about 7–9 PE% at 17 years of age for boys and girls, respectively. The intake of protein in the Nordic nations is, as in many industrialized, greater than enough to meet physiological necessities among teenagers.

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5.4 SOY PRODUCTS

Soy Milk

- Grinding, soaking and straining soybeans creates a mild-tasting liquid known as soy milk. Soy milk is usually a suitable replacement for dairy milk. Vanilla and chocolate soy milk are often sold alongside unflavored soy milk, which are all typically packaged in aseptic containers. A 1-cup serving of soy milk has 104 calories, 6 grams of protein and 3.5 grams of fat, on average. Fortified soy milk is a good source of calcium, iron, vitamin B-12 and vitamin D.

Tofu

- Soybean curd -- or tofu -- is created by curdling soy with a coagulant. Tofu, which has minimal flavor, can absorb seasonings and flavorings easily. Firm tofu is dense and useful in stir fries or soups. Soft tofu is mushier and works in place of yogurt in smoothies. A 1/2-cup serving of firm tofu has 88 calories, over 10 grams of protein and 5 grams of fat. Creamy desserts using tofu are common in grocery stores, as are plain blocks of tofu with varying firmness. Most Asian markets carry fresh tofu, which has a smoother texture and flavor.

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Soy Sauces

- Soy sauce is one of the most common soy products available. This dark brown liquid with a salty taste is made by fermenting soybeans. Shoyu and tamari are common varieties of soy sauce and are typically available in different levels of darkness. A 1-teaspoon serving of tamari has 4 calories and 335 milligrams of sodium. Vegetable, meat and tofu dishes often call for soy sauce, but it is even used in some cookie recipes.

Soybean Oil

- Most margarines, shortenings and salad dressings contain soybean oil. In addition, most of the “vegetable oil” you see in the grocery store is pure soybean oil. The American Heart Association lists soybean oil as a safe fat for maintaining health and longevity. A 1-teaspoon serving of soybean oil has 40 calories, 4.5 grams of fat and less than 1 gram of saturated fat. Soybean oil is mostly flavorless, making it a non-intrusive ingredient in most dishes.

Other Soy Products

- Soybeans are an incredibly versatile ingredient used to make numerous products found around the world. A few examples include whipped soy topping, soy cheese, soy yogurt, soy nut butter, soy grits, soy ice cream, soy meat alternatives and soy nuts. Yuba, which is a thin sheet made from soybeans, is useful for making wraps and soups; tempeh is a pressed, fermented block of soybeans; miso is a fermented soybean concoction used in soup; natto is a sticky, fermented soybean dish

5.5 PROTEIN CONCENTRATES AND ISOLATES

Proteins that are utilised in meals processing are of a variety of origins, and can roughly be categorized into animal proteins (gelatins), vegetable proteins (e.g. peanut protein, soy protein, wheat proteins, Almond protein, canola meal protein etc.), and animal derived protein (e.g. milk proteins). However, many vegetable proteins require processing to grant food material having desirable practical properties such as emulsification, oil and water absorption, texture modifications, color manipulate and whipping properties, which are primarily attributed to the protein characteristics.

Many have attracted a deal of pastime as a source of low-cost protein to supplement human diet, this includes amongst others, soybeans and peanut.

Whey Protein Isolates (WPI)

Whey is the liquid derivative of cheese which can further be processed into a spray dried product like whey protein concentrates (WPC), whey protein isolate (WPI) or whey protein hydrolysate. Liquid elements acquired with the aid of separating the coagulum from milk or cream in the cheese making. During cheese making, the whey protein remains in the serum segment which represents about 20 per cent of the milk protein. In the manufacturing of whey protein isolates, considerable quantity of fats and lactose get removed, as an end result of which individual with lactose-intolerant can safely consume these merchandises.

Fish Protein Isolates (FPI)

To clear up the hassle of utilisation of unconventional uncooked fabric (dark muscle fish, fatty fish) and also fish by-products (fish trims, fish frames etc.) a procedure was once developed to economically boost a practical protein isolates from these

variety of raw materials. This technology uses the pH dependant's solubility properties of fish muscle proteins for their separation and healing from different components of muscle that are not applicable in a last product. Fish protein isolate is a protein concentrate which is prepared from fish muscle without preserving the authentic structure of the muscle. It is not normally consumed directly, but used as raw fabric for production of different value brought products. Fish protein isolate does not retain the authentic shape of muscle and is normally utilized as ingredient for the production of cost introduced products.

It is still a good supply of protein for the production of ready to devour fish products.

Peanut Protein Isolates (PPIs)

Peanut incorporates 26-29% protein with precise nutritional quality. Peanut proteins are used for their functional properties (emulsification, forming) or for their dietary houses in different food products. They are also used for human diet in developing international locations to supplement cereals, liquids and skim milk.

Soy Protein Isolates (SPIs)

Soy protein isolate is a frequent isolate. It has high protein content material of about 90%. It is made out of defatted soy meal by means of eliminating most of the fat and carbohydrates (Seyam 1983). Soybean is beaten into oil and defatted meal. The meal is typically used as animal feed, whilst smaller quantity is further processed into meals ingredients along with soy flour, protein concentrate, protein isolates and textured protein (Kinsella 1976). Soy protein isolate is typically combined with different food substances such as vitamins, minerals and flavour in guidance of soy protein shake powder.

Canola Pprotein Isolates (CPIs)

Canola meal has been the biggest feed meal after soybean meal. It has a appropriate amino acid profile with a well balance amino acid composition even though it has found only marginal used in the food industry, due to the presence of anti-nutritional factors. The considerable majority of canola protein isolates are organized by alkaline extraction method fallowed through isoelectric precipitation.

Chick pea protein Isolate

Chick pea protein is the world's 1/3 biggest pulse crop in term of area, grown ordinarily in West Asia and Mediterranean region. It is one of the major vegetable proteins. Many purposeful properties of this protein isolate has been studied whereas, information on gelation residences of chick pea protein isolate was once scares. The chick pea protein isolate dispersed with sodium and calcium salts showed specific rheological behaviour at distinct ionic energy and pH.

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Cashew nut protein isolate

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Cashew has widespread financial significance because its elements have several economic uses. The kernel has excessive meals of about 40-57% oil and 21% protein content. A cashew kernel meal consists of about 42% crude protein, a low crude fibre and 0.5% and 0.2% calcium and phosphorous, respectively, which is comparable to that of peanut composition, which has been used for peanut protein isolate and concentrate. Protein isolates and concentrates can be bought from defatted cashew nut powder via both alkaline extraction-isoelectric precipitation (IP) and alkaline extraction-methanol precipitation (MP).

Check Your Progress

1. What are all proteins made up of?
2. What is a peptide bond?
3. Name any three essential amino acids found in protein.
4. State one use of peanut proteins.

5.6 TEXTURIZED VEGETABLE PROTEIN

Texturized Vegetable Protein (TVP) has top significance in food industry as properly as from the health factor of view. TVP is cholesterol free and used worldwide due to exceptional protein of plant source. Its utilization is additionally associated with religious, cultural and financial troubles in particular it is famous in vegetarian. Also international remedy corporations use this product without its utilization in toddler college diet programmes. It is convenient to cope with and larger shelf lifestyles than actual meat and also have health benefits. Textured vegetable protein (TVP) are generally, these fabricated vegetable products that can be used to change meat definitely in a food serving and those textured vegetable protein entities that can be eaten in mixture with meat as extenders. These textured plant protein resemble meat in chewiness and flavor. Today, due to increasing client demand for healthy diets and worries about rising meat prices, it is perception that plant protein based food materials will get prime importance as meat picks worldwide. This is the reason that more than a few types of plant protein based totally meat products are now seen in the market. There are three classes of consumers. The texturization of plant proteins has been a major development in the food industry. Processes, like extrusion, have been developed to impart a fibrous structure to amorphous plant proteins. In this production system proteins are successfully denatured for the duration of moist thermal procedure of extrusion. Denaturation of protein lowers solubility, renders it digestible and destroys organic pastime of enzymes and toxic proteins. Depending upon chemical composition of proteins and homes of individual constituent's legumes specifically soybean is treasured for manufacturing of texturized vegetable proteins mostly via extrusion process. Texturizing is completed

the use of high temperature, strain and shear forces on proteineous and nonproteineous constituents, retaining limited excess of water in extruder. Legume grains occupy an essential location in human nutrition, in particular in low-income businesses of people in developing countries. Legumes are prepared for consumption in many ways, such as total legumes known as grains or de-husked and split legumes, recognized as dals. They are generally true sources of gradual release carbohydrates and are wealthy in proteins (18–25%) and Soya bean is special in containing about 35–43% proteins. They are also good sources of minerals and vitamins. It has been mentioned that germinated legumes are prosperous in diet C and in some cases, there is an make bigger in the riboflavin as well as niacin contents upon germination. They are also the cheapest sources of supplementary proteins in vegetarian diets. Dehulled chickpea splits as chana dhal contains about 20.8% protein, 5.6% fat, 2.7% minerals, 1.2% fiber and 59.8% carbohydrate. The Chickpea splits are used in substantial range of forms. They may additionally be floor to flour (besan), cooked into thick or thin gruels or blended with cereals in various way to make common foods (khichdi, dhokla, puran poli) and used in the instruction of sweet meats. Soybeans fluctuate widely in nutrient content based totally on the particular variety and developing conditions, however commonly they comprise 35 to 40% protein, 15 to 20% fat, 30% carbohydrates, 10 to 13% moisture, and round 5% minerals and ash.

Soy protein, were earlier known as “mystery meat,” today is on the warm list of elements for its ability to make contributions to two top food developments - the continued quest for excessive quality, low fats meals and the thriving subject of practical and nutraceutical foods. The greater performance of soy protein concentrates and soy protein isolates and their neutral taste profile, account for their broad application in the meals industry. two There are countless exclusive definitions of texturized vegetable protein in the literature relying upon the sources. Texturized vegetable can be described as “fabricated palatable food ingredients. processed from safe to eat protein source, including among others soy grits, soy protein isolates, and soy protein concentrates with or except suitable alternative elements introduced for dietary or technological purposes. They are made up as fibers, shreds, chunks, bits, granules, slices or different forms. When organized for consumption by using hydration, cooking, retorting or other procedures, they continue their structural integrity and typical ‘chewy’ texture”.

Methods of Estimating Protein Quality

Proteins differ greatly in their nutritive value. This can be demonstrated grossly by any number of methods such as comparison of rates of growth, nitrogen retention, or other measures of physiological performance of animals or human subjects consuming diets containing approximately equal amounts of different proteins. It is also clear that these differences are in most instances related to the amino acid composition of the proteins since additions of essential amino acids to proteins often greatly improve their nutritive value.

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Biological Value (BV)**NOTES**

- Biological value, as defined by Thomas and Mitchell has long been considered the method of choice for estimating the nutritive value of proteins. It has been defined as the “percentage of absorbed nitrogen retained in the body” and a complete evaluation of the dietary protein includes measurement of the Biological Value and the Digestibility. These values are obtained by measuring the fecal and urinary nitrogen when the test protein is fed and correcting for the amounts excreted when a nitrogen-free diet is fed. True digestibility is defined as the percentage of food nitrogen absorbed from the gut

$$\text{Digestibility} = \frac{I - (F - F_0)}{I} \times 100$$

and Biological Value as

$$\text{BV} = \frac{I - (F - F_0) - (U - U_0)}{I - (F - F_0)} \times 100$$

where

I = Nitrogen intake of test protein

F = Fecal nitrogen

F₀ = Fecal nitrogen on nitrogen-free diet (Metabolic N)

U = Urinary nitrogen

U₀ = Urinary nitrogen on nitrogen-free diet (Endogenous N)

- In practice Mitchell found that the endogenous N was very similar to that obtained when a small amount of very high quality protein was fed and preferred to feed limited amounts of egg protein rather than a nitrogen-free diet in order to prevent severe weight loss. The basic assumption made in the measurement of Biological Value is that the endogenous N and metabolic N are constant values and can be legitimately subtracted from the test values as shown in the equation. There is limited information to suggest that this may not always be true. For example, the excretion of urinary nitrogen in rats and dogs on a nitrogen-free diet may be lowered substantially by the administration of methionine yielding a Biological Value of methionine alone much above 100%. This may not happen in man but has not been thoroughly studied. Also, Mitchell et al. found the Biological Value of gelatin to be 20%, i.e., 20% as satisfactory as the best quality proteins. Since animals will not survive on gelatin alone, this must be an overestimate of the real nutritive value. The discrepancy here appears to be similar to that observed by Bender in NPU values for diets that provided low intakes of most of the essential amino acids.

- The overall nutritive value of a protein (**Net Protein Value**) should be obtained from the Mitchell method as Biological Value x Digestibility and this should be identical with NPU as defined below.

Net Protein Utilization (NPU)

- Like Biological Value, NPU estimates nitrogen retention but in this case by determining the difference between the body nitrogen content of animals fed no protein and those fed a test protein. This value divided by the amount of protein consumed is the NPU which is defined as the “percentage of the dietary protein retained”. Miller proposed a procedure which involved replicate groups of 4 weanling rats housed in group cages which were fed either the “protein-free” or the “test” diet for 10 days. These conditions were chosen empirically and the particular merits of these conditions remain to be demonstrated. Since in young animals there is a high correlation between body nitrogen and body water content, the substitution of body water measurements for body nitrogen measurements has been widely used. Indeed, measurement of body water may be more accurate than measurement of body nitrogen because sampling errors are eliminated; also, it is much more convenient and less expensive.
- Since both NPU and BV are based upon estimates of “retained nitrogen”, they should measure the same thing except that in the calculation of NPU the denominator is the total protein eaten whereas in the calculation of BV it is the amount absorbed. BV would be expected to be higher than NPU by the amount of nitrogen lost owing to lack of digestibility (lack of absorption). In weanling rats, it is possible that total carcass analysis is a more accurate measure of “retained nitrogen” that can be obtained from nitrogen balance measurements although this has not been proven. It is certainly less tedious. Nitrogen balance measurements must be used in large animals and in studies on man.

Amino Acid Score

- Block and Mitchell originally proposed that since all amino acids must be present at the site of protein synthesis in adequate amounts if protein synthesis is to proceed, a comparable deficit of any amino acid would limit protein synthesis to the same degree. Thus, they suggested that if the composition of an “ideal protein” was known, i.e., a protein which contained every essential amino acid in sufficient amounts to meet requirements without any excess, then it should be possible to compute the nutritive value of a protein by calculating the deficit of each essential amino acid in the test protein from the amount in the “**ideal protein**”. The “**most limiting amino acid**”, the one in greatest deficit, would presumably determine the nutritive value.
- In practice they suggested the protein in whole egg as the “ideal” since this was known to have a Biological Value closely approaching 100. They

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recognized that egg proteins might contain some amino acids in excess of requirements. If so, deficits of these in other proteins calculated by this procedure would be misleadingly high. That is, the calculated nutritive value would be lower than it actually was. However, Block and Mitchell compared Biological Values which were thought to have been accurately estimated and with “amino acid deficits” calculated using egg protein as the standard found a rather high correlation ($r = .86$) suggesting the overall validity of this procedure.

- Amino Acid Scores have been widely used since that time. Generally they have been calculated as the “percentage of adequacy” rather than as deficits as suggested by Block and Mitchell. The FAO Committee of 1957 recognizing again that egg proteins might contain various essential amino acids in excess of the amounts required proposed that Amino Acid Scores be calculated from an amino acid pattern that was based upon estimates of amino acid requirements in man. A similar approach was recommended by the Amino Acid Committee of the Food and Nutrition Board. However, the second Expert Group of FAO/WHO concluded that the previously suggested pattern was not appropriate in certain respects and that there was not sufficient information to state that egg, cow’s milk or human milk proteins differed in nutritional quality. They thus suggested that any of these patterns might be considered “ideal” for the calculation of Amino Acid Scores. Since these three proteins differ substantially in amino acid composition, this suggestion has led to confusion in the calculation of Amino Acid Scores. They also suggested that the ratio of essential amino acid nitrogen to total nitrogen (E/T) was related to, and might be a determinant of, protein quality. Since no method was proposed for combining this ratio with the Amino Acid Score, this has led to further confusion.

Protein Efficiency Ratio (PER)

- The qualitative differences in protein quality can be demonstrated by many methods. Protein Efficiency Ratio (PER) has been the method most widely used because of its simplicity. Osborne, Mendel and Ferry observed that young rats fed certain proteins gained little weight and ate little protein whereas those which were fed better quality proteins gained more weight and consumed more protein. In an attempt to compensate for the difference in food intake, they calculated the gain in weight per gram of protein eaten and this has been called PER. It is known that the PER for any protein is dependent upon the amount of protein incorporated in the test diet. Standardized conditions have therefore been proposed. These include the use of 10 weanling rats per test group, diets containing 9.09% protein ($N \times 6.25$), a test period of 4 weeks’ duration, and that each experiment include a group which receives standardized casein. The PER is calculated as the average total weight gain divided by the average grams of protein consumed.

Since PER in various laboratories was not constant for the same protein, it was recommended that a corrected value be calculated using an assumed PER of the standardized casein of 2.50 (Corrected PER = $2.50 \times \text{PER} / \text{PER of reference casein}$).

- In spite of its simplicity PER has been severely criticized as a measure of protein quality. The most common criticisms have been that some dietary protein is required for the maintenance of the animal and this is not credited to the protein in the measurement of PER and that body composition may vary and not be an adequate measure of nitrogen retention. From the theoretical point of view the major criticisms of PER are that it is not a direct function of the nutritive value of the protein but is related to the weight gain, the amount of food consumed, the amount of protein in the diet, and the nutritive quality of the protein in the diet. The relationship between these is complex and undefined. PER also has the *disadvantage* that even under standardized conditions it is not reproducible in different laboratories. It is of interest that in the collaborative study corrected PER values showed larger differences between laboratories than the uncorrected values indicating that this correction was not appropriate and of no advantage.
- It is clear that PER is not proportional to the nutritive quality of the proteins tested and, for example, a protein which demonstrates a PER of 1.5 cannot necessarily be assumed to have 50% of the value of a protein showing a PER of 3.0.

Net Protein Ration (NPR)

- A major criticism of the PER has been that it does not take into account the protein required for maintenance since only gain in weight is used in the calculation. Bender and Doell suggested that this criticism could be avoided by the inclusion in each test of a group of animals fed a protein-free diet. Net Protein Ratio (NPR) was then calculated as the overall difference in gain (gain in weight of the test group plus loss in weight of the protein-free group) divided by the protein eaten. It is apparent that if body composition is constant, this procedure is identical to NPU except that it is expressed in arbitrary units which are less useful than the percentage of protein utilized. The weaknesses are, of course, identical with those discussed under NPU.

Relative Nutritive Value (RNV)

- Hegsted et al proposed a slope-ratio assay using rats in which the slope of the regression line relating body protein (or body water) of a standard protein (egg protein or lactalbumin) assumed to have maximal nutritive value was compared to that of the test protein. The tacit assumption made in the measurement of NPU or BV that these values are independent of the level of protein fed is thus tested in this procedure. As in the calculation of NPU and BV the original assumption was made that the regression line should

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bisect the Y axis at the point defined by the group fed the protein-free diet. As has already been discussed above, this often and perhaps, usually, does not happen. The regression lines above the maintenance level of intake are, however, linear over a substantial range of intakes with young growing rats contrary to the conclusions of Miller and Payne. In young growing rats where maintenance requirements are relatively small compared to the growth requirements, this method is probably the most logically defensible of the assays available as an estimate of the protein quality for growth. The important question remains as to whether estimates of protein quality for growth in young rats are adequate estimates of quality for man including those of the young infant. Presumably, many proteins will be more efficiently utilized in human beings than they are for young growing rats.

Nitrogen Balance Index

- Allison and Anderson showed Biological Value is the slope of the regression line relating nitrogen balance and nitrogen intake and suggested that this might have certain advantages in practice over the usual method of determining BV. The concept of this index is rather similar to Relative Nutritive Value discussed above. Since it is becoming increasingly clear that nitrogen retention is not linearly related to nitrogen intake in the region of intake below maintenance, the validity of this index requires confirmation.

Tissue Regeneration

- A variety of techniques involving the recovery of weight or of specific tissues after protein depletion have been proposed. The specific merits of such assays as opposed to weight gain of young rats, for example, remain to be demonstrated.

Microbiological Assays

- Many micro-organisms require the essential amino acids required by monogastric animals. If it were possible to find organisms which required not only the same pattern of amino acids but in the same relative amounts, their growth response when supplied with limited amounts of various proteins or protein hydrolysates would provide a simple and efficient assay of nutritive value. Considerable effort has been directed toward this and it is clear that the responses of some organisms resemble those observed with some of the rat assays described. The difficulties are clear, however, since the limitations in the animal assays mean that they provide an inadequate base for comparison with assays of this kind.

Plasma Amino Acids

- The changes in plasma amino acid levels after the feeding of various proteins can under certain conditions yield estimates of the nutritional quality. It may

be noted, however, that the range of each of the amino acids in the plasma in normal animals is relatively large. This variability imposes serious limitations upon the quantitative interpretation of any changes in the levels observed. Thus, while it may be possible to identify the limiting amino acid in certain proteins by this technique, the likelihood that good quantitative assays for nutritional quality can be developed using plasma amino acid levels is not promising.

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5.7 NUTRITIONAL VALUE OF NUTS AND OILSEEDS

Besides their prosperous taste, nuts are known for their very desirable nutritional value. This is as follows:

- Nuts and oilseeds are in truth prosperous in fat and for this reason are a targeted supply of calories. A handful of nuts can grant a giant amount of energy.
- They are additionally remarkable sources of desirable pleasant proteins. Therefore they are advisable for all age- groups, from teens up to elderly. To render them digestible, they must be precise masticated and have to be consumed in small quantities. For too small children and aged people, it is always better to use nuts in powdered form.
- Nuts with high amounts of fat – Example almonds, cashew nuts & walnuts which contain 50 p.c or more of fats. Nuts with excessive amounts of proteins – Example groundnuts which include about 25 per cent proteins.
- Even almonds and pistachios contain around 20 per cent proteins. Most of the protein wealthy nuts comprise high amount of fat also. Nuts with high quantities of carbohydrates - Example chestnut contains about 50 per cent carbohydrates however it is tremendously negative in proteins and fats.
- Nuts include about 2 per cent minerals, with a exact proportion of phosphorous and potassium. Calcium, sodium, magnesium and iron are additionally existing in some nuts.
- They are now not precise sources of carbohydrates and roughage. Exception is Chestnut which has about 50 per cent carbohydrate.
- They include much less than 5 per cent of water. This only is the reason why they can be saved for long periods.
- They are exact sources of B-vitamins and groundnut is especially wealthy in thiamine and nicotinic acid.
- Some nuts are tremendous sources of vitamin E, like almonds.

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Uses of Nuts

- Most of the Nuts are eaten in the raw shape e.g. almonds, walnuts, groundnuts etc. To enhance flavor from time to time they are roasted, cooked, fried and salted. The amendment in the oil section of the nuts on cooking and roasting brings about change in flavor, making nuts more flavourful.
- They are used in coaching of range of Indian sweets like laddus, halwas and other sweetmeats.
- They are used to garnish a number of sweet & salty two preparations.
- They are used in the confectionery industry and are delivered in a variety of nut- chocolates.
- Nuts are brought to salads for taste as well as for dietary enhancement.
- They are used as ingredients for stuffing meat products.
- Nuts in the flour structure serve a range of functions in the kitchen for fee addition of quite a number of recipes.
- Nuts are cooked in sugar syrup and crystallized to put together chikkies.
- Nuts like coconut and groundnut are used for making chutneys and dips.
- Flavoured milk drinks are made out of nuts like pistachios & almonds.
- Pastes made out of nuts are used as thickeners for one-of-a-kind vegetable curries.
- Peanut Butter serves a pleasant dips and spreads for breads and bakery products.
- Oilseed desserts are used in weaning meals for infants, and in multipurpose food for the prone corporations to combat malnutrition.
- Oil extracted from quite a number nuts and oilseeds, serves as a medium of cooking.

Check Your Progress

5. Why was Protein Efficiency Ratio criticised?
6. Mention one nutritional value of nuts.

5.8 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. All the proteins are made up of amino acids.
2. The covalent linkage between two adjacent amino acids in a protein chain is called a peptide bond.

3. Three essential amino acids found in protein are Arginine, Histidine and Isoleucine.
4. Peanut proteins are used for their functional properties (emulsification, forming) or for their dietary houses in different food products.
5. A major criticism of the Protein Efficiency Ratio has been that it does not take into account the protein required for maintenance since only gain in weight is used in the calculation.
6. Nuts include about 2 per cent minerals, with an exact proportion of phosphorous and potassium.

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5.9 SUMMARY

- Pulses are a low-fat source of protein with excessive stages of protein and fibre.
- Studies have shown that human beings who eat at least ½ cup of pulses per day have greater intakes of fibre, protein, calcium, potassium, folate, zinc, iron, and magnesium as well as lower intakes of whole and saturated fat. Pulses are a necessary plant-based source of protein.
- All proteins are created from twenty exceptional amino acid constructing blocks. Nine of these amino acids cannot be produced via the body and are known as “essential” because they need to come from foods we eat.
- Soluble fibre can help control body weight, blood sugar levels and decrease cholesterol. Insoluble fibre on the other hand, assists with digestion and regularity.
- They also include resistant starch, a kind of carbohydrate that behaves like fibre in the body; and has been shown to have similar health benefits such as reduced circulating LDL cholesterol and blood sugar ranges as properly as well as improved intestine health.
- India is the biggest producer of pulses in the world.
- The predominant areas with high productiveness are Punjab, Haryana, Western Uttar Pradesh, West Bengal delta region, coastal Andhra Pradesh, Tamil Nadu, Kerala, coastal and Japanese Karnataka and some parts of Maharashtra.
- Proteins are very complex organic compounds. They are made up of carbon, hydrogen, oxygen and nitrogen (16 per cent).
- All the proteins are made up of **amino acids**. Thus, amino acids are the building blocks of proteins. The number, type, amount and arrangements of these amino acids cause variation in the types of proteins.

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- There are twenty different types of amino acids found in nature. The amino acids form a linear chain to form proteins. This chain is known as polypeptide chain.
- In nature about 300 types of amino acids are found of which 20 amino acids are found in proteins.
- All the amino acids are required by the body, but some are known as indispensable nutritionally essential amino acids, as these cannot be synthesized by the body.
- There are ten essential amino acids for human beings. These include Arginine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Threonine, Tryptophan and Valine.
- Both best and extent of protein consumption in infancy and childhood are of pastime with regard to later danger of non-communicable illnesses (NCDs).
- The speculation that excessive protein in infants' diet stimulates growth and at the same time as increases the probability of obese and weight problems later in existence used to be first proposed in 1995 by way of Rolland-Cachera et al.
- Proteins that are utilised in meals processing are of a variety of origins and can roughly be categorized into animal proteins (gelatins), vegetable proteins (e.g. peanut protein, soy protein, wheat proteins, Almond protein, canola meal protein etc.), and animal derived protein (e.g. milk proteins).
- Whey is the liquid derivative of cheese which can further be processed into a spray dried product like whey protein concentrates (WPC), whey protein isolate (WPI) or whey protein hydrolysate.
- Texturized vegetable protein is cholesterol free and used worldwide due to exceptional protein of plant source.
- Depending upon chemical composition of proteins and homes of individual constituent's legumes specifically soybean is treasured for manufacturing of texturized vegetable proteins mostly via extrusion process.
- Biological value, as defined by Thomas and Mitchell has long been considered the method of choice for estimating the nutritive value of proteins.

5.10 KEY WORDS

- **Vegetarian:** It refers to a person who does not eat meat or fish, and sometimes other animal products, especially for moral, religious, or health reasons.
- **Cholesterol:** It is a compound of the sterol type found in most body tissues.

- **Whey:** It is the watery part of milk that remains after the formation of curds.

5.11 SELF ASSESSMENT QUESTIONS AND EXERCISES

NOTES

Short Answer Questions

1. What do you know about sources and functions of proteins?
2. What are amino acids?
3. Write short notes on the following:
 - Net Protein Ration
 - Biological Value (BV)
4. What do you understand by Protein Efficiency Ratio?
5. State the nutritional value and uses of nuts and oilseeds.

Long Answer Questions

1. Explain the nutritive value of pulses in detail. Write a note on the composition of proteins.
2. Write a detailed note explaining protein foods for infants and children.
3. Discuss the various types of protein concentrates and isolates as given in the unit.
4. Describe the concept of texturized vegetable proteins.
5. What are the various types of soy products? Describe.

5.12 FURTHER READINGS

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UNIT 6 FRUITS AND VEGETABLES

NOTES

Structure

- 6.0 Introduction
- 6.1 Objectives
- 6.2 Nutritional Value and Composition of Fruits
 - 6.2.1 Classification of Fruits
- 6.3 Post-Harvest Technology of Fresh Fruits
- 6.4 Nutritional Value and Composition of Vegetables
 - 6.4.1 Classification of Vegetables
- 6.5 Post-Harvest Handling of Vegetables
- 6.6 Answers to Check Your Progress Questions
- 6.7 Summary
- 6.8 Key Words
- 6.9 Self Assessment Questions and Exercises
- 6.10 Further Readings

6.0 INTRODUCTION

Fruits are the edible, quite often juicy, product of a tree or plant and consist of mature ovary including seeds and adjacent parts. Fruits are processed in order to supply a wholesome, safe, nutritious and acceptable food to the consumers throughout the year. Besides that, it also aims in earning foreign currency by exporting various fruits and their products like squashes, jams, jellies etc. This in turn increases both rural and urban employment. Processing of fruits reduces losses and makes the fruits available during off-season as well. It generates new sources of income for the farmers and artisans. New value-added products are being introduced by the processing of fruits.

Vegetables are one of the most essential commodities of the Indian diet as they serve the main course of the meal. They have high nutritive value. They are used for bringing variety to the meal. This is possible because they provide wide range of color, flavour and texture to the food. Thus, they can enhance the appearance of the meal if cooked and processed in a suitable way.

6.1 OBJECTIVES

After going through this unit, you will be able to:

- Explain the nutrient composition of fruits and vegetables
- Discuss pigments, changes in colour and flavour of fruits and vegetables
- Describe enzymatic and non-enzymatic changes
- Analyse post-harvest handling of fruits and vegetables

6.2 NUTRITIONAL VALUE AND COMPOSITION OF FRUITS

Nutrient composition of tropical fruits

Water

- Water plays a vital role in the evolution and reproduction cycle and in physiological processes.
- It has effects on the storage period length and on the consumption of tissue reserve substances.
- The normal water content in fruits ranges from 80 to 90%

Minerals

- Minerals in fruits are present as:
 - Salts of organic or inorganic acids
 - Complex organic combinations (chlorophyll, lecithin, etc.);
 - Dissolved in cellular juice.
- Fruits like strawberries, cherries, peaches and raspberries are rich in minerals.
- Fruits are high in potassium (K). They lack sodium chloride (NaCl) and because of this composition fruits are of therapeutic importance.
- Fruits like pears, lemons, oranges and some temperate climate mountain fruits and wild berries are of great significance as they have Ca/P ratio above 1.0.
- Apples are rich in iron.
- Fruits help in maintaining the acid-base equilibrium in the blood as they show basic reactions in the human body.

Carbohydrates

- Carbohydrates constitute about 90% of the dry matter of fruits.
- They are produced by the process of photosynthesis in green plants.
- They are the structural components of plants (cellulose); they may be stored as energy reserves (starch) in plants; they may function as essential components of nucleic acids as in the case of ribose; and as components of vitamins such as ribose and riboflavin.
- Pectins present in fruits helps to hold the cell walls tightly. It has a very important role in manufacture of jams and jellies as pectins in solution form gels when sugar and acid are added.
- Starch provides a reserve energy source in plants and supply energy in nutrition.

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- The sugars present in fruits are glucose, fructose, maltose and sucrose. They are very helpful in processing of fruits as they supply energy for nutrition. They are readily fermented by micro-organisms. Their high concentrations help to prevent the growth of micro-organisms and that is why they may be used as a preservative. Sugars, on heating, darken in colour (caramelization) and when they combine with proteins to give dark colours (Maillard reaction).

Fats

- Fruit contain very low level of fats, below 0.5%.
- Significant quantities are found in nuts (55%), apricot kernel (40%), grapes seeds (16%), apple seeds (20%) and tomato seeds (18%).
- Avocado contains maximum amounts of fats (25%).

Organic acids

- Fruit contains natural acids, such as:
 - i. Citric acid in oranges and lemons,
 - ii. Malic acid of apples,
 - iii. Tartaric acid of grapes.
- These acids give the fruits tartness and slow down bacterial spoilage.
- Apple juice is fermented to produce alcohol and vinegar.
- Color of fruits is also influenced by organic acids.
- The taste of fruits is determined by its acidity and presence of sugars.

Proteins

- Proteins have a colloidal structure.
- They are of great significance in the processing of fruits.
- Proteins, amines, amides, nitrates and other nitrogen containing substances are present in amounts less than 1% in case of fruits.
- Avocado contains more proteins as compared to other fruits.

Vitamins

Beta-carotene:

- Plants do not contain vitamin A; they contain beta-carotene which is a precursor of vitamin A. Beta-carotene is converted to vitamin A in human body.
- Beta-carotene is found in the orange and yellow fruits.
- A deficiency of vitamin A leads to night blindness, failure of normal bone and tooth development in the young and diseases of epithelial cells and membrane of the nose, throat and eyes which decrease the body's resistance to infection.

Vitamin C

- The deficiency of vitamin C leads to scurvy.
- It is also known as ascorbic acid.
- Citrus fruits are excellent sources of this vitamin.

Enzymes

- They are the biological catalysts that play following roles in fruits processing and storage:
 - i. They control reactions associated with ripening in the living fruits.
 - ii. After harvest, unless destroyed by heat, chemicals or some other means, enzymes continue the ripening process, in many cases to the point of spoilage - such as soft melons or overripe bananas.
 - iii. They are responsible for changes in flavour, colour, texture and nutritional properties of fruits.
 - iv. They are inactivated by heating the fruits during their processing in order to improve the storage ability of fruits.
- In fruit storage and processing the most important roles are played by the enzymes classes of hydrolases (lipase, invertase, tannase, chlorophylase, amylase, cellulase) and oxidoreductases (peroxidase, tyrosinase, catalase, ascorbinase, polyphenoloxidase).

Phytochemicals

Phytochemicals are non-nutritive or nutritive, biologically active compounds present in edible natural foods including fruits, vegetables, grains, nuts, seeds and tea. They can prevent or delay the onset or continuation of chronic diseases in humans and animals.

Factors responsible for the turgidity and texture of fruits:

- The osmotic pressures in the cell vacuoles and protoplasts in greatly responsible for the turgidity of the cells.
- The cell vacuoles contain most of the water in plant cells and sugars, acids, salts, amino acids, some water-soluble pigments and vitamins, and other low molecular weight constituents are dissolved in this water. This helps in maintaining the turgidity of the fruit cells.
- Presence of cellulose, hemicellulose and lignin affects the texture of fruits. Cell walls in young plants are very thin and are composed largely of cellulose. As the plant ages cell walls tend to thicken and become higher in hemicellulose and in lignin. These materials are fibrous and tough and are not significantly softened by cooking.
- The cement-like substance found in the middle lamella which helps hold plant cells to one another is a water-insoluble pectic substance. Pectin has an important role in maintaining the texture of fruits.

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- On hydrolysis, pectin forms water-soluble pectin. This water soluble form can form gels with sugar and acid.

Pigments

- The pigments are classified into four major groups which include the chlorophylls, carotenoids, anthocyanins, and anthoxanthins. Pigments belonging to the latter two groups also are referred to as flavonoids and include the tannins.
- The important carotenoids include the orange carotenes of carrot, apricot, peach, citrus fruits, and squash; the red lycopene of watermelon, and apricot; the yellow-orange xanthophyll of peach, and squash.
- One molecule of orange beta-carotene is converted to two molecules of vitamin A.
- The flavonoids include the purple, blue, and red anthocyanins of grapes, berries, and cherry; the yellow anthoxanthins of light coloured fruit and vegetables such as apple, and the colourless catechins and leucoanthocyanins which are food tannins and are found in apples and grapes.

6.2.1 Classification of Fruits

Let us analyse the classification of fruits.

Berries:

- Pericarp is pulpous, juicy, homogenous and present in layers, but the outermost skin is not homogenous. Seeds are embedded in the pulp. Improper handling and freezing may damage the fruit as berries are fragile. High in citric, malic and benzoic acid. High in pectin. Highly acceptable color and flavor. Dessert fruits
- Used in preparation of jams, jellies and various baked products (for e.g., pies)
- For e.g., strawberry, currants, blackberry, raspberry, blueberry, cranberry etc.

Citrus fruits: Belong to genus *Citrus*. Most of the species cultivated in India. Brightly coloured and have pleasant flavour. Served as juices or slices. They contain sugar and acids large proportion. Rich in vitamin C. They are commercial source of pectin and citrus marmalades. Pectin is present in the albedo (the white portion of the skin of these fruits). Essential oils are present in flowers and leaves of the plants and skin of the fruits which is used in perfumery. These fruits were initially the source of citric acid which is now produced microbiologically. For e.g., sweet orange, tangerine, sour orange, lime, lemon, pummelo, grapefruit, citron etc.

Grapes: *Vitis vinifera* is the main source of cultivated grapes. Some of the commercially grown grapes in India are Anab-e-shahi, Bangalore blue, Bhokri, Gulabi etc. The size and composition of fruit depends on the method of cultivation and the variety of the plant. The grapes of European variety (the wine grapes) are elongated, skin and flesh are tender. The grapes of American variety have tough

skin and flesh. The Indian variety grapes that are small in size are known as Kishmish whereas those with the largest berries are known as Anab-e-shahi. The outermost layer (epidermis) is covered with a layer of wax. The color, flavour and aroma of the grapes are dependent on the components of the skin. Pulp contains juice. The fruit may have four seeds or two seeds or it may be seedless. The seedless varieties are used in the preparation of raisins. Grapes are rich in glucose and fructose. They have low pectin content. They are poor in protein but free amino acids are present. The high nitrogen content of grapes is due to the presence of amino acids. This serves as a favourable growth medium for yeasts during the fermentation of grape juice. Grapes are rich in tartaric and malic acids. Low in citric acid. The green colour of the immature grapes is due to chlorophyll that fades away on ripening. The yellow color is due flavone components. Anthocyanins are responsible for the red, blue, purple and black color of the grapes. Poor sources of vitamins. Grapes are used in the preparation of wine and brandy. Raisins are dried products of grapes. Fresh grapes, especially having large size, thin shape and bright color, are used as table fruit. Grapes and grape juice are also canned.

Melons: They belong to the family *Cucurbitaceae*. The flesh contains water (94%) and sugars (5%). Seeds yield edible oil. For e.g., melons, water melon etc.

Tropical and Sub-tropical fruits: These fruits include Indian gooseberry or amla, butter fruit or avocado, banana, carambola, dates, guavas, jackfruit, jambu fruit, mango, papaya, passion fruit, pineapple, pomegranate, sapota, seetaphal, figs, litchi, wood apple bael etc. Amla is the richest known source of vitamin C. it has medicinal uses. Avocado contains more proteins than any other fruit. The fat content in avocado is 25%. Bananas have high starch and low sugar content. They are not ripened on the plant but they are ripened after harvesting by smoking or heating in closed chambers at a temperature of about 18 to 20 degree C. They cannot be refrigerated. Bananas are used in the preparation of Indian confectionaries, jams, jellies etc. Dates or khajur are high in sugar, vitamin A, B1 and B2 and nicotinic acid. 'Nira' is obtained from the palm tree which is used as beverage. It can be fermented to prepare toddy. Guavas are used as table fruit. It is used in the preparation of jams and jellies. Guava juice is used as a beverage. They are rich in vitamin C. Mangoes are rich in sugar, Vitamin A, B and C. they are used as table fruit. They are used in the preparation of juice and squash, jams, jellies, preserves, shakes etc. Papaya is a commercial source of enzyme pappain which is used for tenderizing meat. Pineapples are rich in vitamin A and C.

Spoilage of fruits:

The following changes occur during spoilage and deterioration of fruits:

Enzymic changes:

- The following deteriorative sign are observed due to enzymatic changes:
 - o post-harvest senescence and spoilage of fruits
 - o oxidation of phenolic substances in plant tissues by phenolase (leading to browning)

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- o Sugar - starch conversion in plant tissues by amylases
- o Post-harvest demethylation of pectic substances in plant tissues (leading to softening of plant tissues during ripening, and firming of plant tissues during processing).

Control:

- o The major factors useful in controlling enzyme activity are:
 - Temperature
 - Water activity
 - pH
 - chemicals which can inhibit enzyme action
 - Alteration of substrates
 - Alteration of products
 - Pre-processing control.

Chemical changes:

Sensory quality

- The two major chemical changes which occur during the processing and storage of foods and lead to a deterioration in sensory quality are as follows:
 - o Lipid oxidation
 - o Non-enzymatic browning.
- Chemical reactions are also responsible for changes in the colour and flavour of foods during processing and storage.
- **Lipid oxidation rate** and course of reaction is influenced by:
 - o Light
 - o Local oxygen concentration
 - o High temperature
 - o Presence of catalysts like iron and copper
 - o Water activity.

Control

- o If the aforementioned factors are controlled, then lipid oxidation can be reduced.
- **Non-enzymatic browning** is one of the major causes of deterioration which occurs during storage of dried and concentrated foods.

Changes in color

- Food processing or storage causes some deterioration of the chlorophyll pigments. Phenophytinisation (with consequent formation of a dull olivebrown phenophytin) is the major change; this reaction is accelerated by heat and is acid catalysed.

- The rate of anthocyanin destruction is pH dependent, being greater at higher pH values. Some anthocyanins form complexes with metals such as Al, Fe, Cu and Sn during packaging. For example, red sour cherries react with tin to form a purple complex and making it undesirable.
- The carotenoid pigments may auto-oxidise by reaction with atmospheric oxygen at rates dependent on light, heat and the presence of pro- and antioxidants.

Changes in Flavour:

- The enzymically generated compounds derived from long-chain fatty acids play an extremely important role in the formation of characteristic flavours in case of fruits.
- These types of reactions can even lead to development of off-flavours.
- The characteristic aromas developed during the ripening of fruits and disrupted tissues are due to enzyme-induced oxidative breakdown of unsaturated fatty acids.

Nutritional quality

- The following factors are responsible for degradation of nutrients:
 - o Light
 - o Oxygen
 - o Temperature
 - o Water activity
- Ascorbic acid is the most sensitive nutrient present in fruits. Its stability is affected by the following factors:
 - o pH
 - o oxygen
 - o presence of metal ions
 - o nature of packaging material used
- Problems of ascorbic acid instability have been observed in aseptically packaged fruit juices. This is because of the oxygen permeability of the package and the oxygen dependence of the ascorbic acid degradation reaction.
- The citrus juices packaged in cans with a tin contact surface exhibit greater stability of ascorbic acid than those in enamelled cans or glass containers because of the preferential oxidation of metallic tin.
- The aerobic and anaerobic degradation reactions of ascorbic acid in reduced-moisture foods have been shown to be highly sensitive to water activity, the reaction rate increasing in an exponential fashion over the water activity range of 0.1-0.8.

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Processing of fruits

- It is important to note that the fruits that are to be processed are accepted by the consumers in its processed form.
- Moreover, there should be regular supply of the raw materials as well as the raw materials that are used should be able to withstand the processing treatments such as high temperature and pressure.
- A processing unit processes four or five types of fruits harvested at different times of the year.
- The processing unit must also be capable of handling dried/dehydrated finished products, juices, pickles, jams, jellies and marmalades, semi-processed fruit products.
- The location of the processing plant should be such that it minimizes the average production cost along with transportation and handling. Another important aspect is to choose the location of the plant where a regular supply of fresh raw materials can be maintained.

6.3 POST-HARVEST TECHNOLOGY OF FRESH FRUITS

Let us analyse the post-harvest technology of fresh fruits.

- **Harvest maturity**
 - o This is particularly important with fruit for export.
 - o The measurement of resonant frequency of the fruit enables the grading out of over mature and under-mature fruit before they are packed for export.
- **Harvest method**
 - o Various methods of mechanical harvesting of perishable crops are being practiced in order to minimizing damage.
 - o In fruit trees, controlling their height by use of dwarfing rootstocks, pruning and growth regulating chemicals will lead to easier, cheaper more accurate harvesting.
- **Handling systems**
 - o Field packing of various tropical fruits for export has been carried out for many years.
 - o This system has considerable economic advantages in saving the cost of building, labour and equipment and can result in lower levels of damage into crops.
- **Pre-cooling**
 - o High velocity, high humidity forced air systems are used in crop pre-cooling.

- o These methods are suitable for all types of fruits.
- o These are relatively simple to build and operate and, while not providing the speed of cooling of a vacuum or hydrocooler, have the flexibility to be used with almost all crops.
- **Chemicals**
 - o Now days, the use of chemicals in agriculture and particularly during the post-harvest period is strongly protested.
 - o Researches are carried out to develop new ways to control post-harvest diseases, pest and sprouting.
- **Coatings**
 - o The metabolism of fruit and vegetables is lowered by coating them with a material which affects their gaseous exchange.
- **Controlled environment transport**
 - o Recent innovations in this technique have produced great progress as a result of the development and miniaturization of equipment to measure carbon dioxide and oxygen.

Preservation of fruits by dehydration/drying and concentration:

This is one of the oldest methods of preservation of fruits. Drying removes moisture from the fruits and thereby inhibits the microbial growth. This method not only prevents microbial growth but also reduces the weight and volume of the fruit and thereby facilitates its transportation and storage.

- **Role of water and water activity (a_w):**
 - o Microorganisms require water or available moisture present in food for their optimal growth. The water activity affects the growth and multiplication of microbial cells.
 - o Bacteria and yeasts require more moisture as compared to molds.
 - o At the usual temperatures permitting microbial growth, most bacteria require a water activity in the range of about 0.90 to 1.00.
 - o Some yeasts and moulds grow slowly at a water activity down to as low as about 0.65.
- **Role of heat:**
 - o Dehydration involves the application of heat to vaporise water. Thus, water vapour after its separation from the fruit tissues is vaporized.
 - o Thus, dehydration involves a combined and simultaneous (heat and mass) transfer operation for which energy must be supplied.
 - o The transfer of heat via air and convection methods is involved to dry tissue.
 - o The mass transfer involves the transfer of water to the surface of material being dried and the removal of water vapour from the surface.

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- o In order to assure products of high quality at a reasonable cost, dehydration must occur fairly rapidly.
- o Dehydration is affected by the particle size of the fruits, properties of drying air and medium and the characteristics of the drying equipment.
- **Surface area**
 - o Generally, the fruit to be dehydrated is cut into small pieces or thin layers to speed heat and mass transfer.
 - o This method accelerates drying.
 - o Cutting of fruits increases the surface area. The large surface areas provide more surface in contact with the heating medium (air) and more surface from which moisture can escape.
 - o The smaller particles or thinner layers reduce the distance heat must travel to the centre of the food and reduce the distance through which moisture in the centre of the food must travel to reach the surface and escape.
- **Temperature**
 - o The rate of heat of heat transfer will be greater if the temperature difference between the heating medium and the food is more.
 - o This provides the driving force for moisture removal.
 - o When the heating medium is air, temperature has a very important role.
 - o The water vapour produced, if not removed immediately, may saturate the surrounding air near the food and may slow down the rate of subsequent water removal. The hotter the air the more moisture it will hold before becoming saturated.
- **Air velocity**
 - o The high velocity air in motion takes up moisture and sweeps it away from the drying food's surface and consequently prevents the moisture from creating a saturated atmosphere which would slow down subsequent moisture removal.
- **Dryness of air**
 - o It has been observed that, the drier the air (medium) the more rapid is the rate of drying because dry air is capable of absorbing and holding moisture as compared to moist air.
- **Atmospheric pressure and vacuum**
 - o If food is placed in a heated vacuum chamber the moisture can be removed from the food at a lower temperature than without a vacuum.

- **Evaporation and temperature**
 - o The evaporation of water resulting in the cooling of the surface of food because of absorption by the water of the latent heat of phase change from liquid to gas.
 - o In this process, heat is taken from the drying air or the heating surface and from the hot food, resulting in cooling of food.
- **Time and temperature**
 - o We have seen that all important methods of food dehydration employ heat. It is also noted that food constituents are sensitive to heat. That is why, it should be kept in mind that the quality of the food to be dehydrated should be maintained along with maximum possible drying rate.
 - o For e.g., in case of pasteurization (UHT) and sterilisation, high temperatures for short times are employed that do less damage to food than drying processes employing lower temperatures for longer times.

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Check Your Progress

1. State one role of enzymes.
2. What are phytochemicals?

6.4 NUTRITIONAL VALUE AND COMPOSITION OF VEGETABLES

- Vegetables differ widely in their composition.
- The vegetables have very high-water content, especially the green leafy vegetables. The water content affects the cooking of the vegetables and its acceptability.
- Leguminous vegetables are high in proteins whereas all the other classes of vegetables are low in proteins.
- Cellulose, starch and sugars are the principal carbohydrates present in vegetables.
- Potatoes and tapioca are high in starch.
- Pectin is also present.
- Volatile acids, like citric, malic, oxalic and succinic acids, that contribute flavour to the vegetables, are present.
- Presence of sulphur-containing compounds in vegetables like onion, garlic, cauliflower etc., give characteristic string flavour to these vegetables.

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- Green leafy vegetables contain chlorophyll whereas yellow and orange vegetables such as carrots, tomatoes etc. have carotenoids and vegetables such as radishes and red cabbage have flavonoids.
- When the plant cells are killed by ageing, processing, or cooking, the protein of these complexes is denatured, and the chlorophyll may be released. Such chlorophyll is highly unstable and rapidly changes in colour to olive green and brown. This colour change is believed to be due to the conversion of chlorophyll to the compound pheophytin.
- Conversion to pheophytin is favoured by acid pH but does not occur readily under alkaline conditions.
- That is why, peas, beans, spinach, and other green vegetables which tend to lose their bright green colours on heating can be largely protected against such colour changes by the addition of sodium bicarbonate or other alkali to the cooking or canning water.
- It is important to note that; alkaline pH also has a softening effect on cellulose and vegetable texture and also destroys vitamin C and thiamin at cooking temperatures.
- In food processing the carotenoids are fairly resistant to heat, changes in pH, and water leaching since they are fat-soluble. They are very sensitive to oxidation, which results in both colour loss and destruction of vitamin A.
- The anthocyanins include a shifting of colours with pH. Many of the anthocyanins which are violet or blue in alkaline media become red upon addition of acid.
- Cooking of beets with vinegar tends to shift the colour from a purplish red to a brighter red, while the effect of alkaline water changes the colour of red fruits and vegetables toward violet and gray-blue.
- The anthocyanins form the violet and blue hues when they react with metal ions. This results in lacquering inside the metal cans when the true colour of anthocyanin-containing fruits and vegetables is to be preserved.
- The water-soluble property of anthocyanins also results in easy leaching of these pigments from cut fruit and vegetables during processing and cooking.
- The yellow anthoxanthins also are pH sensitive tending toward a deeper yellow in alkaline media.
- Thus, potatoes become somewhat yellow when cooked in water with a pH of 8 or higher. Acidification of the water to pH 6 or lower favours a whiter colour.

Nutritive value of vegetables

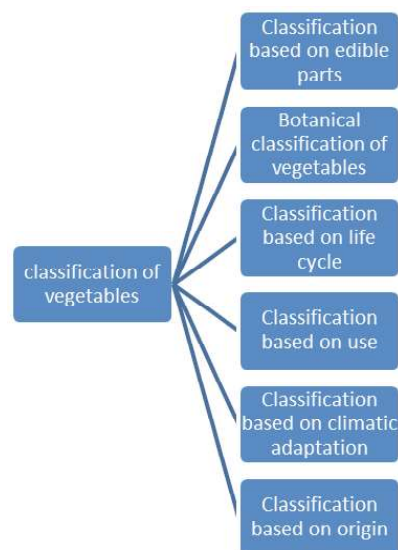
- Vegetables contribute indigestible fiber, minerals and vitamins to the diet. Most vegetables are low in calories, except for those that contain starch for e.g. potatoes. They are low in fat content also.
- Vegetables contain large quantities of water. Water plays a vital role in the evolution and reproduction cycle and in physiological processes such as bound water or dilution water which is present in the cell and forms true solutions with mineral or organic substances; colloidal bound water which is present in the membrane, cytoplasm and nucleus and acts as a swelling agent for these colloidal structure substances; it is very difficult to remove during drying/dehydration processes and constitution water, directly bound on the chemical component molecules and which is also removed with difficulty. Vegetables contain generally 90-96% water.
- Vegetables are richer in minerals as compared to fruits. The mineral content ranges from 0.60 to 1.80%. Some of the major elements are: K, Na, Ca, Mg, Fe, Mn, Al, P, Cl, S. they are more commonly found in spinach, carrots, cabbage and tomatoes. Vegetables are good source of phosphorus. Vegetables usually contain more calcium than fruit; green beans, cabbage, onions and beans contain more than 0.1% calcium. The calcium/phosphorus or Ca/P ratio is essential for calcium fixation in the human body; this value is considered normal at 0.7 for adults and at 1.0 for children. Vegetables contain between 1.0 and 5.5% while in fruit nitrogen-containing substances are less than 1% in most cases.
- Vegetables are low in proteins; except for the leguminous vegetables. The proteins provided by the leguminous vegetables are incomplete. The proteins present in vegetables have a colloidal structure and, by heating, their water solution above 50°C they become insoluble. This nature of proteins is kept in mind during the heat processing of the vegetables. Plants contain no vitamin A but contain its precursor, beta-carotene.
- Beta-carotene is found in the orange and yellow vegetables as well as the green leafy vegetables, mainly carrots, squash, sweet potatoes, spinach and kale. Potatoes also are a fair source (although the content of vitamin C is relatively low) because we consume large quantities of potatoes. If freshly prepared tomato juice or paste is allowed to stand the original viscosity gradually decreases due to the action of pectin methyl esterase (which is present naturally in vegetables) on pectin gel. This can be prevented if the tomato products are quickly heated to a temperature of about 82°C (180 F°) to deactivate the pectin methyl esterase liberated from broken cells before it has a chance to hydrolyze the pectin. Such a treatment is commonly practiced in the manufacture of tomato juice products. This is known as the “hot-break process” and yields products of high viscosity.

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6.4.1 Classification of Vegetables

Vegetables can be classified on the following basis:

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Root vegetables

- The members of this group include carrots, parsnip, radish, turnip, beetroot etc.
- Carrots are rich source of beta carotene; which is maximum in orange carrots.
- Carrots have high sugar content.
- Carrots are consumed both raw and cooked. They are used in the preparation of *halwa* which is the most acceptable dessert in winters.
- Carrots are also used in preserves and pickles. Carrot juice is a refreshing beverage.
- Pickled carrots and turnips are produced in Asia and Africa. They are known as hua-chai po in Thailand and tai tan tsoi in China.
- Parsnip is not widely used in our country.
- Parsnip has a quantity of sugar and starch. It is used in the preparation of parsnip wine.
- Radishes can be of varied color and shapes.
- Radishes are characterized by their pungent smell.
- Radishes are commonly used as salads. Leaves can be used after boiling.

Tuber vegetables

- They are rich in carbohydrates.
- For e.g., potato, sweet potato, tapioca, yams, colocasia, arrowroot etc.
- Potato is cultivated throughout India. It is perennial herb.

- Potatoes have high water and starch content.
- Potatoes are consumed boiled, steamed, fried, baked, roasted, and in soups, stews and fries.
- A number of products like potato chips, dehydrated mashed potatoes, frozen French fries, potato fries, potato starch, dextrose etc can be processed from potatoes.
- Sweet potatoes are rich in vitamin A.
- Sweet potatoes have high nutritive value because of their high starch content.
- The sweet taste of sweet potato is attributed to the free sugar present in it.

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Cucurbits

- Cucurbits are tender crops of summers having plenty of water.
- The examples of this class of vegetables are cucumber, pumpkin, squashes, gourds etc.
- Cucumbers are rich in fiber and water. They are eaten raw and used on salads and sandwiches and pickles.
- The seed kernels of cucumbers are used in confectionery.
- Pumpkins are used after cooking. They are also used in the preparation of pumpkin pie.
- The seeds of pumpkin are rich in fats and proteins. They can be deep fried for consumption.
- The pumpkin seeds are used for extracting edible oil.
- Squashes have two varieties, viz. summer squash and winter squash.
- Winter squashes contain less water, more proteins, fats, carbohydrates and vitamin A than summer squashes.
- Immature summer squashes are consumed after boiling, whereas, winter squashes are consumed when they are mature.
- Gourds are of following types:
 - o Ridged gourd or ribbed gourd
 - o Bitter gourd
 - o Sponge gourd
 - o Snake gourd
 - o Ash or white gourd
 - o Bottle gourd

Stem vegetables

- The examples of this group of vegetables are Asparagus, bamboo shoots, rhubarb, artichoke etc.

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- The young shoots of asparagus are used in soups or poached in water and served with butter.
- The tender shoots of bamboo are soaked in water, boiled, and used in curries. They are also in making pickles.
- The leaf stalks of rhubarb are eaten either raw or boiled and sprinkled with salt and pepper. It can also be used as a fruit or stewed with sugar, in pies and preserves. It is also used in home-made wines. It is also used in medicines. The leaves are rich in oxalic acid.
- The young flower heads of or chokes with numerous large scales or bracts are used as vegetables. The heads of the flower are consumed raw or they can also be baked, fried, boiled, stuffed or served with sauces or dressings.
- *Naw-mai-dong* is a preparation of pickled bamboo shoots (*Bambusa glaucescens*) from Thailand.

Leafy vegetables

- The green leafy vegetables are rich in fibre, vitamins and minerals.
- For e.g., agathi, amaranth, beet green, celery, curry leaves, fenugreek, Indian spinach, lettuce, parsley, purslane, sowa, spinach etc.
- Tender leaves, pods and flowers of agathi are eaten as vegetables. The leaves are excellent source of vitamin C and calcium. The proteins are of high quality with good digestibility and biological value. The flowers are also edible and sweetish in taste and also good sources of thiamine, nicotinic acid and vitamin C.
- The tender shoots of vegetables of amaranth are used as vegetables.
- The leaves and stalk of beet greens are used as vegetables.

Bulbs

- The most common bulbs are onion, garlic and leek.
- Onion is used as salad, spice and also cooked as other vegetables. The presences of volatile sulphur compounds (cysteine sulphoxide derivatives) are responsible for its characteristic pungent flavor.
- Onions and garlic of different types are grown worldwide for the flavour they contribute to food. They are also commonly regarded as having medicinal properties.

Fruit vegetables

- The examples of this group are tomatoes, Bell pepper, egg plant, okra, chow-chow etc.
- The unripe green tomatoes are used as vegetable and are used in the preparation of wide range of dishes.
- The ripe fruits of tomatoes have color, flavour and appearance of high acceptability. They are used in salads.

- Tomatoes can be fried, baked and stuffed. They can be used in the preparation of soups, sauces and ketchups. They can also be pureed. They can also be canned. Tomato juice is a refreshing beverage.
- Different varieties of tomatoes like cherry tomato, pear tomato, tree tomato etc. are cultivated for their varied properties and are of great significance in culinary uses.
- Bell pepper or green pepper or capsicum is used as salad and vegetables when green and unripe. The ripe fruits are red, yellow and brown. Capsicum has a pungent flavour. They are also as spice.

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Cole crops

- The examples of this group are cabbage, cauliflower, broccoli etc.
- Cabbage is used in curries, pickles etc. it is used raw as an ingredient of salad. It is used in the preparation of 'cole slaw' and sauerkraut.
- Red cabbage is used for pickling. Chinese cabbage is consumed as salad.
- Knol-khol is consumed as boiled vegetable.
- Brussels sprout are consumed as vegetable. They can be subjected to quick freezing and canning.
- The flower heads of cauliflower are used in curries, pickles, soups etc.
- **Sauerkraut:** Lactic acid bacteria are the primary group of organisms involved in sauerkraut fermentation. In addition to the desirable bacteria there are a range of undesirable micro-organisms present on cabbage (and other vegetable material) which can interfere with the sauerkraut process if allowed to multiply unchecked.
- **Soft kraut** can result from many conditions such as large amounts of air, poor salting procedure and varying temperatures.
- **Pink kraut** is a spoilage problem. It is caused by a group of yeasts which produce an intense red pigment in the juice and on the surface of the cabbage.
- **Kimchi (pickled cabbage)** is the most important processed food product in Korea. It is an essential dish, eaten at most mealtimes.

6.5 POST-HARVEST HANDLING OF VEGETABLES

Let us analyse how vegetables are handled post-harvest.

Curing

- Roots, tubers and bulbs are cured for extending their shelf life.
- This process involves of high temperatures and high relative humidity to the roots and tubers for long periods, in order to heal the skins wounded during harvesting.

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- A new protective layer of cells is formed in this process.
- Curing can be accomplished in the field or in curing structures conditioned for that purpose.
- Commodities such as yams can be cured in the field by piling them in a partially shaded area.
- Canvas, burlap, or woven grass matting serve as insulating material and therefore increases the heat to reach high temperatures and high relative humidity.
- This stack is kept for three to four days.
- Onions and garlic can be cured in the field in windrows or after being packed into large fibre or net sacks.
- Now days, fans and heaters are installed to produce the heat necessary for high temperatures and high relative humidity.

Cleaning

- The chemical treatments such as spraying of insecticides and pesticides in the field should be removed as they are poisonous to human beings.
- The vegetables are passed over rotary brushes where they are rotated and transported to the washing machine and exposed to the cleaning process from all sides.
- From the washing machine, the vegetables are passed onto a set of rotary sponge rollers (similar to the rotary brushes).
- The rotary sponges remove most of the water as it is rotated and transported through the sponger.

Disinfection

- After washing vegetables, disinfectant agents are added to the soaking tank to avoid propagation of diseases among consecutive batches of vegetables to be produced.
- Low concentrations of chlorine solution are also used as disinfectant for many vegetables.
- The advantage of this solution is that it does not leave a chemical residue on the product.

Artificial waxing

- Artificial wax is applied to produce to replace the natural wax lost during washing of vegetables.
- This adds a bright sheen to the product.
- The function of artificial waxing of vegetables are described below:
 - o Provides a protective coating over entire surface.
 - o Seals small cracks and dents in the rind or skin.

- o Seals off stem scars or base of petiole.
- o Reduces moisture loss.
- o Permits natural respiration.
- o Extends shelf life.
- o Enhances sales appeal.

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Packaging

- According to Wills et al. (1989), modern packaging must comply with the following requirements:
- The package must have sufficient mechanical strength to protect the contents during handling, transport, and stacking.
- The packaging material must be free of chemical substances that could transfer to the produce and become toxic to man.
- The package must meet handling and marketing requirements in terms of weight, size, and shape.
- The package should allow rapid cooling of the contents.
- Mechanical strength of the package should be largely unaffected by moisture content (when wet) or high humidity conditions.
- The security of the package or ease of opening and closing might be important in some marketing situations.
- The package must either exclude light or be transparent.
- The package should be appropriate for retail presentations.
- The package should be designed for ease of disposal, re-use, or recycling.
- Cost of the package in relation to value and the extent of contents protection required should be as low as possible.

Cooling

- Cooling is used to extend the shelf life of vegetables and maintain the freshness of vegetables.
- The following methods of cooling available:
 - o Pre-cooling
 - o Air pre-cooling
 - o Icing
 - o Room cooling
 - o Forced air cooling
 - o Hydro-cooling
 - o Vacuum cooling
- A combination of cooled air and water in the form of a mist called hydra air cooling is an innovation in cooling of vegetables.

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- Ice is commonly added to boxes of produce by placing a layer of crushed ice directly on the top of the crop. Ice slurry can be applied in the following proportion to lower the melting point:
 - 60% finely crushed ice
 - 40% water
 - 0.1% sodium chloride
- The water to ice ratio may vary from 1:1 to 1:4.
- This method involves placing the crop in cold storage. The type of room used may vary, but generally consists of a refrigeration unit in which cold air is passed through a fan.
- The circulation may be such that air is blown across the top of the room and falls through the crop by convection.
- The principle of forced air cooling is to place the crop into a room where cold air is directed through the crop after flowing over various refrigerated metal coils or pipes.
- Forced air-cooling systems blow air at a high velocity leading to desiccation of the crop.
- To minimize this effect, various methods of humidifying the cooling air have been designed such as blowing the air through cold water sprays.
- In hydro-cooling, the transmission of heat from a solid to a liquid is faster than the transmission of heat from a solid to a gas. Therefore, cooling of crops with cooled water can occur quickly and results in zero loss of weight.
- To achieve high performance, the crop is submerged in cold water, which is constantly circulated through a heat exchanger.
- When crops are transported around the packhouse in water, the transport can incorporate a hydrocooler. This system has the advantage wherein the speed of the conveyer can be adjusted to the time required to cool the produce.
- Hydro-cooling has a further advantage over other precooling methods in that it can help clean the produce.
- Chlorinated water can be used to avoid spoilage of the crop.
- Hydro-cooling is commonly used for vegetables, such as asparagus, celery, sweet corn, radishes, and carrots, but it is seldom used for fruits.
- Cooling in this case is achieved with the latent heat of vaporization rather than conduction.
- Water boils at normal air pressure (760 mmHg). The boiling point of water is reduced as the air pressure reduces. Water boils at 0degree C at 4.6 mmHg.

- It has been observed that for every 5 or 6 degree C reduction in temperature, the crop loses about 1% of its weight (Barger, 1961).
- Spraying the vegetables with water either before enclosing it in the vacuum chamber or towards the end of the vacuum cooling operation can minimize this loss in weight (hydrovacuum cooling).
- The speed and effectiveness of cooling is related to the ratio between the mass of the crop and its surface area. This method is used for the processing of green leafy vegetables such as lettuce.
- Vegetables like tomatoes are not suitable for vacuum cooling as they have a thick wax cuticle.

Storage of vegetables

- The importance of factors such as mould growth and chilling injuries must be taken into account, as well as the required length of storage (Wills et al., 1989).
- Storage temperature for fruits and vegetables can range from -1 to 13 degree C, depending on their perishability.
- Highly perishable vegetables can be stored up to 4 weeks such as asparagus, beans, broccoli, and Brussels sprouts at -1-4 degree C for 1-4 weeks; cauliflower at 5-9 degree C for 2-4 weeks.
- Green tomato is less perishable and can be stored at 10 degree C for 3-6 weeks and non-perishable vegetables such as carrots, onions, potatoes and parsnips can be stored at 5-9 degree C for 12-28 weeks.
- Sweet potatoes can be stored at 10 degree C for 16-24 weeks.
- The storage life of produce is highly variable and related to the respiration rate; there is an inverse relation between respiration rate and storage life in that vegetable with low respiration generally keeps longer.
- The shelf life of most fresh vegetables can be extended by prompt storage in an environment that maintains product quality.
- The desired environment can be obtained in facilities where temperature, air circulation, relative humidity, and sometimes atmosphere composition can be controlled.
- Storage rooms can be grouped accordingly as those requiring refrigeration and those that do not.
- Storage rooms and methods not requiring refrigeration include: in situ, sand, coir, pits, clamps, windbreaks, cellars, barns, evaporative cooling, and night ventilation.

Factors affecting storage life

The natural limits to the post-harvest life of all types of fresh vegetables are severely affected by other biological and environmental conditions:

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- 1) **Temperature.** An increase in temperature causes an increase in the rate of natural breakdown of all produce as food reserves and water content become depleted. The cooling of produce will extend its life by slowing the rate of breakdown.
- 2) **Water loss.** High temperature and injuries to produce can greatly increase the loss of water from stored produce beyond that unavoidably lost from natural causes. Maximum storage life can be achieved by storing only undamaged produce at the lowest temperature tolerable by the crop.
- 3) **Mechanical damage.** Damage caused during harvesting and subsequent handling increases the rate of deterioration of produce and renders it liable to attacks by decay organisms. Mechanical damage to root crops will cause heavy losses owing to bacterial decay and must be remedied by curing the roots or tubers before storage.

Clamps. These are simple, inexpensive structures used to store root crops, particularly potatoes in Europe and Latin America. The potatoes are placed on a bed of straw 1 to 3 m wide, but not more than 1.5 m wide in warm climates. A ventilating duct should be placed along the bottom. The piled potatoes are covered with about 20 cm of compacted straw which can subsequently be encased in soil, applied without compaction up to 30 cm deep. The clamp system can be modified for different climatic conditions. In warm climates extra straw casing may be used instead of soil in order to give added ventilation.

Contamination

Fruits and vegetables are normally susceptible to infection by bacteria, fungi, and viruses. Microbial invasion of plant tissue can occur during various stages of fruit and vegetable development, and hence, to the extent that the tissues are invaded, the likelihood of spoilage is increased. A second factor contributing to the microbial contamination of fruits and vegetables pertains to their post-harvest handling. Mechanical handling is likely to produce breaks in the tissue which facilitates invasion by microorganisms. The pH range for vegetables is slightly higher as compared to fruits (5.0 to 7.0) and hence they are more susceptible than fruits to attack by bacteria.

Enzymic changes

Enzymes which are endogenous to plant tissues can have undesirable or desirable consequences. Examples involving endogenous enzymes include a) the post-harvest senescence and spoilage of fruit and vegetables; b) oxidation of phenolic substances in plant tissues by phenolase (leading to browning); c) sugar - starch conversion in plant tissues by amylases; d) post-harvest demethylation of pectic substances in plant tissues (leading to softening of plant tissues during ripening, and firming of plant tissues during processing).

The major factors useful in controlling enzyme activity are: temperature, water activity, pH, chemicals which can inhibit enzyme action, alteration of substrates, alteration of products and pre-processing control.

Chemical changes

Sensory quality

The two major chemical changes which occur during the processing and storage of foods and lead to a deterioration in sensory quality are lipid oxidation and non-enzymatic browning. Chemical reactions are also responsible for changes in the colour and flavour of foods during processing and storage.

Lipid oxidation rate and course of reaction is influenced by light, local oxygen concentration, high temperature, the presence of catalysts (generally transition metals such as iron and copper) and water activity. Control of these factors can significantly reduce the extent of lipid oxidation in foods.

Non-enzymic browning is one of the major causes of deterioration which occurs during storage of dried and concentrated foods. The non-enzymic browning, or Maillard reaction, can be divided into three stages: a) early Maillard reactions which are chemically well-defined steps without browning; b) advanced Maillard reactions which lead to the formation of volatile or soluble substances; and c) final Maillard reactions leading to insoluble brown polymers.

Colour changes

Chlorophylls. Almost any type of food processing or storage causes some deterioration of the chlorophyll pigments. Phenophytinisation (with consequent formation of a dull olivebrown phenophytin) is the major change; this reaction is accelerated by heat and is acid catalysed.

Other reactions are also possible. For example, dehydrated products such as green peas and beans packed in clear glass containers undergo photo-oxidation and loss of desirable colour.

Anthocyanins. These are a group of more than 150 reddish water-soluble pigments that are very widespread in the plant kingdom. The rate of anthocyanin destruction is pH dependent, being greater at higher pH values. Of interest from a packaging point of view is the ability of some anthocyanins to form complexes with metals such as Al, Fe, Cu and Sn.

These complexes generally result in a change in the colour of the pigment (for example, red sour cherries react with tin to form a purple complex) and are therefore undesirable. Since metal packaging materials such as cans could be sources of these metals, they are usually coated with special organic linings to avoid these undesirable reactions.

Carotenoids. The carotenoids are a group of mainly lipid soluble compounds responsible for many of the yellow and red colours of plant and animal products.

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The main cause of carotenoid degradation in foods is oxidation. The mechanism of oxidation in processed foods is complex and depends on many factors. The pigments may auto-oxidise by reaction with atmospheric oxygen at rates dependent on light, heat and the presence of pro- and antioxidants.

Flavour changes

In fruit and vegetables, enzymically generated compounds derived from long-chain fatty acids play an extremely important role in the formation of characteristic flavours. In addition, these types of reactions can lead to significant off-flavours. Enzyme-induced oxidative breakdown of unsaturated fatty acids occurs extensively in plant tissues and this yield characteristic aromas associated with some ripening fruits and disrupted tissues.

The permeability of packaging materials is of importance in retaining desirable volatile components within packages, or in permitting undesirable components to permeate through the package from the ambient atmosphere.

Nutritional quality

The four major factors which affect nutrient degradation and can be controlled to varying extents by packaging are light, oxygen concentration, temperature and water activity. However, because of the diverse nature of the various nutrients as well as the chemical heterogeneity within each class of compounds and the complex interactions of the above variables, generalizations about nutrient degradation in foods will inevitably be broad ones.

Vitamins. Ascorbic acid is the most sensitive vitamin in foods, its stability varying markedly as a function of environmental conditions such as pH and the concentration of trace metal ions and oxygen. The nature of the packaging material can significantly affect the stability of ascorbic acid in foods. The effectiveness of the material as a barrier to moisture and oxygen as well as the chemical nature of the surface exposed to the food are important factors.

For example, problems of ascorbic acid instability in aseptically packaged fruit juices have been encountered because of oxygen permeability of the package and the oxygen dependence of the ascorbic acid degradation reaction.

Also, because of the preferential oxidation of metallic tin, citrus juices packaged in cans with a tin contact surface exhibit greater stability of ascorbic acid than those in enamelled cans or glass containers. The aerobic and anaerobic degradation reactions of ascorbic acid in reduced-moisture foods have been shown to be highly sensitive to water activity, the reaction rate increasing in an exponential fashion over the water activity range of 0.1-0.8.

Physical changes

One major undesirable physical change in food powders is the absorption of moisture as a consequence of an inadequate barrier provided by the package; this

results in caking. It can occur either as a result of a poor selection of packaging material in the first place, or failure of the package integrity during storage. In general, moisture absorption is associated with increased cohesiveness.

Anti-caking agents are very fine powders of an inert chemical substance that are added to powders with much larger particle size in order to inhibit caking and improve flowability. Studies in onion powders showed that at ambient temperature, caking does not occur at water activities of less than about 0.4.

At higher activities, however, ($a_w > 0.45$) the observed time to caking is inversely proportional to water activity, and at these levels anti-caking agents are completely ineffective. It appears that while they reduce inter-particle attraction and interfere with the continuity of liquid bridges, they are unable to cover moisture sorption sites.

Check Your Progress

3. Name the principal carbohydrates present in vegetables.
4. What is *Naw-mai-dong*?

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6.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Enzymes control reactions associated with ripening in the living fruits.
2. Phytochemicals are non-nutritive or nutritive, biologically active compounds present in edible natural foods including fruits, vegetables, grains, nuts, seeds and tea.
3. Cellulose, starch and sugars are the principal carbohydrates present in vegetables.
4. *Naw-mai-dong* is a preparation of pickled bamboo shoots (*Bambusa glaucescens*) from Thailand.

6.7 SUMMARY

- Fruits are the edible, quite often juicy, product of a tree or plant and consist of mature ovary including seeds and adjacent parts.
- Fruits are processed in order to supply a wholesome, safe, nutritious and acceptable food to the consumers throughout the year.
- Vegetables are one of the most essential commodities of the Indian diet as they serve the main course of the meal. They have high nutritive value.
- Phytochemicals are non-nutritive or nutritive, biologically active compounds present in edible natural foods including fruits, vegetables, grains, nuts, seeds and tea.

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- The pigments are classified into four major groups which include the chlorophylls, carotenoids, anthocyanins, and anthoxanthins.
- The following deteriorative signs are observed due to enzymatic changes:
 - post-harvest senescence and spoilage of fruits
 - oxidation of phenolic substances in plant tissues by phenolase (leading to browning)
- The two major chemical changes which occur during the processing and storage of foods and lead to a deterioration in sensory quality are as follows:
 - Lipid oxidation
 - Non-enzymatic browning
- Non-enzymatic browning is one of the major causes of deterioration which occurs during storage of dried and concentrated foods.
- Food processing or storage causes some deterioration of the chlorophyll pigments. Phenophytinisation (with consequent formation of a dull olivebrown phenophytin) is the major change; this reaction is accelerated by heat and is acid catalysed.
- The enzymically generated compounds derived from long-chain fatty acids play an extremely important role in the formation of characteristic flavours in case of fruits.
- When the plant cells are killed by ageing, processing, or cooking, the protein of these complexes is denatured, and the chlorophyll may be released. Such chlorophyll is highly unstable and rapidly changes in colour to olive green and brown.
- Vegetables contribute indigestible fiber, minerals and vitamins to the diet. Most vegetables are low in calories, except for those that contain starch for e.g. potatoes.
- Enzymes which are endogenous to plant tissues can have undesirable or desirable consequences.
- Examples involving endogenous enzymes include a) the post-harvest senescence and spoilage of fruit and vegetables; b) oxidation of phenolic substances in plant tissues by phenolase (leading to browning).
- Non-enzymic browning is one of the major causes of deterioration which occurs during storage of dried and concentrated foods.
- In fruit and vegetables, enzymically generated compounds derived from long-chain fatty acids play an extremely important role in the formation of characteristic flavours.

6.8 KEY WORDS

- **Flavour:** It is the distinctive taste of a food or drink.
- **Oxidation:** It is a process in which a chemical substance changes because of the addition of oxygen.
- **Harvest:** It is the time of year when crops are cut and collected from the fields, or the activity of cutting and collecting them.

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6.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. Write short notes on the following:
 - Cole crops
 - Sauerkraut
2. What are enzymatic and non-enzymatic changes in fruits and vegetables?
3. What leads to spoilage of fruits?

Long Answer Questions

1. Discuss the composition of fruits in detail.
2. Classify fruits and vegetables giving suitable examples.
3. What are the various methods of fruit preservation? Describe any two methods in detail.
4. What products are obtained after the processing of fruits? Discuss any four products.
5. Discuss the composition and nutritive value of vegetables?
6. What do you understand by the post-harvest handling of vegetables? Discuss.
7. What are conditions required for the storage of vegetables? How is it different from or similar to fruits?

6.10 FURTHER READINGS

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UNIT 7 FLESH FOODS

Structure

- 7.0 Introduction
- 7.1 Objectives
- 7.2 Structure and Composition of Meat
- 7.3 Contamination and Spoilage of Meat
 - 7.3.1 Cooking of Meats
 - 7.3.2 Changes Produced during Cooking
- 7.4 Nutritive Value of Egg
 - 7.4.1 Structure of Egg
 - 7.4.2 Composition of Egg
 - 7.4.3 Egg Quality and Quality Deteriorating Factors
 - 7.4.4 Spoilage of Eggs
- 7.5 Effect of Heat on Egg Proteins
 - 7.5.1 Egg Foams
- 7.6 Answers to Check Your Progress Questions
- 7.7 Summary
- 7.8 Key Words
- 7.9 Self Assessment Questions and Exercises
- 7.10 Further Readings

NOTES

7.0 INTRODUCTION

Meat is referred to as the muscle of warm blooded terrestrial four legged animals. The meat used for human consumption includes meat from cattle, sheep and pigs. Glands and organs of these animals are also consumed. Meat is rich in almost all the nutrients. It is rich in proteins, vitamins and minerals. The proteins of meat are of high quality as they contain all the essential amino acids. The most common minerals present in meat are phosphorus, iron and copper. Liver is the centre for iron and copper. Amongst the minerals, riboflavin, niacin and vitamin A are found in meats in good amounts.

Eggs are the most important source for providing a highly nutritious diet. The eggs used in our diets are infertile. The knowledge of significance of eggs in our diets is increasing day by day. Eggs and their various preparations made from them are becoming popular. The high nutritive value of eggs is useful in supplementing inadequate diets. The protein found in eggs is of high biological value. Eggs are very good sources of lipids, proteins, vitamins and minerals. Vitamin D is also found in eggs.

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7.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the structure and composition of meat
- Explain the nutritive value of meat
- Analyse the spoilage and contamination of meat
- Describe the effect of heat on egg proteins
- Discuss the effect of heat on egg proteins

7.2 STRUCTURE AND COMPOSITION OF MEAT

Meat is defined as those animal tissues which are suitable for use as food. These are the main soft tissues of the carcass muscle, viz. skeletal tissue (30–65 percent), fatty tissue (10–45 percent) and connective tissues. Internal organs and blood is also consumed.

Structure of muscle tissue

The structural unit of muscle is a specialized cell known as the muscle fibre. The muscle fiber constitutes 72–92 percent of the muscle volume. The membrane surrounding the muscle fibre is called the sarcolemma and the intracellular substance is known as the sarcoplasm. The muscle fibre is composed of many myofibrils, which consist of thick and thin filaments (myofilaments). The muscle fibres give striated appearance under electron microscope because of the special arrangement of myofilaments and the bands of myofibrils. The filaments consist of following proteins: actin which is thin and constitutes about 20–25 percent; myosin which is thick and constitutes about 50–55 percent. The muscle proteins constitute about 7 percent of muscle weight. They are mainly responsible for water-holding capacity or WHC which is of great importance in meat processing.

Structure of connective tissue

Connective tissues are distributed throughout all body components -skeleton, skin, organs, fat, tendons and muscles. There are three kinds of connective tissue fibre: collagen, reticulin and elastin. Collagen constitutes 20–25 percent of total protein and has a major (negative) influence on meat tenderness. Skin (from pigs only) has excellent swelling and binding abilities owing to its high collagen content. It is therefore ideal for meat products such as emulsion-type cooked sausages provided it is properly scalded, completely dehaired, usually singed, scraped, washed and de-fatted.

Fatty tissues

Fatty tissues are found as Intramuscular fat (present in septa between muscle bundles); Intermuscular fat (in spaces between muscles) and Subcutaneous fat (between skin and muscles).

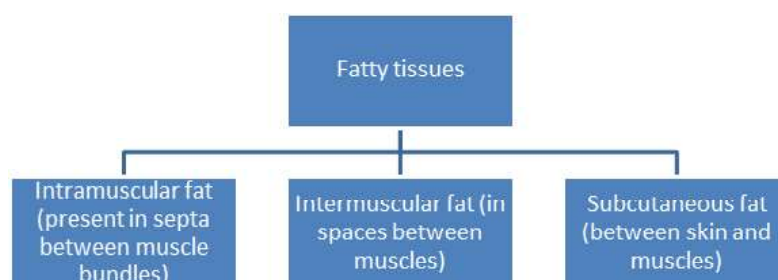


Fig. 7.1 Types of Fatty Tissues

Fat depots are also found around internal organs like kidneys. The fatty tissues found around the kidneys are known as perirenal, leaf or kidney fat. Fatty tissues can be graded as:

- o “firm” (backfat, jowl and brisket) and
- o “soft” fatty tissues (leaf perirenal fat) depending mainly on their connective tissue content.
- **Beef fat** or suet means fat obtained from a beef carcass. It shall have a saponification value varying from 193 to 200 and an iodine value from 35 to 46.
- **Mutton fat** means fat obtained from the carcass of sheep. It shall have a saponification value varying from 192 to 195 and an Iodine value from 35 to 46.
- **Goat fat** means the rendered fat from goat. It shall have a Saponification value varying from 193 to 196 and an Iodine value from 36 to 45.
- **Lard** means the rendered fat from hogs and shall not contain more than one per cent of substances other than fatty acids and fat. It shall have a Saponification value varying from 192 to 198 and an Iodine value from 52 to 65.
- o Hot-boned meat has a high WHC so the use of phosphate is avoided.
- o Beef must be processed within four hours and pork within one hour of slaughter.

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Classes of meat

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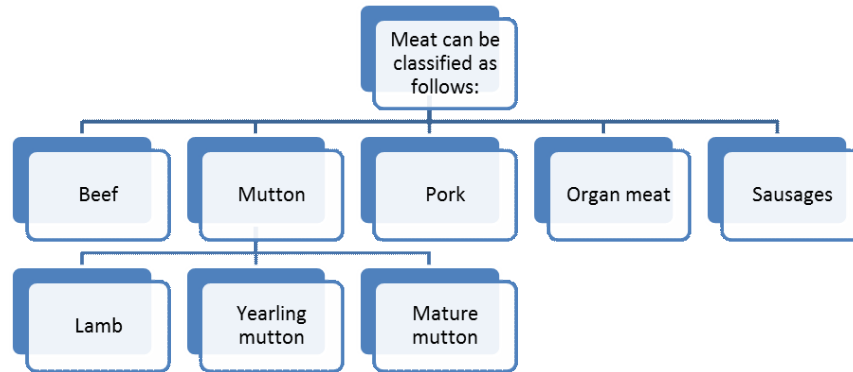


Fig. 7.2 Classes of Meat

Beef

Beef is the meat of cattle over one year old. Beef can be classified as follows:

Stear	Young bovine castrated male
Heifer	Female bovine that is not a calf
Cow	Female bovine that is a calf
Stag	Male bovine castrate after maturing
Calf	Male or female up to 12 months of age (usually from 3 to 8 months)

Mutton

Lamb	The flesh of young ovine animals of both sexes whose age is twelve months or under; smaller and lighter bones, lighter colored flesh and softer and whiter external and internal fats.
Yearling mutton	Carcasses of young sheep usually from 12 to about 20 months old; harder and whiter bones, darker and coarse flesh and thicker external and internal fat
Mature mutton	Flesh of both the males (castrated and un-castrated) and females of the ovine species that are 20 months in age at the time of slaughter; Mutton has a strong characteristic flavour

Pork

- The meat of swine is pork.
- It is normally obtained from animals between the ages of 3 to 12 months before the amount of fat becomes excessive.
- There is no differentiation of pork according to the age and size of pig.
- Pork has more fat than other meats and that is why it is a tender cut of meat.
- The colour of young lean pork is highly pink and changes to rose as the animal matures. Bacon is the cut from the belly portion of hog carcass and has a high percentage of fat
- Presence of worm, *Trichinella spiralis*, is found that causes “trichionosis”. This worm enters the body of swine when the animals are fed uncooked contaminated garbage.
- It can be destroyed by smoking or cooking to an internal temperature of 58°C.
- It can also be destroyed by freezing to -5°C for 20 days or -28°C for 6 days.

NOTES**Organ meats**

- These include liver, kidney, heart, thymus, pancreas, brain, lung, tripe (first and second stomach of the ruminants), head and tail of the animal.
- Organ meats are less expensive and more nutritive.
- The cooking methods for organ meats vary according to tenderness.

Sausages

- These are made of ground or minced meat.
- For preparation of sausages, cured meat is usually used for this purpose.
- The varieties of sausages de-pend upon whether the ground meat is fresh or cured, and whether the sausage is cooked or uncooked, smoked or unsmoked, and dried or not during manufacture.

7.3 CONTAMINATION AND SPOILAGE OF MEAT

Aerobic spoilage by bacteria and yeasts usually results in slime formation, undesirable odours and flavours (taints). Colour changes, rancidity, tallowy or chalky flavours from the breakdown of lipids may also occur. Colour changes as a result of pigment oxidation may be grey, brown or green discoloration. Aerobic spoilage by moulds results in a sticky surface, musty odours, alcohol flavours and creamy, black or green discoloration.

Anaerobic spoilage which occurs either within the meat or on the surface in sealed containers where oxygen is absent or very limited is marked by a souring due to the production of organic acids and gases.

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Post-mortem Changes in Meat

The carcass of a healthy animal slaughtered for meat and refrigerated, is likely to have only nominal surface contamination while the inner tissues are sterile. Fresh meat cut from the chilled carcass has its surface contaminated with the microorganisms that come from the environment (saws or knives used to cut the meat). Each new surface of meat, resulting from a new cut, adds more microorganisms to the exposed tissue. Among the more common species of bacteria occurring on fresh meats are pseudomonas, staphylococci, micrococci, enterococci, and coliforms. Apart from these genera of bacteria are Pseudomonas, Archaeobacter, Leconostoc, Lactobacillus and Clostridium are also very common. The temperature at which fresh meats are held favours the growth of psychrophilic microorganisms. The common species of molds are Cladosporium, Geotrichium, Mucor, Penicillium and Alternaria. The raw meat is subject to change by the action of its own enzymes. The fat present in meat in presence of air and catalyst oxidizes chemically to produce fatty acids. **Ageing** is a process in which meat is kept for a long period. During this period, the juice and meat fibers and cells are acted upon by its own enzymes making meat tender. Thus during this process **autolysis** of meat takes place. Autolytic changes may be accompanied by proteolysis i.e. breakdown of proteins and slight hydrolysis of fats. Meat is an ideal culture medium for many organisms because it is high in moisture, rich in nitrogen and has good amounts of mineral and other growth factors. The factors that contribute to growth of microorganisms are:

- The kind and number of microorganisms under the favorable conditions.
- The physical properties of meat such as the surface area exposed to the microorganisms, the amount of fat on the exposed surface, activity of enzymes etc.
- The chemical properties of meat such as presence of moisture favours the growth of microorganisms.
- The proteolytic enzymes act on proteins and degrade it. The pH of raw meat changes from 5.7 to 7.2 depending on the amount of glycogen present.
- Aerobic conditions at the surface of meat favours the growth of molds and anaerobic bacteria.
- Low temperature treatment should be given in order to prevent the growth of microorganisms in meat.

There are two **types of spoilage** in meat:

Spoilage under aerobic conditions:
<p>Facultative and anaerobic microorganisms cause spoilage.</p> <p>The following bacteria may act on meat resulting in changes that are described below:</p> <ul style="list-style-type: none"> • Surface slime is caused by Pseudomonas, Leuconostoc, Lactobacillus etc. • Changes in colour of meat from red to green, brown or grey as a result of the production of oxidizing substances as peroxides or hydrogen sulphides by bacteria (Lactobacillus and Leuconostoc). • Changes in fats (Lipolysis by lypolytic bacteria as Lactobacillus) which causes oxidation of fats to fatty acids resulting in development of off flavour. • Formation of red spots on the surface by Serratia sp.
Spoilage under anaerobic conditions:
<p>Anaerobic growth of molds results in:</p> <ul style="list-style-type: none"> • stickiness, that is formation viscous substances on the surface, • Formation of black spores (by Cladosporium sp.), • formation of white spots (caused by Geotrichium sp.) and • Formation of green spots (by Penicillium).

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Souring: The term souring refers to a sour odour and taste due to the formation of formic acid, glutamic acid, acetic acid and higher fatty acid by bacterial action.

Putrefaction: It is the anaerobic decomposition of proteins with the production of foul-smelling compounds like hydrogen sulphide, ammonia, amines etc. It is usually caused by Clostridium, Pseudomonas etc.

Cuts of Meat

Meat carcasses are commonly divided into relatively larger wholesale cuts and these are further divided into smaller retail cuts. A cut of meat is distinguished by the following features: size, shape and location of bone, size and shape of muscle found in the cut and amount and distribution of fat. The analogous parts of beef, veal, lamb and pork are similar as their skeletal structure is basically the same. The carcasses of beef are cut into more number of wholesale cuts than those of other animals because its size is bigger. The wholesale cuts of lamb are legs, loin, racks, breasts, shanks and shoulders. Each of the wholesale cuts is further cut into retail cuts, such as chops (different types of legs), roasts, neck slices, etc. According to Indian Standards Institution, the animals from which meat is obtained should be healthy and slaughtered in a hygienically managed slaughter house. The animals and the carcasses thereof should be subjected to antimortem and postmortem examination.

The carcasses and cuts should be certified as being sound and free from contagious and infectious diseases. It should be fit for human consumption.

7.3.1 Cooking of Meats

Cooking is done to make the meat tenderer or less tender than the original raw cut. Three types of changes are observed when meat is cooked to increase the tenderness. These changes are as follows:

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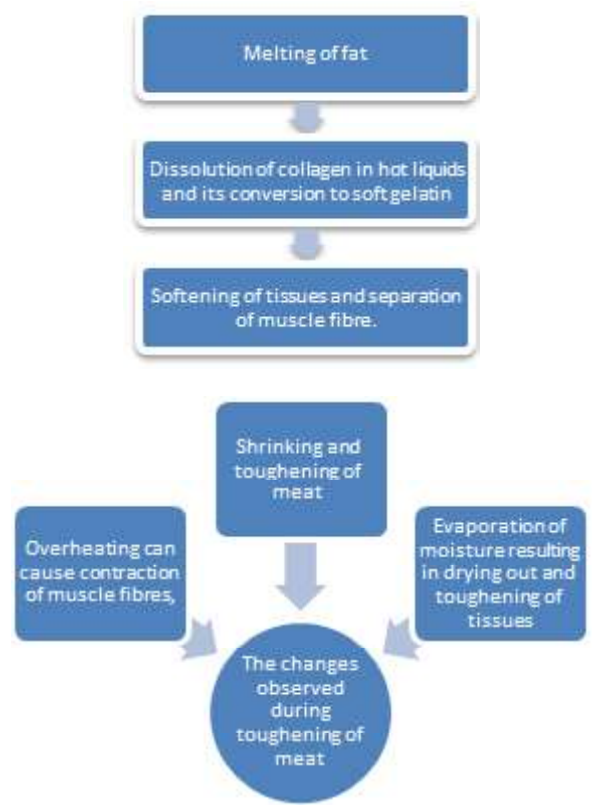
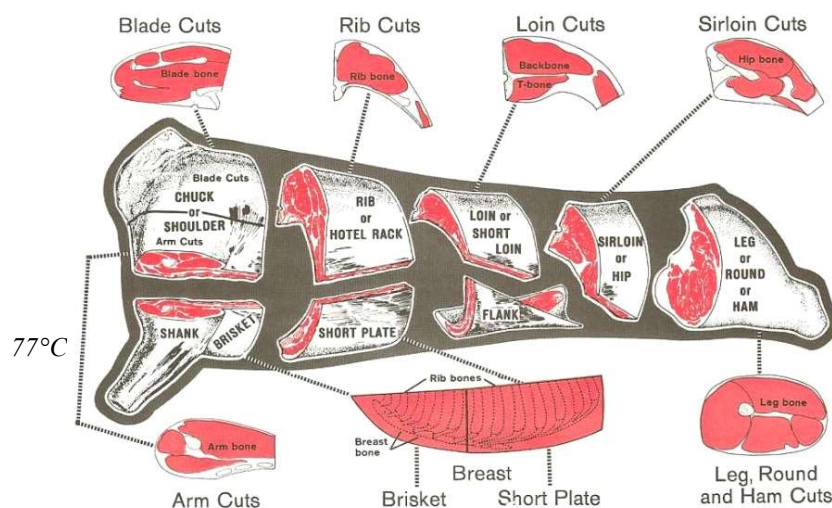


Fig. 7.3 Cooking of Meat

Cooking temperature

- An appropriate cooking temperature must be selected for desired cooking.
- For better results, lower cooking temperature for a longer duration is better than a higher temperature for short periods of time.
- Low temperature cooking has following advantages:
 - o Decreased drip loss
 - o Less shrinkage of flesh
 - o Increased juici-ness
 - o Uniform colour of the meat.
- Doneness is tested by the use of a meat thermometer.
- The recommended cooking temperatures are as follows:

Type of meat	Rare stage	Medium stage	Well-done stage
Lamb	77°C	79°C	82°C
Beef	60°C	71°C	77°C
Fresh pork	77°C	77°C	77°C



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Methods of cooking meat

There are two methods of cooking meat:

- Moist heat method: It includes Braising, Stewing, Pressure cooking.
- Dry heat method: It includes Roasting, Broiling, Pan broiling, Frying

Moist heat method:

- It includes the following:
 - Braising
 - Stewing
 - Pressure cooking

Dry heat method

- It includes the following:
 - Roasting
 - Broiling
 - Pan broiling
 - Frying

Dry Heat Methods

- Tender cuts of beef, lamb and pork may be cooked by these methods. It allows reaching the final interior temperature of meat.

Roasting

- Roasting is one of the simplest methods of cooking meat.
- The meat is placed uncovered on a rack in a shallow pan. This is done to keep the meat out of drippings.
- Then, a meat thermometer is inserted into the thickest part of the meat. The thermometer should not touch bones or fat.
- The roasting pan is placed in the centre of the oven and an oven temperature of 163°C is maintained till the desired internal temperature is indicated on the meat thermometer.

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- Temperature is maintained for the satisfactory browning of meat. Browning brings about fine flavour and acceptable appearance.
- As the heat is transmitted into the interior from the outer surface of the roasts, they continue to cook at the centre even after they are removed from the oven.
- The pan is never covered when meat is being roasted. If this is not followed, then the meat cookery method becomes moist heat cookery as the steam from the roasting meat is trapped inside the container.

Broiling

- Broiling consists of cooking meat by direct radiant heat, such as the open fire of a gas flame, coils or electric oven.
- In open fire or coal broiling heat comes from below, whereas in oven broiling, the heat comes from above.
- Broiling is applied to tender cuts of minimum 12.5 cm.
- Thinner cuts will be too dry if broiled.
- The meat is placed on a rack.
- The top of the meat is about 5 to 10 cm from the source of heat.
- Shorter distances are used for thinner cuts of meat.
- As the fat melts during broiling, that is why a tray should be placed beneath the rack.
- Broiling is carried out at a temperature of 176°C until the upper surface is brown.
- This side is salted and turned and broiled on the other side.
- Broiling is a faster method of cooking meat by dry heat than roasting. However, juicy and tender meats are obtained on roasting than broiling.

Pan broiling

- In pan broiling, heat is transferred to meat primarily by conduction from the pan or griddle.
- Meat is placed in a cold griddle and heated so that meat cooks slowly.
- The meat should be turned occasionally for uniform browning.

Frying

- Tender and thin cuts of meat are fried.
- Frying is of following two types:
 - o **Pan frying**
 - o **Deep-fat frying**

Pan frying

- Small amount of fat is added to the pan (0.5 cm) deep.
- The meat should be turned occasionally for uniform browning.
- Temperature should be controlled to prevent burning and drying of meat. Formation of acrolein is responsible for unpleasant flavor of meat at higher temperatures.
- It is important to note that the interior of the meat should be well cooked before excessive browning of the exterior.

Deep-fat frying

- The amount of fat is sufficient enough to cover the meat during frying.
- The temperature should be controlled in deep fat frying also s it may result in uncooked middle and acceptable pleasing brown color of the exterior.

Moist heat methods

- Less tender cuts of meat are cooked.
- The connective tissue is converted to gelatin in the presence of heat, moisture and prolonged cooking.
- Moist heat methods include the following:

Braising

- The meat is browned on all sides by broiling or frying.
- Small amount of water is then added to the meat and the pan is covered with a tight-fitted lid.
- It is cooked on low heat until meat becomes tender.
- The moisture of meat converts to steam and facilitates the cooking process and that is why water is not necessarily added during braising. If water is added the quantity should be kept to minimum.
- Tomatoes and fruits juices may also be added. They facilitate cooking process and increase the acidity and palatability of the product.

Stewing

- Meats with bigger pieces are cooked in presence of water.
- Meats are first browned and then placed in the vessel with sufficient water so as to cover all the pieces of meat.
- The vessel in covered with a lid.
- Cooking is continued till the pieces become soft and tender.

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Pressure cooking

- Cooking is done under steam at a temperature higher than that of boiling water.
- Cooking is faster as compared to braising and simmering. However, pieces are less juicy and there are heavy losses during cooking.

7.3.2 Changes Produced during Cooking

The changes that take place during the cooking of meat are as follows:

1. Heat destroys the microorganisms present in the meat.
2. Changes in colour, flavour and tenderness also take place during cooking.
3. Shrinking of meat, toughening of protein and loss of juiciness of meat pieces are observed at high temperatures.

1. Changes in the colour

- a. The protein pigments of fresh meat are denatured when cooked.
- b. Denaturation of the proteins causes rapid release of the haem pigments from the globin part of the molecule. As the free haem is very sensitive to oxidation, that is why, on heating, red meat turns brown due to the formation of oxidized pigments.
- c. The changes in the color of pigment in meat are measure of deciding the degree of doneness.
- d. It is important to note that meat cooked to rare condition is more red as it has less of denatured oxymyoglobin and well done meat is more brown as it is more denatured.

2. Changes in texture

- a. Heat treatment not only brings about the denaturation of proteins but also the enzymes present in meat are inactivated.
- b. Myosin and actin are also enzymes and their inactivation brings about textural changes. This is because the contractile proteins become tougher.
- c. It is observed that tough cuts of meat are cooked for a long time in the presence of water. This is because the above discussed reaction is counter-acted by the simultaneous conversion of the collagen of the connective tissues to gelatin.

3. Changes in connective tissue

- a. The cooking of meat minimizes the hardening of contractile proteins and maximizes the softening of the connective tissues.
- b. Cooking temperature and time should be adjusted so that the tenderizing effect due to the conversion of collagen to gelatin is not counterbalance by

the increasing toughness due to an excessive coagulation of contractile proteins.

4. Changes in flavor

- a. A number of components of meats are responsible for its flavor, when heated.
- b. Proteins and free amino acids of meat produce some volatile breakdown products. These include the following:
 - i. Sulphur-containing compounds
 - ii. Aldehydes
 - iii. Ketones
 - iv. Alcohols
 - v. Amines
- c. Lipid components also break down into various volatile compounds. These volatile compounds are present in both the fat and lean portions of the meat. During heating, the changes occur in meat fat in the following sequence:
 - i. Meat fat melts
 - ii. Adipose tissue cells are ruptured.
 - iii. Redistribution of fat takes place.
 - iv. Dispersion of fat where collagen has been hydrolyzed.

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5. Changes in water content

- a. Meat contains a high percentage of water but only a small percentage of this water is bound very closely to the protein of muscle tissue and the remaining is found as free molecules within the muscle fibres and connective tissues.
- b. Heating reduces the water holding capacity (WHC) of meat.
- c. The water holding capacity of meat is directly related to its juiciness.

6. Changes in the nutritive value

- a. The nutritional value of cooked meat generally remains high.
- b. Cooking does not bring about changes in the nutritive value of proteins.
- c. Usually minerals are not lost by heat but some may be lost in meat drippings.
- d. It is observed that cooking dissolves some calcium from bone.
- e. There is loss of some B vitamins during cooking.

Check Your Progress

1. Define meat.
2. What does aerobic spoilage of meat lead to?

7.4 NUTRITIVE VALUE OF EGG

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Eggs have a very high nutritive value. An average egg provides about 80 kilo calories of energy.

- **Proteins**
 - o They contain 12-14 per cent proteins.
 - o The proteins of egg are composed of essential amino acids.
 - o The egg proteins are easily digestible.
- **Lipids**
 - o The lipids of egg constitute 10-12 per cent.
 - o They are composed of large amounts of unsaturated fatty acids.
 - o The fat contained in yolk contributes large amount of its calories.
- **Minerals**
 - o Minerals are present to the extent of 1 per cent in egg.
 - o The most common minerals are iron, phosphorus, calcium and sulphur.
 - o Maximum iron is present in the yolk.
- **Vitamins**
 - o Eggs are an excellent source of vitamin A which is present in the yolk.
 - o The yolk is also a good source of vitamin D.
- **Cholesterol**
 - o A large amount of cholesterol is present in the egg yolk.

7.4.1 Structure of Egg

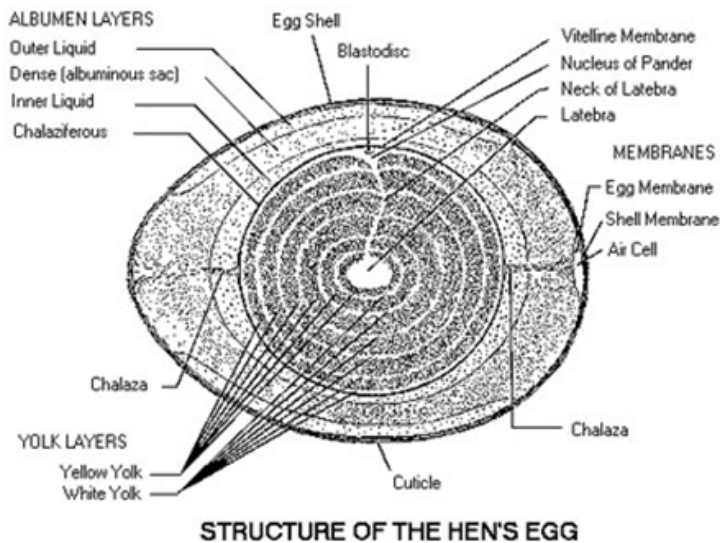


Fig. 7.4 Structure of the Hen's Egg

- An egg has following characteristic parts:
 - o Shell
 - o two membranes
 - o egg white or albumen
 - o egg yolk
 - o germinal disc
- **Shell of the egg** is made of calcium carbonate. It forms protective covering of the inner contents of the egg. It may be white or brown depending on the breed of the bird. It is brittle and easily breakable. It is porous and contains numerous small holes (7,000—17,000 per egg) which allow gases to pass in and out of the egg. Air is important for the developing embryo in a fertilized egg.
- These small holes or pores are covered with a thin layer of a gelatinous material (mucoprotein) called the cuticle or bloom. The cuticle seals off the pores of the shell and serves following functions:
 - o It avoids excessive evaporation from the inner contents of the egg
 - o It restricts the entry of microorganisms into the egg thereby protecting the inner contents from various infections.
- As the cuticle is soluble in water, it can deteriorate the egg quality as it is easily removed by washing.
- There are **inner and outer membranes** that protect the quality of the egg. Both the membranes are porous and composed of fibres.
- The outer membrane is thicker (48 μm) than the inner one (22 μm). the outer layer is firmly attached to the shell.
- The outer membrane has six layers of fibres, whereas the inner has three.
- The inner membrane is attached to the outer membrane and the two membranes are loosely attached to one place at the broad end of the egg.
- The membranes are composed of protein-polysaccharide.
- The eggs contain little or no **air-cells** when it is laid. The inner contents contract after being laid as lower temperature of the surrounding of the egg is lower than that in the hen's body. This results in formation of air cell between the shell membranes at the large end of the egg, as the air is drawn into the shell.
- The **egg white** consists of three layers:
 - o Two areas of thin white
 - o One area of thick white within the two thin layers.
- The **egg yolk** is enclosed in a sac known as the **vitelline membrane**.

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- Immediately beyond this is another membranous layer known as the **chalaziferous layer**.
- The yolk is connected to thick or firm albumen by two twisted rope-like extensions of the chalaziferous layer called **chalazae**. It anchors the yolk in the white and keeps it centred in the egg.
- The yolk carries the **germinal disc or germ spot** which is not distinct. Under suitable conditions, the germ spot develops into a chick.
- There is a white column beneath the germ spot called the **latebra**.
- There are layers of white and yellow in the yolk.
- The infertile eggs are also known as 'lifeless' because the female reproduction nucleus is not fertilized by union with the sperm of the cock and that is why these are incapable of producing chicks.

7.4.2 Composition of Egg

- The **shell of the egg** contributes 8-11 per cent of its weight.
- An average contains about two parts white (55 to 60 per cent) to one part yolk (27 to 32 per cent) by weight.
- The whole egg contains about:
 - o 65 %————→ water
 - o 12 to 14 percent————→ protein
 - o 10-12 per cent————→ fat
 - o 1 percent————→ minerals
- There is a difference in the composition of the egg-white and egg yolk.
- The following table shows the composition of ash, fats, proteins and water in whole egg, egg white and egg yolk:

Composition of Hen's Egg (In %)

Nutrients	Whole egg	Egg white	Egg yolk
Ash	1.0	0.8	1.5 to 2.0
Fat	10.5	0.05 to 0.2	31.6 to 32.5
Proteins	13.4	10 to 11	16.7 to 17.5
Water	73.7	87.77 to 88	48 to 49

- The albumen CONTAINS negligible amount of lipids as compared to that of yolk.
- The carbohydrate in albumen is present in combined and Free states (glucose).

- Proteins and lipids are the major constituents of yolk.
- Yolk contains very little amounts of carbohydrates.
- The lipid contains 32 to 36 % yolk of which about 68 per cent constitutes triglycerides, 2 percent phospholipids, 5 per cent cholesterol and minor amounts of other lipids.
- The yolk is rich in fat-soluble vitamins.
- Egg-white contains a number of proteins that are also known as albumen.
- All egg-white proteins are globular. They have an important in the foaming properties of egg-white.
- Ovalbumin is the main protein constituting 55 per cent of the proteins of egg-white. This is a phosphoglycoprotein and is composed of three components that differ in their phosphorus content.
- The carbohydrate components of ovalbumin are mannose and glucosamine in the ratio of 5:3.
- Conalbumin constitutes 13 per cent of the proteins of egg albumen. It consists of two forms neither of which contains phosphorus or sulphur.
- Conalbumin is more easily heat coagulated and less susceptible to denaturation than ovalbumin. It forms heat-stable complexes.
- Ovomuroid constitutes about 10 per cent of the egg-white proteins. It exists in three forms, all of which are trypsin inhibitors. It is resistant to heat denaturation in acid media, but is rapidly denatured in alkaline solutions.
- Ovomucin is responsible for the thickness of albumen. Its content in the thick layers of albumen is about four times more than in thin layers. It is insoluble in water but is soluble in dilute salt solutions.
- Lysozyme is present in egg albumin
- Avidin binds biotin and makes it unavailable. It is denatured when egg are cooked.
- Ovoglobulin is also present in egg white which is responsible for foaming properties of egg,
- Ovoinhibitor is a protein which is responsible for inhibiting trypsin and chymotrypsin.
- The egg yolk proteins include phosphovitin, lipovitellins, livetin, low density lipoproteins etc.
- The color of the egg yolk varies from pale yellow to brilliant orange depending on the amount and type of pigment present in the diet of the hen. The colour is due to the presence of carotenoids and xanthophylls. The carotenoids are converted into vitamin K in the body. Vitamin A is present in deep colored yolk.

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- Xanthophylls are responsible for the yellow color.
- Calcium is the most abundant mineral in egg and is mostly found in the shell.
- Phosphorus is found in the yolk.
- Eggs are excellent source of iron.
- Other minerals present are sodium, potassium, magnesium, sulphur and chlorine.

7.4.3 Egg Quality and Quality Deteriorating Factors

The physical structure and chemical composition determines the quality of eggs and their stability during storage. The persons who are given the responsibility of the handling of eggs should be knowledgeable enough to understand that eggs need to be treated in specific ways and to have a rational basis for day-to-day marketing decisions.

The factors that deteriorate the quality of eggs include natural factors, temperature, humidity, time, handling, storage, tainting etc.

- Natural factors may include blood spots. The blood spots may range from small specks to a square centimeter in size. They may vary in colour from light grey to bright red and may be found in the yolk or in the egg white.
- 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 formation of objectionable odour.
- Weak shells and rough handling during packing and transport increase the chances of damage to the shell.
- In advanced stages of deterioration, the thick white may disappear entirely. The egg yolk may enlarge up to such extent that its membranes are weakened and break as soon as the egg is opened.
- As discussed earlier, temperature, humidity, air movement and storage time all have adverse effects on interior quality. These factors, if not controlled, can cause loss of moisture in eggs through porous shell. This results in loss of weight of egg.
- Eggs with enlarged air cells have decreased size of egg contents.
- Coating eggs with oil and other substances and storing them at low temperatures and high humidity may control moisture loss.
- The best conditions for storage are at a temperature of about -1°C and relative humidity between 80 and 85 percent. At a temperature of 10°C , lower relative humidity is needed, between 75 and 80 percent.

- At all temperatures there is the risk of mould spoilage where the relative humidity is too high.
- Packaging materials that are too dry or are excessively moist and absorbent will also bring out evaporation losses.
- The albumen of a newly-laid egg contains carbon dioxide. Carbon dioxide begins to escape through the pores of the shell soon after the egg is laid resulting in rise of the pH of the egg. The pH of egg-white increases from 7.9 to about 9.3, in the first three days. Increased alkalinity results in thinner, yellow and cloudy white that spreads additionally when the egg is broken out. The thinner white will not be able to keep the yolk centered in the egg. The pH of the yolk is initially about 6.3 and it increases slowly during prolonged storage. A Change in pH influences its functional properties.
- In a fertile egg, the development of the germinal disc is ceased when the egg is laid. As soon as the egg is brought to temperature of 20°C or above, the embryo starts growing and the development of the embryo deteriorates the quality of the egg content.

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7.4.4 Spoilage of Eggs

Let us discuss the spoilage of eggs.

Microbial Spoilage of Eggs

The interior of a freshly laid egg is usually free of microorganisms. The microbial content of egg is determined by the sanitary conditions under which it is held, as well as the conditions of storage, i.e., temperature and humidity. Microorganisms, particularly bacteria and molds, may enter the egg through cracks in the shells or penetrate the shells when the “bloom” covering the shell deteriorates. “Bloom” is the thin protein coat that covers the shell. *Salmonella* sp. is the main spoilage microorganism. A rapid change in storage temperature may permit bacteria to overcome the physical barrier to the shell and its membrane. For example, if a warm egg is placed in cold environment microorganisms on the shell surface may be drawn into the interiors through the pores when the egg contents contract.

The rate of the growth and multiplication of the bacteria depends upon the time and temperature of storage, relative humidity and the air composition of surrounding atmosphere of the egg. Low storage temperature storage upto zero-degree centigrade limits the number of microorganisms which cause spoilage.

A defected egg may show presence of cracks, loss of gloss, dirty or stains on the exteriors or spots. It has been observed that presence of translucent spots in egg yolk is found in stale or spoiled egg. Such types of breaks and dirt cause spoilage of egg on storage.

The bacterial spoilage in eggs is known as “rots”. The various types of rots are:

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Green rots is caused by *P. fluorescens*. The egg contents become green in color and are clearly visible when egg is broken.

Colorless rots: It is caused by *P. alacaligens* and Coliforms. It is detected by candling; colorless rots produce highly offensive odour.

Black rots: it is caused by *Proteus*; hydrogen sulphide is produced during spoilage which imparts offensive flavour; opaque contents visible during candling

Pink rots and red rots: The pink rots of egg are very rare caused by various strains of *Pseudomonas* where as red rots are caused by *Serratia*.

A **fishy flavour** is produced by *E. coli*.

Molds causing spoilage are *Penicillium*, *Mucor*, *Alternaria*, and some other genera. The contents become jelly-like.

In general, more spoilage is caused by bacteria than molds in eggs.

Non-microbial spoilage of eggs

Eggs lose their moisture during storage and thus lose weight. The amount of shrinkage is shown on exposure to candle by the size of air space at the blunt end of the egg. A large air space indicates staleness of the egg. It has been observed that the egg white becomes thinner and watery on ageing followed by weakening of the egg yolk. A stale egg shows more movement of the egg contents. During storage, the pH changes from 7.6 to 9.5.

7.5 EFFECT OF HEAT ON EGG PROTEINS

- The coagulation of egg proteins when heated makes it useful in a number of preparations. Thus, eggs are used as thickening agents, binding agents and clarifying agents.
- A variety of proteins are present in eggs.
- The egg white proteins and egg yolk proteins coagulate at different temperatures that can be tabulated below:

Part of egg	Coagulation starts at	Coagulation is completed at
Egg white proteins	52 to 60 degree C	65 degree C
Egg yolk proteins	65 degree C	70 degree C

Factors affecting coagulation

The rate and extent of coagulation is dependent on the following factors:

1. Time
2. Temperature

3. Addition of ingredients

- a. Water
 - b. Milk
 - c. Sugar
 - d. Acids
 - e. Salt
- An egg mixture that is heated very rapidly at a higher temperature coagulates earlier than the mixture that is slowly heated. However, the egg white coagulated at higher temperature becomes firm and tough. In cookery, soft and tender products are preferred that are obtained at a lower temperature.
 - The temperature of coagulation is increased when milk or water is added.
 - Addition of sugar also increases the coagulation temperature.
 - Addition of acids lowers down the coagulation temperature.

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7.5.1 Egg Foams

- Eggs are used to produce foam. These foams are stable and can be used in various types of recipes. They can be baked along with various foods or even alone.
- Egg-whites produce foams of a very large volume when beaten properly.
- When egg white is beaten then, air is trapped into thin layers of white.
- When the product containing the foam is heated, then the air trapped in the foam expands until the albumen surrounding the air undergoes some denaturation. This denaturation takes place at the liquid-air interface as a result of the drying and stretching of albumen.
- During beating some components of the ovomucin (albumen) become insoluble. This results in the stiffening and stabilizing of the foam.
- The tenderness of any product is dependent on the volume of foam. Egg-white is thus utilized in making meringues and several other products that have been discussed in the next section.
- Egg-yolks do not produce foams of larger volume.

Factors influencing Foaming and Egg Products

The factors that affect the quality of the foam produced by eggs are as follows:

1. Beating of egg
2. pH
3. Presence of other ingredients
 - a. Water
 - b. Fats

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- c. Salt
- d. Sugar

4. Time and temperature of beating

- An optimum amount of beating is required for maximum stability. Precautions must be taken when an electric blender is used because there is always a danger of overbeating of the mixture. Overbeating results in dull and dry foams. Beaters with fine wires or thin blades produce finer foams.
- The time of beating the egg-white depends upon the type and speed of the beater.
- Egg-white at room temperature can be beaten more readily than at refrigerator temperature.
- Thin white produces foams of larger volume than thick white as they are more easily beaten. It has been found that stored eggs may be beaten more quickly than white from fresh eggs as they have thinner whites.
- The pH of the egg-white is important for foam formation. The lower pH increases the stability of the foam. This can be done by the addition of an acid, such as cream of tartar or lemon juice. This results in the coagulation of egg proteins. However, uncontrolled lowering of pH may delay the foam formation.
- The addition of water to egg white increases the volume but decrease the stability of the foam.
- Fat obstructs the formation of foam. The beater, bowl and other equipments used for formation of foam should be completely free from any fat or oil. As the yolk contains fat, that is why, presence of even a small amount of yolk obstructs the formation of egg white foam.
- Addition of salt during beating reduces the volume and stability of the foam.
- Addition of sugar delays the formation of foam.

Egg has following functions in food:

1. It acts as **coloring agent**
2. It acts as **flavoring agent**
3. It acts as **texturizer**
4. It acts as **binding agent**
5. It acts as **emulsifying agent**
6. It acts as **foaming agent**

It is important to note that eggs and egg containing recipes should be cooked at low to moderate temperatures. This is because high temperature results in toughening of the egg proteins.

Check Your Progress

4. What is the composition of lipids?
5. What does egg white consist of?

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7.6 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Meat is defined as those animal tissues which are suitable for use as food.
2. Aerobic spoilage of meat by bacteria and yeasts usually results in slime formation, undesirable odours and flavours (taints).
3. Lipids are composed of large amounts of unsaturated fatty acids.
4. The egg white consists of three layers, i.e. two areas of thin white and one area of thick white within the two thin layers.

7.7 SUMMARY

- Meat is defined as those animal tissues which are suitable for use as food.
- These are the main soft tissues of the carcass muscle, *viz.* skeletal tissue (30–65 percent), fatty tissue (10–45 percent) and connective tissues.
- The structural unit of muscle is a specialized cell known as the muscle fibre.
- Aerobic spoilage by bacteria and yeasts usually results in slime formation, undesirable odours and flavours (taints).
- Colour changes, rancidity, tallowy or chalky flavours from the breakdown of lipids may also occur.
- Anaerobic spoilage which occurs either within the meat or on the surface in sealed containers where oxygen is absent or very limited is marked by a souring due to the production of organic acids and gases.
- The carcass of a healthy animal slaughtered for meat and refrigerated, is likely to have only nominal surface contamination while the inner tissues are sterile.
- Ageing is a process in which meat is kept for a long period. During this period, the juice and meat fibers and cells are acted upon by its own enzymes making meat tender.

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- There are two methods of cooking meat:
 - o Moist heat method: It includes Braising, Stewing, Pressure cooking.
 - o Dry heat method: It includes Roasting, Broiling, Pan broiling, Frying
- Eggs have a very high nutritive value. An average egg provides about 80 kilo calories of energy.
- Shell of the egg is made of calcium carbonate. It forms protective covering of the inner contents of the egg.
- The egg yolk is enclosed in a sac known as the vitelline membrane.
- The physical structure and chemical composition determines the quality of eggs and their stability during storage.
- The interior of a freshly laid egg is usually free of microorganisms.
- The rate of the growth and multiplication of the bacteria depends upon the time and temperature of storage, relative humidity and the air composition of surrounding atmosphere of the egg.
- Eggs are used to produce foam. These foams are stable and can be used in various types of recipes. They can be baked along with various foods or even alone.

7.8 KEY WORDS

- **Bloom:** It is the covering of egg shell.
- **Egg Yolk:** The yellow part of the egg that contains fat, protein, iron, vitamin A, vitamin D, choline, and phosphorus.
- **Membrane:** It is a pliable sheet-like structure acting as a boundary, lining, or partition in an organism.
- **Broiling:** It is cooking by exposing food to direct radiant heat, either on a grill over live coals or below a gas burner or electric coil.

7.9 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. Discuss the methods of cooking of meat. What are the changes that occur in meat during cooking?
2. What are the factors that are responsible for deteriorating the quality of eggs?
3. Draw a well labeled diagram of structure of hen's egg.

4. Write short notes on:
 - a) Microbial spoilage of eggs
 - b) Non-microbial spoilage of eggs
5. Write short notes on:
 - a) Egg foam
 - b) Factors affecting egg coagulation

Long Answer Questions

1. Write a detailed note on the grading of eggs.
2. Describe the structure and composition of meat?
3. Discuss the spoilage and contamination of meat.
4. Discuss the following topics in depth:
 - a) Structure of eggs
 - b) Composition of eggs
 - c) Nutritive value of eggs
5. Analyse the effect of heat on egg protein?

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BLOCK - III
MARINE FOODS, MILK PRODUCTS, FATS AND
BEVERAGES

UNIT 8 MARINE FOODS AND ITS
NUTRITIVE VALUE

Structure

- 8.0 Introduction
- 8.1 Objectives
- 8.2 Classification of Fish
 - 8.2.1 Composition and Nutritive Value of Fish
- 8.3 Spoilage and Preservation and Processing of Fish
- 8.4 Seaweed and Shrimps: Nutritive Value
- 8.5 Answers to Check Your Progress Questions
- 8.6 Summary
- 8.7 Key Words
- 8.8 Self Assessment Question and Exercises
- 8.9 Further Readings

8.0 INTRODUCTION

Marine food or seafood is defined as any form of sea life which is considered as food by humans. It primarily includes fish, shellfish, and shrimps and so on. Edible plants such as seaweed and microalgae are also eaten as seafood.

Marine food is an excellent source of minerals and vitamins. It is low in calories and helps in preventing heart attacks, obesity, hypertension and stroke. It also helps to build strong muscles and tissues.

In this unit, the types of fish have been discussed. The reasons for spoilage and the methods for preservation of fish have been discussed in this unit. In this unit, the nutritive value of fish, seaweed and shrimp have been explained in detail.

8.1 OBJECTIVES

After going through this unit, you will be able to:

- Describe the main types of fish
- Interpret the reasons for the spoilage of fish
- Describe the process of preservation of fish
- Discuss the nutritive value of fish
- Analyse the nutritive value of seaweed and shrimps

8.2 CLASSIFICATION OF FISH

We will in this section, discuss the main types of fish and its nutritive value.

On the basis of **anatomical differences**, fish are classified into two major categories.

1. Finfish

- a) Have vertebrae with fin-appendages.
- b) Presence of protective scales on the skin.
- c) Consumption of finfish is more than shellfish.
- d) Classification of finfish: Finfish are of the following types:
 - i. **Sea or marine fish:** The examples of marine or sea fish include shark, salmon, mackerel, Bombay duck, ribbon fish, pomfret, sale and tuna and so on.
 - ii. **Fresh water fish:** The examples of fresh water fish include sardine, mullet, catfish and perch.

2. Shellfish

- a) Absence of skeleton but covered with hard shell.
- b) Classification of shellfish: Shellfish are of the following types:
 - i. **Molluscs:** The following are the characteristics of molluscs:
 - Have soft unsegmented body.
 - Partially or wholly enclosed in a hard shell that is composed of minerals.
 - The examples of molluscs include oysters, clams, scallops and mussels.
 - ii. **Crustaceans:** The following are the characteristics of crustaceans:
 - The crustaceans are covered with crust like shells
 - The examples of crustaceans include lobsters, crabs, shrimps and crayfish. Edible shellfish are mainly salt water fish.

On the basis of **presence of fat**, fish are classified into three major categories. They are as follows:

1. Lean fish

- a. Less than 2 per cent fat.
- b. The examples of lean fish include Bombay duck, halibut, cod and perch.

2. Medium fat fish

- a. 2 to 5 per cent fat.

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3. Fatty fish

- a. More than 5 per cent.
- b. The examples of fatty fish include salmon, sardine, mackerel and tuna.

8.2.1 Composition and Nutritive Value of Fish

Let us discuss the nutritive value of fish:

Fats

- The fat content of fish varies from 0.1 per cent to about 25 per cent and is dependent on season, sex and stage of maturity of fish.
- Fat is present in the liver, viscera muscle tissue, skin, milt and roe.
- Fish oils are composed of triglycerides that constitute up to 95 per cent of the oil.
- Fish-fat also contains cholesterol, lecithin, waxes and fatty alcohols.

Proteins

- Fish is an excellent source of high quality protein.
- The protein content of finfish is about 20 per cent but the protein content of shellfish is lower than that of finfish.
- Fish proteins are easily digested.
- Have high levels of amino acids, histidine and lysine.

Carbohydrates

- Small amounts of glycogen are present in fish.
- The amount of glycogen in shellfish varies and the sweet taste of shellfish is due to glucose formed from the glycogen by the action of enzymes.

Minerals

- Fish is a good source of minerals.
- The most common minerals are:
 - a) Copper
 - b) Sulphur
 - c) Phosphorus
 - d) Iron
 - e) Iodine

Vitamins

- Fish oils are the richest known sources of vitamins A and D.
- Apart from this, fish flesh also contains thiamine, niacin, riboflavin.
- Vitamin C content is low in fish.

Check Your Progress

1. What are the characteristics of molluscs?
2. Why does shellfish taste sweet?

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8.3 SPOILAGE AND PRESERVATION AND PROCESSING OF FISH

In this section, we will discuss the reasons for the spoilage of fish and the ways in which fish are preserved and processed.

Spoilage of Fish

- The microbial content of water is one of the first and foremost factors responsible for the microflora of the fish.
- Fish are highly perishable.
- The type of processing and the method of handling largely depend on the spoilage of fish as fish are more perishable than other animal tissue even under refrigeration. The shelf life of a freshly caught fish at a temperature of 16°C is not even 24 hours. However, the shelf life of on ice at 0°C can be up to about 14 days.
- The spoilage of fish is because of the following reasons:
 - Microbiological
 - Non-microbiological
 - a) Physiological
 - b) Chemical
- The bacteria responsible for the spoilage of fish are Alcaligenes, Vibrio, Serratia and Micrococcus; however, flesh of healthy live fish is bacteriologically sterile but bacteria are found on the skin surface, gills, and the digestive tract of living fish.
- Immediate evisceration of the fish should be done to cease the activity of the gut enzymes.
- Spoilage of fish starts shortly after the death of the fish. This happens because bacteria attack the tissues and continue to grow even under common refrigeration conditions.
- Apart from the microbial spoilage other non-microbiological factors are also responsible for the spoilage of fish. These factors are autolysis, oxidation and lipolysis of the fish.
- Shellfish are even more perishable than finfish.

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Preservation and Processing of Fish

- Fish is a highly perishable commodity that is why various methods are used for its preservation.
- The fish are washed with clean water before preservation. This is done to remove impurities, dirt and blood stains.
- Then all the internal organs or viscera are removed and the body cavity is washed thoroughly with clean water.
- The various methods adopted for preservation of fish are sun drying, salting, smoking, freezing and canning.

We will in the following section discuss the advantages and disadvantages of some of these methods.

Sun Drying

The following are the advantages of sun drying:

- **Advantages**
 - a) Sun drying removes moisture from tissues. As moisture provides favorable conditions of microbial growth that is why sun drying helps to cease the bacterial growth.
 - b) The deterioration of fish due to autolysis is also inhibited.

Salting or Pickling:

The following are the two main types of salting:

a) Dry salting

- i. In dry salting method, the fish are first rubbed with salt powder.
- ii. They are then packed in tubs with dry salt powder sprinkled in between layers of fish.
- iii. After a period of about 10-20 hours the fish are removed, washed in brine and dried in the sun for 2-3 days.

b) Wet salting

- i. In wet salting method, cleaned fish are packed in large vats containing con-centrated salt solutions.
- ii. They are stirred daily till properly pickled.
- iii. To allow better penetration of salt, longitudinal slits are made into the fish.
- iv. After pickling for 7 to 10 days, the salty water that oozes out from the fish is drained off and sold as such or smoked and then sold.

Disadvantages of sun drying and salting methods

The following are the disadvantages of sun drying and salting methods:

- These methods are not hygienic
- Loss is observed due to putrefaction and spoilage
- Development of off-odours is reported in the dried fish
- Case-hardening
- Rancidity development
- Colour changes
- Mold growth
- Infestation by insects and mites

Use of Chemicals

The chemicals used for preservation of fish are acids, sodium and ethylene oxide.

The main disadvantage of using chemicals is that continuous consumption of these chemicals may be harmful if not used under permissible limits and that is why these chemicals are not permitted universally.

Irradiation

- Irradiation of fish prolongs their shelf life by 20 to 25 days.

Freezing

- Freezing extends the shelf life of fish for up to two years.
- The clean whole fish is frozen or the fish is gutted (internal organs removed) and frozen down to -29°C within two hours of its catch.
- Finfish are usually frozen in form of fillets or sticks.

Disadvantages of Freezing

The following are the disadvantages of freezing:

- If proper care is not taken during freezing then some undesirable changes can take place.
- In some cases, it has been found that slow freezing can cause protein denaturation because of increase in the salt concentration of the muscle tissue as the water freezes in the fish. It toughens the fish tissues and makes them rubbery.
- Freezing can also cause desiccation or drying of tissues due to the transfer of moisture from the surface of the fish to the cold surface of the freezing equipment.
- Frozen fish can also become rancid. This is observed more in fatty fish.

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- Prevention from desiccation and rancidity.
- Desiccation and oxidation can be prevented by properly protecting fish with suitable wrappers before freezing.

Canning

- Canning is done to overcome the disadvantages of freezing. The fish which are most commonly canned are sardine, herring, lobster, shrimp, mackerel and tuna.
- In some fish, vegetable oil is added to the fish before sealing the cans and some are stored in brine.
- The most important advantage of canning is that it retains the natural flavour of the fish.

One of the disadvantages of canning is that the shellfish becomes dark or discoloured during canned storage due to the release of hydrogen sulphide. This is released from the sulphur components of the fish. Hydrogen sulphide reacts with the iron in the can to give black iron sulphide.

8.4 SEAWEED AND SHRIMPS: NUTRITIVE VALUE

In the following section, we will discuss the nutritive value of seaweeds and shrimps.

Seaweed

Seaweed is of various types, however only very few of them can be consumed. The most common types of seaweed which can be consumed are kombu and wakame which are types of brown seaweed and dulse and nori which are red seaweed. In the ancient times, the Chinese considered seaweed as a cure for goiter and urinary problems. Seaweed helps to maintain cholesterol levels. It is a rich source of protein, for instance, red seaweed contains more than 50 grams of protein.

It is a rich source of several vitamins which includes vitamin A, vitamin C, vitamin D and vitamin E. It is also a rich source of vitamin K which plays a crucial role in blood clotting. Seaweed is also a rich source of various minerals such as calcium, magnesium, copper, iron and potassium. It has high iodine content and helps in maintaining cholesterol levels.

Shrimps

Shrimps are a rich source of protein and are low in fats. It is a good source of vitamin B12 which helps to prevent heart diseases. It is an excellent source of amino acid which helps to maintain a good sleep pattern in human beings and helps to stabilize the hormones too. It helps in enhancing immunity and thyroid function too.

Check Your Progress

3. What are the various methods adopted for preservation of fish?
4. State the main disadvantage of using chemicals.
5. What are the various vitamins in which seaweed is rich?

NOTES

8.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The following are the characteristics of molluscs:
 - Have soft unsegmented body.
 - Partially or wholly enclosed in a hard shell that is composed of minerals.
 - The examples of molluscs include oysters, clams, scallops and mussels.
2. Shellfish taste sweet because of the glucose formed from the glycogen by the action of enzymes.
3. The various methods adopted for preservation of fish are sun drying, salting, smoking, freezing and canning.
4. The main disadvantage of using chemicals is that continuous consumption of these chemicals may be harmful if not used under permissible limits and that is why these chemicals are not permitted universally.
5. Seaweed is a rich source of several vitamins which includes vitamin A, vitamin C, vitamin D and vitamin E.

8.6 SUMMARY

- The fat content of fish varies from 0.1 per cent to about 25 per cent and is dependent on season, sex and stage of maturity of fish.
- Fat is present in the liver, viscera muscle tissue, skin, gut and roe.
- Fish oils are composed of triglycerides that constitute up to 95 per cent of the oil.
- Fish -fat also contains cholesterol, lecithin, waxes and fatty alcohols.
- The protein content of finfish is about 20 per cent but the protein content of shellfish is lower than that of finfish.
- The amount of glycogen in shellfish varies and the sweet taste of shellfish is due to glucose formed from the glycogen by the action of enzymes.
- Fish oils are the richest known sources of vitamins A and D.

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- The microbial content of water is one of the first and foremost factors responsible for the microflora of the fish.
- The type of processing and the method of handling largely depend on the spoilage of fish as fish are more perishable than other animal tissue even under of refrigeration. The shelf life of a freshly caught fish at a temperature of 16°C is not even 24 hours.
- The bacteria responsible for the spoilage of fish are Alcaligenes, Vibrio, Serratia and Micrococcus; however; flesh of healthy live fish is bacteriologically sterile but bacteria are found on the skin surface, gills, and the digestive tract of living fish.
- Immediate evisceration of the fish should be done to cease the activity of the gut enzymes.
- Spoilage of fish starts shortly after the death of the fish. This happens because bacteria attack the tissues and continue to grow even under common refrigeration conditions.
- Fish is a highly perishable commodity that is why various methods are used for its preservation.
- The various methods adopted for preservation of fish are sun drying, salting, smoking, freezing and canning.
- Sun drying removes moisture from tissues. As moisture provides favorable conditions of microbial growth that is why sun drying helps to cease the bacterial growth.
- The chemicals used for preservation of fish are acids, sodium and ethylene oxide.
- The main disadvantage of using chemicals is that continuous consumption of these chemicals may be harmful if not used under permissible limits and that is why these chemicals are not permitted universally.
- Freezing can also cause desiccation or drying of tissues due to the transfer of moisture from the surface of the fish to the cold surface of the freezing equipment.
- Desiccation and oxidation can be prevented by properly protecting fish with suitable wrappers before freezing.
- Canning is done to overcome the disadvantages of freezing. The fish which are most commonly canned are sardine, herring, lobster, shrimp, mackerel and tuna.
- One of the disadvantages of canning is that the shellfish becomes dark or discoloured during canned storage due to the release of hydrogen sulphide.
- Seaweed is a rich source of several vitamins which includes vitamin A, vitamin C, vitamin D and vitamin E.

- Seaweed is also a rich source of various minerals such as calcium, magnesium, copper, iron and potassium.
- Shrimps are a rich source of protein and are low in fats. It is a good source of vitamin B12 which helps to prevent heart diseases.

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8.7 KEY WORDS

- **Amino Acids:** It refers to organic compounds which contains carboxyl and amine functional groups, along with a side chain which is specific to each amino acid.
- **Irradiation:** It refers to a technology which improves the safety and extends the shelf life of foods by reducing or eliminating microorganisms and insects.
- **Glycogen:** It refers to a multi-branched polysaccharide of glucose which serves as a form of energy storage in humans, animals, fungi, and bacteria.
- **Wet Salting Method:** It refers to a method of preserving fish in which cleaned fish are packed in large vats containing con-centrated salt solutions.

8.8 SELF ASSESSMENT QUESTION AND EXERCISES

Short Answer Questions

1. What are the chemicals used for the preservation of fish?
2. Write a short note on the nutritive value of shrimp.
3. What are the main disadvantages of freezing?
4. State the main types of salting methods.
5. What is canning?

Long Answer Questions

1. Discuss the nutritive value of fish.
2. Identify the main types of fish.
3. What are the reasons which results in the spoilage of fish? Discuss in detail.
4. Explain the disadvantages of sun drying and salting methods.
5. Analyse the nutritive value of seaweed.

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UNIT 9 MILK AND MILK PRODUCTS

NOTES

Structure

- 9.0 Introduction
- 9.1 Objectives
- 9.2 Nutritive Value of Milk Powders
 - 9.2.1 Milk Processing
- 9.3 Milk Products: An Introduction
 - 9.3.1 Spoilage of Milk and Milk Products
- 9.4 Answers to Check Your Progress Questions
- 9.5 Summary
- 9.6 Key Words
- 9.7 Self Assessment Questions and Exercises
- 9.8 Further Readings

9.0 INTRODUCTION

Milk is a nutrient-rich, white liquid food which is produced by the mammary glands of mammals. It is the most important source of nutrition for infants. It contains various nutrients such as lactose and protein.

Milk and milk products are considered to be the best sources of calcium because calcium present in the milk is very easily assimilated. This assimilation is facilitated by vitamin D that is also present in the milk. Milk and milk products are poor sources of iron. *Streptococcus*, *Lactobacillus*, *Pseudomonas*, *Bacillus* are the common spoilage causing microbes.

In this unit, the nutritive value of milk and its products, the process of pasteurisation and its various methods have been discussed in detail. The concept of milk products and the ways in which they are obtained has been explained. The unit will also highlight the reason which results in spoilage of milk.

9.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the nutritive value of milk and its products
- Explain the meaning of pasteurisation and its process
- Analyse how milk products are obtained
- Describe the reasons for spoilage of milk

9.2 NUTRITIVE VALUE OF MILK POWDERS

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Milk is a nutrient-rich, white liquid ingredient which is produced via the mammary glands of mammals. It is the most important supply of eating regimen for toddler mammals (including people who are breastfed) formerly than they are in a function to digest exclusive kinds of food. Early-lactation milk comprises of colostrum, which incorporates the mother's antibodies to its younger and can reduce the threat of many diseases. It contains many distinctive nutrients. Pasteurization is used to kill detrimental pathogenic microorganisms with the aid of heating the milk for a quick time and then barring lengthen cooling it. The types of pasteurized milk consist of full cream, reduced fat, skim milk, calcium enriched, flavored, and UHT. The fashionable high temperature quick time (HTST) process of 72°C for 15 seconds truly kills pathogenic micro organism in milk, rendering it secure to drink for up to three weeks if always refrigerated. Dairies print top notch before dates on every container, after which shops dispose of any unsold milk from their shelves.

The cow milk is a rich source of vitamin D and calcium. Fresh and pure cow milk is also ideal to balance your meal. The nutritional record in the cow milk completely relies on the cow milk you are choosing. This is one of the motives as to why clinical experts usually stress on the want to choose cow milk from the suppliers who feed and take exact care of the cows. This ensures that the milk given through such cows is full of necessary nutrients, calories, minerals and vitamins.

In the following section, we will discuss the nutritive value of milk powder.

- **Whole Milk:** One full cup of total milk has 3.25 per cent of milk fat and is additionally right supply of vitamin D. It has 149 calories and about 7.9 g fat and 4.6 g of saturated fat. Whole milk contains 7.7 g protein and 11.7 g of carbohydrates. Whole milk has zero fibres content material and 28 per cent of DV calcium. It consists of 8 per cent of DV vitamin A and about 31 per cent DV of diet D.
- **Low fat Milk:** Low fat milk is often ate up by means of adults and let us now examine about the nutrients of 1 cup of low fats milk. The *Low fat ordinary milk* has 2 per cent of milk fat and this offers approx 122 calories. The low fats milk has 4.8 g of fat and 3.1 g of saturated fat and about 8.1 g of protein. The milk also has 11.7 g of carbohydrates and 0 fibres. The calcium content in the milk is 29 p.c DV calcium, 9 per cent DV nutrition A and 30 per cent DV of Vitamin D. *Low fat cow milk* has 102 energy with 2.4 g fats and about 1.5 g saturated fat. Low fats cow milk additionally has 8.2 g of protein and about 12.2 g of carbohydrates and zero fibres. The milk additionally has 31% DV calcium and 10% DV nutrition A and 29% DV of Vitamin D.
- **Skimmed Milk:** One full cup serving of skim milk has 83 per cent energy and it has 0.2 g fats and about 0.1 g of saturated fat. Skimmed milk

additionally carries about 8.3 g of protein with 12.2 carbohydrates and zero g of fibres. The milk additionally contains 30 per cent DV calcium, 10 per cent DV diet A and 29 per cent DV of diet D.

9.2.1 Milk Processing

The term 'Heat treatment' means pasteurization, ultra-pasteurization, sterilisation, ultra-high temperature cure or boiling. Pasteurization and other related terms refers to a microbicidal heat therapy aimed at reducing the quantity of any pathogenic micro-organisms in milk and liquid milk products, if present, to a level at which they do no longer constitute a giant health hazard. Pasteurization prerequisites shall be designed to correctly wreck the organisms.

Pasteurization, when used in association with milk, shall be taken to refer to the common process of heating every particle of milk to at least 63°C and preserving at such temperature always for at least thirty minutes or heating it to at least 72°C and preserving at such temperature always for at least fifteen seconds, or any other temperature-time combination, enough to provide a microbicidal impact equal to the above defined temperature-time combination and serve to provide a terrible Phosphatase Test that is relevant to milk without delay after pasteurization only, and cooling it without delay to a temperature of 4°C, or less.

Pasteurization is the process of subjecting food to brief exposures to relatively high temperatures to reduce the number of pathogenic microorganisms. This method of food preservation was introduced by Louis Pasteur. It is especially used to kill the microorganisms that are not heat resistant and the food stuff also cannot stand at high temperatures. However, it does not kill all the microorganisms.

Methods of Pasteurization

The following are the main methods of pasteurization:

- High temperature short time (HTST) or Continuous processing
- Low temperature long time (LTLT) or Batch processing
- Ultra high temperature pasteurization (UHT)

Milk is pasteurized in large batches by heating it to 62.8 °C or 140 °F for 30 minutes to inactivate pathogenic microorganisms (LTLT pasteurization). Another example of HTST pasteurization is the pasteurization of whole egg. The mixture of egg white and egg yolk is heated to 62.8°C for 2 to 5 minutes. This method controls the growth of Salmonella species in eggs.

Now days, milk is subjected to HTST processing. In this process milk is subjected to 72°C (161°F) for 30 seconds. The higher processing temperature increases the shelf life of milk. Milk can be pasteurized at a much higher temperature of 140 °C (290 °F) for 2 to 3 seconds. This is known as UHT pasteurization. UHT milk has a very long shelf life and is available as packaged products in the market.

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Apart from milk and egg mixtures, many other food stuffs can be pasteurized like cheese, almonds, spices, beer, wines and canned products. Some of the latest methods of pasteurization can be discussed in the following section:

Dry steam pasteurization: It is used for pasteurizing spices, seeds, botanicals, flavourings, grains, nuts and edible gums. This process involves rapid penetration of steam and transfer of heat throughout the material to be pasteurized.

Ethylene oxide pasteurization: In this method, ethylene oxide gas is passed through spices and herbs that are to be pasteurized.

Propylene oxide pasteurization: In this method, it decreases the microbial growth in the herbs and spices by passing the propylene oxide gas through them.

However, it is important to consider the following points in the process of pasteurisation:

- The pasteurized food products are not sterile, that is, only some of the vegetative body of the microorganisms dies or becomes inactive but the spores are not killed.
- The shelf life of the pasteurized product like milk depends on the type of method of pasteurization and the refrigeration of the product after pasteurization.

Components of the Pasteurizer

The following are the components of a pasteurizer:

- Balance tank
- Feed pump
- Flow controller
- Regenerative preheating sections
- Centrifugal clarifier
- Heating section
- Holding tube
- Booster pump
- Hot water heating sections
- Regenerative cooling sections
- Cooling sections
- Flow generative valve
- Control panel

Sterilization: Commercial milk sterilization techniques have been developed which expose milk to ultrahigh temperatures for very short periods of time, for example, 300° F (148.9°C) for 1 to 2 seconds. This process eliminates any traces of cooked flavour from the food. The final product is comparable in flavour and nutritional quality to pasteurized milk.

The sterile milk product has several attractive features as it does not require refrigeration and it has indefinite shelf life.

Check Your Progress

1. What is the nutritive value of whole milk?
2. What is dry steam pasteurization?

NOTES

9.3 MILK PRODCUTS: AN INTRODUCTION

We will in this section discuss the types of milk products.

Fermented Milk Products

Bacteria have been used in the preparation of yoghurt and cheeses for centuries ago. There was no awareness of the type of bacteria that was used to prepare these milk products but instead the preparation of new batch was dependent on the starter that was a portion of the previous batch. The people who do not have the ability to break down and absorb lactose(milk sugar), the bacteria enters the gut, producing acid and gas, causing pain and diarrhoea many people are intolerant to fermented milk products such as yogurt. The following are some of the bacteria which is used in the diary industry:

- **Acidophilus milk:** It is made with *Lactobacillus acidophilus*.
- **Butter:** It is prepared by the addition of lactic acid starter to pasteurized cream. The starter contains, for example, *Streptococcus cremoris* or *S. lactis*, but requires *Lactobacillus diacetylactis* to give it its characteristic flavour and odour.
- **Dairy products:** The microbes that can produce acid from lactose, breakdown the milk proteins and the flavour to the compounds are used to prepare cheese, yoghurt and fermented milk.
- **Yoghurt:** It is thickened, fermented milk made using a mixture of bacteria which work together to produce the desired acid and flavours. The microbes are only killed if the product is pasteurized to extend its shelf life. Many people believe that eating live yoghurt bacteria is good for their health.
- **Cheese:** Its manufacture depends on microbial activities at several stages to produce the required flavour, texture and appearance. There are many different types of cheeses. **Blue cheese** is made by inoculating the whole cheeses with a fungus which gives the typical taste and appearance. Cheese is often made with *Streptococcus* and *Lactobacillus* bacteria. Fermentation lowers the pH, thus, helping in the initial coagulation of the milk protein, as well as giving characteristic flavors.
- **Ghee:** Its production includes simmering the butter, which makes it nutty-tasting and aromatic.

NOTES

- **Paneer:** *It* is prepared by adding food acid, such as citric acid or yoghurt, lemon juice in hot milk to separate the curds from the whey.
- **Ice cream:** It is a mixture of milk and sugar which is frozen while being churned to create a frozen product.
- **Khoa:** It is made up of either milk or milk thickened by heating in an open iron pan.

Composite Milk Products

Composite milk products include (i) Shrikhand with fruits (ii) ice cream containing fruits (iii) flavoured fermented milks; (iv) Drinks based totally on fermented milks (c) 'Dairy terms' ability names, designations, symbols, pictorial or other units which refer to or are suggestive, immediately or indirectly, of milk or milk products.

'Recombined milk or milk product' skill, a product resulting from the combination of milk fats and milk solids-non-fat in their preserved varieties with or besides the addition of potable water to achieve comparable give up product traits and fantastic milk product composition as per the Standard for that product and in the case of recombined milk, the source of milk-solids-non-fat shall be dried or targeted milks only; 'Reconstituted milk or milk product' skill a product ensuing from the addition of potable water to the dried or centred structure of milk or milk merchandise in the quantity quintessential to re-establish the terrific water-to-solids ratio to obtain similar quit product characteristics and excellent milk product composition as per the requirements for that product.

Milk and milk merchandise may be enriched or fortified with fundamental vitamins such as vitamins and minerals as designated in these policies which include labelling requirements.

For the use of probiotics and prebiotics in dairy products, the provisions distinctive in the Food Safety and Standards (Health Supplements, Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, Functional Food and Novel food) Regulations, 2016 shall apply.

Safe and suitable enzymes may be used as processing aids in milk and milk merchandise. The recommendations are as follows:

- The whole urea content in milk shall now not be extra than seven hundred ppm.
- The products shall be prepared and dealt with in accordance with the necessities distinct in Food Safety and Standards (Licensing and Registration of Food Businesses) Regulations, 2011.
- The following details shall be declared on the label of pre-packaged milk or in any other case if the milk is now not prepackaged and is offered for sale to the consumer, such announcement shall be given on the container from which milk is presented for sale to the consumer:

- a) The classification of milk
- b) The heat treatment
- c) If the milk from any milch animal, combined milk or skimmed milk

‘Milk Product’ refers to a product which is obtained by processing of milk, which may contain food additives and other ingredients functionally necessary for the milk product as permitted in these regulations and shall include the following: (i) cheese (ii) chhana, skimmed-milk chhana, paneer (iii) condensed milk-sweetened and unsweetened (iv) condensed skimmed milk-sweetened and unsweetened (v) cream (vi) curd, skimmed milk curd, dahi (vii) ghee, butter oil (viii) ice-cream (ix) infant milk food (x) khoa.

NOTES

Milk products	Description
Flavoured Milk	Prepared from milk or other products derived from milk, or both, and edible flavourings with or without addition of sugar, nutritive sweeteners, other non-dairy ingredients including, stabilisers and food colours; Other non-dairy ingredients like nuts (whole, fragmented or ground), cocoa solids, chocolate, coffee, fruits and vegetables and products thereof including juices, purees, pulps and Potable water.
Evaporated or Concentrated Milk	Obtained by partial removal of water from milk by heat or any other process which leads to a product of the same composition and characteristics
Sweetened Condensed Milk	Obtained by partial removal of water from milk with the addition of sugar or a combination of sucrose with other sugars, or by any other process which leads to a product of the same composition and characteristics.
Khoa	Obtained by partial removal of water from any variant of milk with or without added milk solids by heating under controlled conditions

9.3.1 Spoilage of Milk and Milk Products

Although milk is sterile when secreted by the cow, it becomes contaminated with bacteria before it leaves the udder and the bacteria contaminate the milk before it is drawn. These bacteria contain an enzyme which is similar to the casein-coagulating enzyme, rennin, found in the rennet extracted from the stomach of the calf. It is used in the manufacture of cheese. Among the foreign materials which may drop into the milk during milking are manure, bedding, soil, and hair. The amount of this contamination is decreased by keeping the cows under the conditions that will reduce the mud and manure on the animals’ coat, by clipping the flanks, by wiping the flanks and udder with a damp cloth before milking, or by using a small-topped milk pail or a properly treated milking machine. The coliform bacteria and Clostridium species get into milk from this from this source and may cause undesirable fermentations in milk.

Smaller numbers of microorganisms are introduced into the milk by the milker directly. The number of microorganisms into the milk by flies is not large, but may introduce undesirable kinds of pathogenic bacteria.

NOTES

Utensils are most likely to cause a large increase in the number of microorganisms. These contaminants are likely to grow rapidly in milk or milk products, and can cause undesirable changes or spoilage. These utensils include the equipment and containers with which the milk comes in contact, such as milk pails, milking machines, strainers, cans, coolers, stirrers, separators, clarifiers, pipes, pumps, homogenizers, vats or kettles, bottle fillers and bottles.

TYPE OF SPOILAGE	MICROORGANISMS	SIGNS OF SPOILAGE
Souring	Streptococcus sp. Lactobacillus sp.	Sour milk and curd formation
Sweet Curdling	Bacillus sp. Proteus sp. Micrococcus sp.	Alkaline pH and curd formation
Gas Production	Clostridium sp. Coliform bacteria	Explosion of curds
Ropiness	Alcaligenes sp.	Stringy or slimy milk
Red Rot	Serratia	Red coloration
Grey Rot	Clostridium sp.	Grey coloration and foul smell
Dairy Mold	Penicillium	Moldy appearance

Milk is a nutrient-rich, white liquid meals produced by the mammary glands of mammals. It is the most important source of diet for toddler mammals (including people who are breastfed) earlier than they are in a position to digest different kinds of food. Early-lactation milk incorporates colostrum, which incorporates the mother's antibodies to its younger and can minimize the risk of many diseases. It incorporates many different nutrients. Pasteurization is used to kill harmful pathogenic bacteria with the aid of heating the milk for a brief time and then without delay cooling it. Types of pasteurized milk include full cream, reduced fat, skim milk, calcium enriched, flavoured, and UHT. The fashionable high temperature brief time (HTST) process of seventy two °C for 15 seconds absolutely kills pathogenic micro organism in milk, rendering it secure to drink for up to three weeks if continuously refrigerated. Dairies print fantastic before dates on every container, after which stores dispose of any unsold milk from their shelves.

A facet impact of the heating of pasteurization is that some vitamin and mineral content material is lost. Soluble calcium and phosphorus minimize with the aid of 5 per cent thiamin and diet B12 through 10 per cent, and diet C via 20 per cent. Because losses are small in comparison to the massive quantity of the two B-vitamins present, milk continues to grant enormous amounts of thiamin and diet B12. The loss of vitamin C is no longer nutritionally significant, as milk is no longer a necessary dietary source of diet C.

Check Your Progress

3. How is butter prepared?
4. How is khoa obtained?

NOTES

9.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Whole milk contains 7.7 g protein and 11.7 g of carbohydrates. Whole milk has zero fibres content material and 28 per cent of DV calcium. It consists of 8 per cent of DV vitamin A and about 31 per cent DV of diet D.
2. Dry steam pasteurization is used for pasteurizing spices, seeds, botanicals, flavourings, grains, nuts and edible gums. This process involves rapid penetration of steam and transfer of heat throughout the material to be pasteurized.
3. Butter is prepared by the addition of lactic acid starter to pasteurized cream. The starter contains, for example, *Streptococcus cremoris* or *S. lactis*, but requires *Lactobacillus diacetylactis* to give it its characteristic flavour and odour.
4. Khoa is obtained by partial removal of water from any variant of milk with or without added milk solids by heating under controlled conditions.

9.5 SUMMARY

- Milk is a nutrient-rich, white liquid ingredient which is produced via the mammary glands of mammals.
- Early-lactation milk comprises of colostrum, which incorporates the mother's antibodies to its younger and can reduce the threat of many diseases. It contains many distinctive nutrients.
- Pasteurization is used to kill detrimental pathogenic microorganisms with the aid of heating the milk for a quick time and then barring lengthen cooling it.
- The cow milk is a rich source of vitamin D and calcium. Fresh and pure cow milk is also ideal to balance your meal.
- Whole milk contains 7.7 g protein and 11.7 g of carbohydrates. Whole milk has zero fibres content material and 28 per cent of DV calcium.
- The low fats milk has 4.8 g of fat and 3.1 g of saturated fat and about 8.1 g of protein. The milk also has 11.7 g of carbohydrates and 0 fibres.
- Skimmed milk additionally carries about 8.3 g of protein with 12.2 carbohydrates and zero g of fibres.

NOTES

- Pasteurization is the process of subjecting food to brief exposures to relatively high temperatures to reduce the number of pathogenic microorganisms.
- Milk is pasteurized in large batches by heating it to 62.8 C or 140 F for 30 minutes to inactivate pathogenic microorganisms (LTLT pasteurization).
- Now days, milk is subjected to HTST processing. In this process milk is subjected to 72°C (161°F) for 30 seconds.
- Dry steam pasteurization is used for pasteurizing spices, seeds, botanicals, flavourings, grains, nuts and edible gums.
- In ethylene oxide pasteurization, ethylene oxide gas is passed through spices and herbs that are to be pasteurized.
- In Propylene oxide pasteurization, it decreases the microbial growth in the herbs and spices by passing the propylene oxide gas through them.
- Commercial milk sterilization techniques have been developed which expose milk to ultrahigh temperatures for very short periods of time, for example, 300° F (148.9°C) for 1 to 2 seconds.
- The microbes that can produce acid from lactose, breakdown the milk proteins and the flavour to the compounds are used to prepare cheese, yoghurt and fermented milk.
- ‘Milk Product’ refers to a product which is obtained by processing of milk, which may contain food additives and other ingredients functionally necessary for the milk product as permitted in these regulations.
- Although milk is sterile when secreted by the cow, it becomes contaminated with bacteria before it leaves the udder and the bacteria contaminate the milk before it is drawn.
- Milk is a nutrient-rich, white liquid meals produced by the mammary glands of mammals. It is the most important source of diet for toddler mammals (including people who are breastfed) earlier than they are in a position to digest different kinds of food.
- The fashionable high temperature brief time (HTST) process of seventy two °C for 15 seconds absolutely kills pathogenic micro organism in milk, rendering it secure to drink for up to three weeks if continuously refrigerated.

9.6 KEY WORDS

- **Ethylene Oxide Pasteurization:** It refers to a pasteurisation method in which ethylene oxide gas is passed through spices and herbs that are to be pasteurized.
- **High Temperature Short Time (HTST):** It refers to a process in which milk is subjected to 72°C (161°F) for 30 seconds. The higher processing temperature increases the shelf life of milk.

- **Pasteurization:** It refers to the process of subjecting food to brief exposures to relatively high temperatures to reduce the number of pathogenic microorganisms.
- **Propylene Oxide Pasteurization:** It refers to a pasteurisation method which decreases the microbial growth in the herbs and spices by passing the propylene oxide gas through them.

NOTES

9.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. What are the main methods of pasteurization?
2. Why is the shelf life of UHT milk long?
3. What are the main components of a pasteuriser?
4. Write a short note on sterilisation.
5. How is sweetened condensed milk prepared?

Long Answer Questions

1. Discuss the nutritive value of milk products.
2. Explain the process of pasteurization in detail.
3. What are fermented milk products? Discuss in detail.
4. Analyse the types of composite milk products.
5. Discuss the reasons which result in spoilage of milk.

9.8 FURTHER READINGS

- Jain, J.L., Jain, Sunjay & Nitin Jain. 2004. *Fundamentals of Biochemistry*. New Delhi: S. Chand.
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UNIT 10 FATS AND OILS

NOTES

Structure

- 10.0 Introduction
- 10.1 Objectives
- 10.2 Role of Fat in Cookery
 - 10.2.1 Salad Dressing
 - 10.2.2 Changes of Fat on Heating
- 10.3 Rancidity: An Introduction
- 10.4 Answers to Check Your Progress Questions
- 10.5 Summary
- 10.6 Key Words
- 10.7 Self Assessment Questions and Exercises
- 10.8 Further Readings

10.0 INTRODUCTION

Fat can be classified as one of the three main macronutrients, the other two being: carbohydrate and protein. Fats molecules mainly constitute of carbon and hydrogen atoms; therefore, they are hydrocarbon molecules. Cholesterol, phospholipids and triglycerides are some examples of fat molecules. Fats are in most cases, hydrophobic, and are soluble in organic solvents and insoluble in water.

Fat forms an essential nutrient for many forms of life and serve functions that are structural and metabolic. They constitute a crucial part of the diet of most organisms that cannot manufacture their own food by carbon fixation. Fats are nutrients with maximum energy density, thus the most efficient form of energy storage. They do not bind water and do not lead to the increase body mass in comparison to proteins, especially carbohydrates, both of which bind a lot more water.

In this unit the role of fat in cookery has been discussed. The process of rancidity has been explained. The changes of fat on heating as well as salad dressing have also been highlighted in this unit.

10.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the role of fats and oils in foods
- Describe the changes of fat on heating
- Explain the importance of salad oils in salad dressing
- Discuss the concept of rancidity

10.2 ROLE OF FAT IN COOKERY

Fats are the primary constituents of margarines, butterfat, shortenings, and oils for salad and cooking. In addition to the visible fat contained in food, fats and oils are found in high quantities in many bakery goods, infant formulas, and dairy products and some sweets. Oils, butter or margarine are sometimes used directly on food.

NOTES

Cooking Oils

- The major use of cooking oil is in frying, where it functions as a heat transfer medium and contributes flavour and texture to foods.
- The cooking oil should be stable under high temperatures and moisture during deep-fat frying. For satisfactory results, oil should be kept at a maximum temperature of 180°C during frying.
- Frying food at a temperature that is too low, results in increased fat uptake.
- Stable oil is required when foods that are fried are stored before eating, for example, snack products.
- Frying oils made from sunflower and safflower has lower stability because of their high polyunsaturated fatty acids and low tocopherol content.
- For optimal use of cooking oils, it is necessary to distinguish between different frying conditions. The most important parameters to be monitored are duration of use and nature of the foods to be fried. If food fats enter the frying oil, food components could destabilize the oil and the water content of the material could influence the frying operation. Finally, temperature must be considered.

Margarines

- Margarines must have some crystalline structure to maintain a semisolid consistency at refrigerator and room temperatures.
- Sharp melting at body temperature is needed so that the margarine will melt rapidly in the mouth leaving no waxy feeling.
- In addition to partial hydrogenation, the correct consistency of a margarine can be obtained by blending soft and hard fats. Lower fat spreads, for example, 40 percent or 60 percent fat, contain less trans fatty acids.
- According to FSSAI, margarines should have following properties:

NOTES

1. Fat	Not less than 80 per cent mass/mass
2. Moisture	Not less than 12 per cent and not more than 16 per cent mass/mass.
3. Vitamin A	Not less than 30 I.U. per gram of the product at the time of sale.
4. Melting point of extracted fat	31 degree C to 37 degree C (Capillary Slip method).
5. Unsaponifiable matter of	Not more than 1.5 per cent by weight extracted fat.
6. Free fatty acids (as oleic acid)	Not more than 0.25 per cent weight acid) of extracted fat
7. Acid value	Not more than 0.5

Shortenings

- Shortenings are semisolid fats that impart a 'short' or tender quality to baked goods, enhance the aeration of leavened products, and promote a desirable grain and flavour.
- They coat the gluten proteins of flour and thereby prevent toughness. In baked goods, shortenings are used specifically to leaven, cream and lubricate. In icings and fillings, the fats help to form tiny air bubbles that create a light and fluffy structure. Shortenings used as stable frying fats provide a heating medium, and their crystalline structures are not important.
- The melting behavior of bakery shortenings remains constant over a wide range of temperature and have a wide plastic range. This quality allows the fat to be easily manipulated without melting at room temperature and enhances its mixing ability.

Fat Spread

- Fat spread means a product in the form of water in oil emulsion, or an aqueous phase and a fat phase of edible oils and fats excluding animal body fats.
- Fat spread shall be classified into the following three groups:
 - a) Milk fat spread:** Fat content will be exclusively milk fat.
 - b) Mixed fat spread:** Fat content will be a mixture of milk fat with any one or more of hydrogenated, unhydrogenated refined edible vegetable oils or interesterified fat.
 - c) Vegetable fat spread:** Fat content will be a mixture of any two or more of hydrogenated, unhydrogenated, refined vegetable oils or unesterified fat.

10.2.1 Salad Dressing

We will in this section discuss the concept of salad dressing.

- Salad oils are used in salad dressings.
- Traditional salad dressings, some of which are emulsified, consist of a two-phase system of oil and water with 55-65 per cent oil.
- A salad oil coats the salad ingredients, spreading the flavour of the dressing that improves the palatability of the salad.
- The other major use of salad oils is in mayonnaise and thick salad dressings, which contain 80 and 35-50 per cent oil, respectively.
- The oil in mayonnaise is responsible for viscosity, whereas the oils in thick salad dressings help to modify the mouthfeel of the starch paste that thickens the product.
- For industrial purposes, unhydrogenated or partially hydrogenated soybean, canola, winterized cottonseed, safflower, sunflower, and corn oils are used as salad oils. Olive oil has a unique flavour, although it forms crystals at refrigerator temperature, it is often served at room temperature as a salad oil.

NOTES

10.2.2 Changes of Fat on Heating

The solid fat content (SFC) of a lipid influences many of its sensory and physical properties, such as spread ability, firmness, mouthfeel, processing and stability.

Melting point

Foods lipids contain a wide variety of different triacylglycerols, each with their own unique melting point, and so they melt over a wide range of temperatures. Thus, the 'melting point' of a food lipid can be defined in a number of different ways, each corresponding to a different amount of solid fat remaining.

Clear point.

A small amount of fat is placed in a capillary tube and heated at a controlled rate. The temperature at which the fat completely melts and becomes transparent is called the 'clear point'.

Slip point

A small amount of fat is placed in a capillary tube and heated at a controlled rate. The temperature at which the fat just starts to move downwards due to its weight is called the 'slip point'.

Wiley melting point.

A disc of fat is suspended in an alcohol-water mixture of similar density and is then heated at a controlled rate. The temperature at which the disc changes shape to a sphere is called the 'Wiley melting point'.

NOTES**Cloud point**

Cloud point gives a measure of the temperature at which crystallization begins in liquid oil. A fat sample is heated to a temperature where all the crystals are known to have melted.

Smoke, Flash and Fire points

Smoke, flash and fire tests give a measure of the effect of heating on the physicochemical properties of lipids. They are particularly important for selecting lipids that are going to be used at high temperatures, for example, during baking or frying. The tests reflect the amount of volatile organic material in oils and fats such as free fatty acids.

Saponification

Saponification is the process of breakdown of neutral fat into glycerol and fatty acids by their treatment with alkali. The saponification number is a measure of the average molecular weight of the triacylglycerols in a sample. The saponification number is defined as the mg of KOH required to saponify one gram of fat. The smaller the saponification number the larger is the average molecular weight of the triacylglycerols present.

Check Your Progress

1. Why are frying oils made from sunflower and safflower have low stability?
2. State the major use of cooking oil.
3. What is margarine?

10.3 RANCIDITY: AN INTRODUCTION

We will in this section discuss the concept of rancidity.

Hydrolases

- The presence of hydrolases in foodstuffs and their tendency to liberate short-chain acids which have low odour and aroma thresholds, from the tasteless triacylglycerol components is an extremely important mechanism of introducing sensory alteration in food.
- Changes due to hydrolysis may be desirable as in the case of hydrolysis by molds in blue cheeses or it may be unpleasant as in case of high butyric acid levels in butter.
- In commonly used vegetable oils, the polyunsaturated C18 acids are readily oxidized into very odoriferous compounds.
- In fruits and vegetables and especially when tissues are sliced or homogenized during processing, oxidation and lipolysis are frequently observed.
 - Free acids are responsible for off flavours and enhanced oxidation.

Oxidation of unsaturated fatty acids

- The various types of lipid oxidation can be distinguished depending on the nature of the agents responsible for its onset and rate.
- Induced changes in food aroma are continually assessed by consumers as objectionable, for example, as rancid, fishy, metallic or cardboard-like, or as an undefined aged, stale or warmed up flavour.
- Some volatile compounds, at a level below their off-flavour threshold values, contribute to the pleasant aroma of many fruits and vegetables and to rounding-off the aroma of many fat- or oil-containing food should not be neglected.

NOTES

Check Your Progress

4. What are hydrolases?
5. What are the type of changes in food aroma caused due to oxidation of saturated fatty acids?

10.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Frying oils made from sunflower and safflower has lower stability because of their high polyunsaturated fatty acids and low tocopherol content.
2. The major use of cooking oil is in frying, where it functions as a heat transfer medium and contributes flavour and texture to foods.
3. Margarines are a type of cooking fat with a semisolid consistency.
4. Hydrolases are enzymes present in fatty acids responsible for introducing unpleasant sensory alteration in food items.
5. Induced changes in food aroma is caused due to oxidation of saturated fatty acids could be classified as rancid, fishy, stale or metallic.

10.5 SUMMARY

- Fats are the primary constituents of margarines, butterfat, shortenings, and oils for salad and cooking.
- In addition to the visible fat contained in food, fats and oils are found in high quantities in many bakery goods, infant formulas, and dairy products and some sweets.
- The major use of cooking oil is in frying, where it functions as a heat transfer medium and contributes flavour and texture to foods.

NOTES

- Margarines must have some crystalline structure to maintain a semisolid consistency at refrigerator and room temperatures.
- Stable oil is required when foods that are fried are stored before eating, for example, snack products.
- Sharp melting at body temperature is needed so that the margarine will melt rapidly in the mouth leaving no waxy feeling.
- Shortenings are semisolid fats that impart a 'short' or tender quality to baked goods, enhance the aeration of leavened products, and promote a desirable grain and flavour.
- The melting behavior of bakery shortenings remains constant over a wide range of temperature and have a wide plastic range.
- Fat spread means a product in the form of water in oil emulsion, or an aqueous phase and a fat phase of edible oils and fats excluding animal body fats.
- Traditional salad dressings, some of which are emulsified, consist of a two-phase system of oil and water with 55-65 percent oil.
- The other major use of salad oils is in mayonnaise and thick salad dressings, which contain 80 and 35-50 per cent oil, respectively.
- Olive oil has a unique flavour, although it forms crystals at refrigerator temperature, it is often served at room temperature as a salad oil.
- Foods lipids contain a wide variety of different triacylglycerols, each with their own unique melting point, and so they melt over a wide range of temperatures.
- The temperature at which the fat completely melts and becomes transparent is called the 'clear point'.
- The temperature at which the fat just starts to move downwards due to its weight is called the 'slip point'.
- The temperature at which the disc changes shape to a sphere is called the 'Wiley melting point'.
- Cloud point gives a measure of the temperature at which crystallization begins in liquid oil.
- Smoke, flash and fire tests give a measure of the effect of heating on the physicochemical properties of lipids.
- Saponification is the process of breakdown of neutral fat into glycerol and fatty acids by their treatment with alkali.
- The saponification number is defined as the mg of KOH required to saponify one gram of fat.
- The various types of lipid oxidation can be distinguished depending on the nature of the agents responsible for its onset and rate.

- Induced changes in food aroma are continually assessed by consumers as objectionable, for example, as rancid, fishy, metallic or cardboard-like, or as an undefined aged, stale or warmed up flavour.
- The solid fat content (SFC) of a lipid influences many of its sensory and physical properties, such as spread ability, firmness, mouthfeel, processing and stability.
- Induced changes in food aroma are continually assessed by consumers as objectionable, for example, as rancid, fishy, metallic or cardboard-like, or as an undefined aged, stale or warmed up flavour.

NOTES

10.6 KEY WORDS

- **Alkali:** It refers to a chemical substance which reacts with acids to form a salt and gives a solution with a pH of more than seven when dissolved in water.
- **Hydrophobic:** It refers to a tendency to rebel or not mix with water.
- **Lipid:** It refers to any natural substance that does not dissolve in water.
- **Macronutrients:** It refers to types of food items that are required in considerable amounts in a diet.

10.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. Write a short note on the importance of fat on a diet.
2. Define fat spread.
3. What is meant by 'melting point' with relation to fat?
4. What is 'cloud point'?
5. State the premise of saponification number.

Long Answer Questions

1. Discuss the various ways in which fat is used in cookery.
2. Explain saponification.
3. Analyse the process of rancidification in food stuff.
4. Explain the usage of salad oils in salad dressing in detail.
5. Describe the types of fat spread.

10.8 FURTHER READINGS

NOTES

- Jain, J.L., Jain, Sunjay & Nitin Jain. 2004. *Fundamentals of Biochemistry*. New Delhi: S. Chand.
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UNIT 11 BEVERAGES

Structure

- 11.0 Introduction
- 11.1 Objectives
- 11.2 Beverages: An Introduction
 - 11.2.1 Beverages and Nutritional Significance
 - 11.2.2 Classification of Beverages
- 11.3 Manufacturing of Beverages
- 11.4 Answers to Check Your Progress Questions
- 11.5 Summary
- 11.6 Key Words
- 11.7 Self Assessment Questions and Exercises
- 11.8 Further Readings

NOTES

11.0 INTRODUCTION

A beverage is a fluid which is intended for human consumption. The most common types of beverages are plain drinking water, milk, coffee, tea, hot chocolate and soft drinks. Beverages can be classified in two parts namely, alcoholic beverages and non-alcoholic beverages. Alcoholic beverages include wine, beer, and liquor. Non-alcoholic beverages include drinks that would normally contain alcohol, such as beer and wine, but are made with less than 0.5 percent alcohol by volume. The category includes drinks that have undergone an alcohol removal process such as non-alcoholic beers and de-alcoholized wines.

A wide range of plant materials are used to manufacture beverages such as leaves, stems, sap, fruits, tubers, and seeds (grains). An extensive variety of beverages can be made either pulped natural product or juice. The most widely recognized precedents of alcoholic beverages are wine and beer. Beer is generally produced using a cereal, though wine can be created from either cereal or fruit product. Both can be refined to deliver spirits with a liquor content of 30 to 50 per cent.

In this unit, the nutritive value of beverages and its types have been explained. The process of manufacturing of alcoholic and non-alcoholic beverages has been discussed. The fermentation process of wine and beer and the ways in which beverages are packaged have been highlighted in this unit.

11.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the nutritive and energy value of beverages

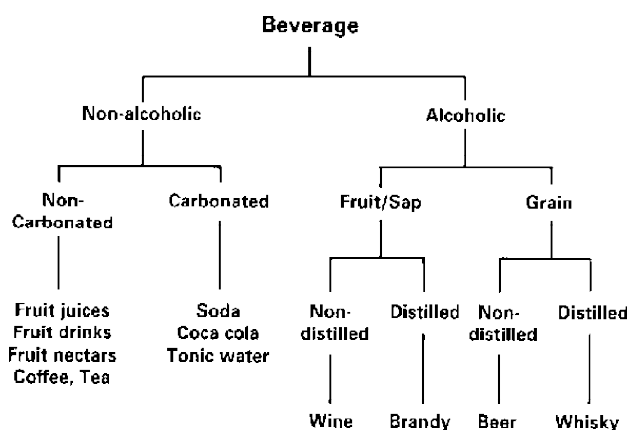
- Explain the various types of beverage
- Analyse the process of manufacturing of beverages
- Discuss the various packaging techniques of beverages

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11.2 BEVERAGES: AN INTRODUCTION

A wide range of plant materials are used to manufacture beverages. These include leaves, stems, sap, fruits, tubers, and seeds (grains).

The classification of beverages has been classified as follows:



The market for beverages is comprehensively isolated in numerous nations into those items that are purchased to extinguish thirst, and those that are expended on special events including celebrations. Generally, non-alcoholic beverages include tea, espresso, and soda pops (juices, nectars, and carbonated beverages). In some of the countries, these items are additionally utilized on social events, while in different regions mixed refreshments are favoured (albeit soda pops are likewise normally accessible). Competition from medium or large-scale producers is most acute for small-scale producers in beverage manufacture. Many large-scale producers promote their products by implying status in their consumption and spend considerable amounts on advertising and packaging. They may have also established sophisticated distribution systems and specific agreements with wholesalers and retailers. Thus, for small-scale producers, manufacturing of beverages is difficult as the large-scale manufacturers have already established themselves in the market.

11.2.1 Beverages and Nutritional Significance

Most of the beverages contains a lot of water. However, it does not add any kind of nutrients to our body but plays a crucial role in maintaining the hydration levels in our body.

Refreshments are not for the most part expended for their sustenance esteem, but rather many, especially the natural product drinks, contain a significant high

level of sugar and along these lines add to the vitality substance of the eating routine. Moreover, natural product juices offer various vitamins and minerals to the consumers.

There are certain beverages which comprises of various flavours and colours are also added to it. The utilization of such added substances is administered by legitimate prerequisites and it is crucial to keep to these controls with the end goal to shield the purchaser from any unfortunate symptoms. Some beverages for instance are thought to cause hyperactivity in youngsters and are therefore, must not be consumed in large quantities or be avoided.

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11.2.2 Classification of Beverages

We will in this section, discuss the main types of beverages.

Non-alcoholic Beverages

An extensive variety of beverages can be made which contain as the base material either pulped natural product or juice. Most of which are consumed as a natural product juice without the addition of other ingredients, whereas others are diluted with sugar syrup.

For simplicity, fruit drinks can be divided into two groups:

- Those that are consumed immediately after opening.
- Those that are consumed in smaller quantities from bottles which are stored for use.

The former category does not need any preservative if processed and packaged properly. However, the latter must contain a definite amount of permitted preservatives to have a long shelf-life after opening.

Let us discuss some of the types of non-alcoholic beverages.

- **Juices:** These are pure fruit juice with nothing added.
- **Nectars:** These normally contain 30 per cent fruit solids and are drunk immediately after opening.
- **Squashes:** These normally contain at least 25 per cent fruit pulp mixed with sugar syrup. They are diluted, to taste, with water and may contain preservatives.
- **Cordials:** These are crystal-clear squashes.
- **Syrups:** These are concentrated juices which are clear. They normally have a high sugar content.

Each of the above products is preserved by its natural acidity and by pasteurization. Some drinks (syrups and squashes) also contain a high concentration of sugar which helps to preserve them.

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Fruit juice <ul style="list-style-type: none"> •100% of fruit in drink •Largely regulated throughout the world; 'juice' is often protected 	Fruit drink <ul style="list-style-type: none"> •10% of fruit in drink •Fruit is liquefied and water added. 	Fruit squash <ul style="list-style-type: none"> •25% of fruit in drink •Produced using strained fruit juice, 45% sugar and preservatives.
Fruit cordial <ul style="list-style-type: none"> •0% •All 'suspended matter' is eliminated by filtration or clarification and 	Fruit punch <ul style="list-style-type: none"> •25% of fruit in drink •A mixture of fruit juices. Contains around 65% sugar. 	Fruit syrups <ul style="list-style-type: none"> •- •1 fruit crushed into puree and left to ferment. Is then heated
Fruit juice concentrates <ul style="list-style-type: none"> •100% of fruit in drink •Water removed from fruit juice by heating or freezing. 	Carbonated fruit drinks <ul style="list-style-type: none"> •- •Carbon dioxide added to fruit drink. 	Fruit nectars <ul style="list-style-type: none"> •30% of fruit in drink •Mixture of fruit pulp, sugar and water which is consumed as 'one shot'.
	Fruit Sherbets <ul style="list-style-type: none"> •- •Cooled drink of sweetened diluted fruit juice. 	

Alcoholic Beverages

The most widely recognized precedents of alcoholic beverages are wine and beer. Beer is generally produced using a cereal, though wine can be produced from either cereal or fruit product. However, both can be refined to deliver spirits with a liquor content of 30-50 percent.

Wine and brew are produced with the help of fermentation which includes the transformation of sugars in the crude material or included sugar into alcohol and carbon dioxide. Various types of yeast are used in the processing of beer and wine.

Product	Type of yeast
Beer	'Top yeast' - <i>Saccharomyces cerevisiae</i>
Lager	'Bottom yeast' - <i>Saccharomyces carlsbergensis</i>
Fruit wine	'Wine yeast' - <i>S. oriformis</i> , <i>S. chevalieri</i> , <i>S. cerevisiae</i> (variety <i>ellipsoideus</i>) or a mixture of these
Palm wine	'Wild yeast'- natural mixture of yeasts
Rice wine	<i>Saccharomyces sake</i>

However, it is possible to use any kind of yeast in the production. However, it is important for a small producer to select a type of yeast which works best for that particular wine and beer and to deliver a consistent product in the market.

Beers <ul style="list-style-type: none"> •typically 5% (range is from 3–15%) of alcohol by volume (ABV) 	Wines <ul style="list-style-type: none"> •typically 13.5% (range is from 8%–17%) of alcohol by volume (ABV) 	Fortified wines <ul style="list-style-type: none"> •15–22% of alcohol by volume (ABV)
Spirits <ul style="list-style-type: none"> •typically 30%-40% (range is from 15% to, in some rare cases, up to 98%) of alcohol by volume (ABV) 	Fruit juices <ul style="list-style-type: none"> •< 0.1% of alcohol by volume (ABV) 	Cider, wine coolers <ul style="list-style-type: none"> •4%–8% of alcohol by volume (ABV)

Check Your Progress

1. What are the two main types of fruit drinks?
2. How is wine produced?

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11.3 MANUFACTURING OF BEVERAGES

Alcohol has a lower boiling-point than water and distillation (vaporizing the alcohol and then condensing it) is used to concentrate the alcohol in spirit drinks. Distillation is carried out in stills which can be purchased for production at all levels. Alternatively, it is possible to construct a basic still using locally-available materials. A cleaned oil drum is fitted with a pipe to divert the vapor, and a safety pipe. Alcoholic liquid is put inside the drum and warmed. On vaporization, the liquor vapor is carried out of the drum by means of the pipe and went through cooled air or cool water. The distillate condenses and is gathered.

Equipment Required

Processing stage	Equipment
Juice pulping/extraction	Fruit press
	Pulper/juicer
Mashing	Fermentation bins
Mixing	Mixers
Boil	Boiling pans
Fermentation	Fermentation bins/jars
Filter	Filters and filter presses
	Sieves
	Strainers
Carbonation	Carbonating equipment
Filling into bottles	Liquid fillers Funnel
Pasteurize	Open boiling pan
	Steam jacketed pan
	Pasteurizer

Processing of Beverages

The processing of non-alcoholic beverages involves the following stages:

Juice extraction: Either the juice or the pulp from fruit is the starting material for the manufacture of soft drinks and wines.

Pulping: Soft fruits, such as papaya, can easily be pulped by hand or by using a pestle and mortar. A wide range of hand-operated pulpers are available, or if electric power is available, multi-purpose kitchen-scale equipment such as blenders can be used. At an industrial level, this process is normally carried out in pulpers

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which brush the fruit through a sieve and eject the skin and stones. Smaller models of this machine can be manufactured and are commercially available.

Extraction: Juice can be extracted from fruit in the following ways:

- With a fruit press, fruit mill or hand pulper/sieve.
- By crushing/pulping with a mortar and pestle and then sieving through muslin cloth or plastic sieves.
- By steaming the fruit.
- Citrus fruit juices need to be extracted by reaming (squeezing) the fruit, and once again, comparatively simple equipment is available for this purpose.

Fermentation: The process for achieving fermentation differs considerably depending upon the product.

Beer and its Process of Fermentation

The process for making beer is known as brewing. Brewing consists of three stages, namely, mashing, boiling and fermentation.

Mashing involves the use of hot water (approximately 68°C) to extract the miscible substances from the malted grains. This results in production of a liquid called wort. The process is carried out in large vessels which may be made of wood or stainless steel.

The wort is then subjected to a process of boiling. This process also involves the addition of hops. Boiling takes place in a similar vessel to the tubs used for mashing except that it is flask-shaped, with the neck being elongated in order to remove the steam, and to put off over-boiling.

Before inoculation (addition of the yeast), the wort is cooled. This is because if added to the hot wort the yeast would be inactivated. The degree to which the wort is cooled differs according to the type of beer to be produced. For example, fermentation for lager is carried out at 12-15°C using the yeast *Saccharomyces carlsbergensis*. In other cases, the yeast *Saccharomyces cerevisiae* is used at a temperature of 20°C. During fermentation, the beer is held in fermentation vats or food-grade plastic containers. When fermentation is complete, the process of packaging will depend on whether the beer is to be sold in draught form (for example, in a keg), or if it is to be bottled and corked. If it is to be draught, the beer is not filtered, and little amounts of yeast are left in it in order to keep it slightly carbonated. In the case of bottled beer, it is filtered and pasteurized.

Wine and its Process of Fermentation

In wine-making, the fruit juice or pulp is mixed with yeast and sugar and held in a fermentation container made from food-grade plastic. This is left for about ten days during the first fermentation stage. Within 48 hours, fermentation becomes dynamic and there is frothing and foaming. It is significant to keep the fermentation vessel closed to avert bacteria and fungi from infecting the wine. After ten days the

fermenting wine is racked. This is done by scooping it up simultaneously with the solids using a sterilized mug, cup, or jug, and passing it through a muslin or nylon straining material. The cloth should have been sterilized and rinsed previously and positioned in a funnel. The wine is transferred into tapered necked fermentation vessels. These may be plugged with stack of cotton wool, or specially-designed vessels provided with an airlock (known as a demijohn) may be used.

Preferably, fermentation is then continued at a temperature of 18°C. The whole process can take from three weeks to three months. The end of fermentation can be judged when it is observed that there are no additional bubbles rising to the surface. At this point, the wine is filtered, to eliminate the sediment from the wine and then drawn off into narrow-necked or food-grade plastic containers and stored for the minimum period in the recipe to permit the wine time to clear and mature before bottling. Subsequent to this phase of maturation, the wine is siphoned off into bottles and sealed with a sterilized cork-stopper or screw cap.

After the process of fermentation, the following steps are followed in case of all the types of beverages.

Carbonation: It involves the introduction of carbon dioxide into a drink. The most usual way of achieving this is to use a pressurized cylinder or tank which contains a mixture of water and carbon dioxide. In the case of soft drinks, the bottle is filled to a certain level with the flavoured syrup, the bottle is positioned under the cylinder head and carbon dioxide is released. The bottles are capped instantaneously. Cylinders for holding carbon dioxide are accessible for both large-scale production and in smaller sizes for use at the household level.

Pasteurization: Liquid products such as drinks may need to be pasteurized if they are to have a shelf-life of more than a few days. Pasteurization involves heating the product to a temperature of 80-90°C and holding it at that temperature for between 0.5 and 5 minutes before filling into clean sterilized bottles. Pasteurization is best carried out over a direct heat in stainless steel pans. Some products can be pasteurized in bottles. The filled bottles, with the lids loosely closed, are stood in a large pan of boiling water with the water-level around the shoulder of the bottle. The time and temperature required for pasteurization will depend on the product and the bottle size.

Packaging: Beverages depending on their type are packed in different ways. However, the one thing common to all the types of packaging is that there must be no leakage.

The following table outlines some of the other storage requirements and the suitability of different types of container.

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	Light	Air	Heat	Micro-organisms	Insects
Fruit juice, cordial	Little requirement	Requirement		Requirement	Requirement
Beer	Requirement	Requirement	Requirement	Requirement	Requirement
Wine	Requirement	Requirement		Requirement	Requirement
Soft drinks				Requirement	Requirement

	Glass bottle/jar	Metal can	Plastic film/pot/pouch	Ceramic pot
Fruit juice cordials	Requirement	Lacquered	Requirement	Requirement
Beer	Coloured	Lacquered	Requirement	requirement
Wine	Requirement			Requirement
Soft drinks	Requirement	Requirement		

Glass bottles are the most popular medium for packaging beverages. On the other hand, due to the expense of new glass, many producers (particularly those operating on a small scale) re-employ the bottles. This means that in order to prevent contamination the bottles must be sterilized and cleaned properly. Simple hand-held bottle-brushes can be used to ensure a good standard of cleanliness, and mechanized brush-cleaners are also available.

Most beverages are thin liquids and can be filled moderately with no trouble by hand, but this is frequently excessively slow for a small industry. Simple filler can be prepared by fitting one or more taps to the bottom of a bucket. The bucket should be made from stainless steel for hot acid liquids (e.g. fruit juices) or food-grade plastic for cold filling. Iron and copper should not generally be used in food handling. The kind of closures used depends upon the type of product and its scrupulous use (for example, for glass bottles does it need to bear up internal pressure from carbonation).

There is a great range of closures available for glass bottles, but the selection for small-scale producers may repeatedly be restricted by what is in the vicinity available. Metal 'crown' caps are usually used for beers and fruit juices, while squashes, carbonated drinks and spirits are more frequently packaged using re-sealable metal screw-caps. Wine is often sealed with a cork other than plastic stoppers are similarly effective and cost less.

With recent advancements, there has been tremendous changes in the field of packaging materials, larger commercial manufacturers are using waxed cartons for beverages such as fruit juice. They are inexpensive and well-situated. Cheaper alternatives include plastic or foil laminated pouches. If sealed correctly, they can also be considered as a convenient way of packaging.

Check Your Progress

3. What are the ways in which juice can be extracted from a fruit?
4. What are the three main stages of brewing?

11.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Fruit drinks are of two types which are as follows:
 - (a) Those that are consumed immediately after opening.
 - (b) Those that are consumed in smaller quantities from bottles which are stored for use.
2. Wine can be produced from either cereal or fruit product. It is produced with the help of fermentation which includes the transformation of sugars in the crude material or included sugar into alcohol and carbon dioxide.
3. The ways in which juice can be extracted from a fruit are as follows:
 - (a) With a fruit press, fruit mill or hand pulper/sieve.
 - (b) By crushing/pulping with a mortar and pestle and then sieving through muslin cloth or plastic sieves.
 - (c) By steaming the fruit.
 - (d) Citrus fruit juices need to be extracted by reaming (squeezing) the fruit, and once again, comparatively simple equipment is available for this purpose.
4. The three main stages of brewing are mashing, boiling and fermentation.

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11.5 SUMMARY

- A wide range of plant materials are used to manufacture beverages. These include leaves, stems, sap, fruits, tubers, and seeds (grains).
- The market for beverages is comprehensively isolated in numerous nations into those items that are purchased to extinguish thirst, and those that are expended on special events including celebrations.
- Many large-scale producers promote their products by implying status in their consumption and spend considerable amounts on advertising and packaging.
- Most of the beverages contains a lot of water. However, it does not add any kind of nutrients to our body but plays a crucial role in maintaining the hydration levels in our body.
- Refreshments are not for the most part expended for their sustenance esteem, but rather many, especially the natural product drinks, contain a significant high level of sugar and along these lines add to the vitality substance of the eating routine.

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- The utilization of such added substances is administered by legitimate prerequisites and it is crucial to keep to these controls with the end goal to shield the purchaser from any unfortunate symptoms.
- An extensive variety of beverages can be made which contain as the base material either pulped natural product or juice.
- The former category does not need any preservative if processed and packaged properly. However, the latter must contain a definite amount of permitted preservatives to have a long shelf-life after opening.
- Each of the above products is preserved by its natural acidity and by pasteurization. Some drinks (syrops and squashes) also contain a high concentration of sugar which helps to preserve them.
- The most widely recognized precedents of alcoholic beverages are wine and beer. Beer is generally produced using a cereal, though wine can be produced from either cereal or fruit product.
- Wine and brew are produced with the help of fermentation which includes the transformation of sugars in the crude material or included sugar into alcohol and carbon dioxide.
- Distillation is carried out in stills which can be purchased for production at all levels.
- A wide range of hand-operated pulpers are available, or if electric power is available, multi-purpose kitchen-scale equipment such as blenders can be used.
- Citrus fruit juices need to be extracted by reaming (squeezing) the fruit, and once again, comparatively simple equipment is available for this purpose.
- Mashing involves the use of hot water (approximately 68°C) to extract the miscible substances from the malted grains.
- In wine-making, the fruit juice or pulp is mixed with yeast and sugar and held in a fermentation container made from food-grade plastic.
- The most usual way of achieving carbonization is to use a pressurized cylinder or tank which contains a mixture of water and carbon dioxide.
- Pasteurization involves heating the product to a temperature of 80-90°C and holding it at that temperature for between 0.5 and 5 minutes before filling into clean sterilized bottles.
- Glass bottles are the most popular medium for packaging beverages. On the other hand, due to the expense of new glass, many producers (particularly those operating on a small scale) re-employ the bottles.
- Most beverages are thin liquids and can be filled moderately with no trouble by hand, but this is frequently excessively slow for a small industry.

- There is a great range of closures available for glass bottles, but the selection for small-scale producers may repeatedly be restricted by what is in the vicinity available.
- With recent advancements, there has been tremendous changes in the field of packaging materials, larger commercial manufacturers are using waxed cartons for beverages such as fruit juice.

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11.6 KEY WORDS

- **Brewing:** It refers to a process of making beer from a cereal.
- **Carbonation:** It refers to a process which involves the introduction of carbon dioxide into a drink.
- **Mashing:** It refers to a process which involves the use of hot water (approximately 68°C) to extract the miscible substances from the malted grains.
- **Syrups:** It refers to the type of concentrated juices which are clear. They normally have a high sugar content.

11.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. What are the main types of non-alcoholic beverages?
2. What are the various types of yeast used in the production of beer and wine?
3. Write a short note on the process of beer and its fermentation.
4. What are the stages involved in the processing of non-alcoholic beverages?
5. Why is pasteurization an important process in manufacturing of beverages?

Long Answer Questions

1. Discuss the nutritive significance of beverages.
2. Explain the main types of beverage.
3. Discuss in detail the process of manufacturing of beverages.
4. Analyse the process of fermentation of wine.
5. Discuss the ways in which beverages can be packaged.

11.8 FURTHER READINGS

NOTES

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BLOCK - IV
SUGAR, FOOD ADDITIVES AND FOOD
TECHNOLOGY

NOTES

UNIT 12 SUGAR

Structure

- 12.0 Introduction
- 12.1 Objectives
- 12.2 Sugar Related Products
- 12.3 Stages of Sugar Cookery
 - 12.3.1 Crystalline and Non-Crystalline Candy
- 12.4 Artificial Sweeteners
- 12.5 Answers to Check Your Progress Questions
- 12.6 Summary
- 12.7 Key Words
- 12.8 Self Assessment Questions and Exercises
- 12.9 Further Readings

12.0 INTRODUCTION

Sugars are prevalent in environment and are the building blocks of carbohydrates. Sugar is found in many foods, including milk, grains, fruit, and vegetables. The sugar found in these foods provides a significant fuel source. The brain and red blood cells use sugar for energy. In addition, these carbohydrate-rich foods supply a range of other nutrients, such as fiber, vitamins, and minerals. Sugar is also added to countless foods, such as breads and other baked goods, cereals, flavored yogurt, sugared beverages, and sauces. Usually, the foods with added sugar provide energy (calories) but contain few other nutrients. They may perhaps substitute other foods that are high in vitamins, minerals and other important nutrients in the diet. Therefore, it is important to moderate the consumption of these foods.

The World Health Organization recommends consuming no more than 10 per cent of daily calories from added sugar and 'free sugars,' such as honey, syrup, or juices. High consumption of added sugars has been associated to illnesses such as obesity, diabetes, and heart disease. Consequently, it is imperative to consume them in moderation.

In India, sugar is majorly extracted from sugarcane. There are two forms of processed sugars in two forms: non-crystalline and crystalline. Artificial sweeteners, also called sugar substitutes, possess sweet taste like sugar, but without the contributing to the calories usually consumed to cut calories in diet or manage diabetes. The four most common artificial sweeteners used in food industry are:

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Aspartame, Acesulphame K2, Saccharin and Sucralose. Artificial sweeteners are widely used for special situations like diabetes management, weight control and preventing tooth decay.

In this unit, the properties of sugar compounds, their uses and the process of sugar production has been discussed in detail. The difference between crystalline and non-crystalline candy and the various types of artificial sweeteners and their uses have been highlighted.

12.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the types and properties of sugar related compounds
 - Explain the stages of sugar cookery
 - Differentiate between crystalline and non-crystalline candy
 - Analyse the various types artificial sweeteners
 - Discuss the uses of the four common artificial sweeteners
-

12.2 SUGAR RELATED PRODUCTS

Table 12.1 shows a variety of sugar related compounds:

Table 12.1 Sugar related compounds

D-Glucose	<ul style="list-style-type: none"> • It is a natural sugar commonly called as dextrose in confectionery industry. Honey and fruits also contain glucose. The source of glucose for commercial manufacture is starch.
D-fructose	<ul style="list-style-type: none"> • Hexose monosaccharide. • Natural sugar. • Sweeter than sucrose. • Example, honey, ripe fruits, provides sweetness, flavour and colour in confectionery items.
Dextrose Syrup	<ul style="list-style-type: none"> • Produced from starch in a multi-enzyme process. • Contains glucose (94 to 98 per cent), maltose (1 to 3 per cent), saccharides (1 to 2 per cent).
Corn Syrup	<ul style="list-style-type: none"> • Produced by hydrolysis of corn starch in acidic medium at high temperatures. • Contains glucose (10 to 36 per cent), maltose (9 – 20 per cent) and the remainder consisting of higher sugars and dextrans. • Inhibits crystallization in foods. • Used in bakery products and beverage industry (for typical citrus flavour). • Used in dry beverage mixes, instant breakfast mixes, cereal bars and sauce mixes (as Dried corn syrup).
High Fructose Corn Syrup (HFCS)	<ul style="list-style-type: none"> • Manufactured from isomerization of high quality dextrose syrup catalyzed by enzymes. • Sweeter than sucrose. • Inhibits crystallization in foods.

	<ul style="list-style-type: none"> Useful in bakery products and beverage industry Contains fructose in three combinations (Along with glucose, 52-9 per cent, other sugars, 6-1 per cent): <ol style="list-style-type: none"> 42 per cent 55 per cent 90 per cent Osmotic pressure is twice that of sucrose.
Isomalt	<ul style="list-style-type: none"> Derived from beet sugar. Similar sensory and technological properties as that of sugar, aspartame and saccharin.
Maltodextrins	<ul style="list-style-type: none"> These are prepared from corn starch by controlled enzymatic hydrolysis. Low hygroscopicity, insipid flavour, very low sweetness, retards crystal formation in ice-creams, can be used as fat substitutes. Also useful in flavour encapsulation and prevention of oxidation of unstable components of food.
Molasses	<ul style="list-style-type: none"> Molasses is the residue that remains after sucrose crystals have been removed from the concentrated juices of sugar cane or beet. Contains water <25 per cent and mineral ash <5 per cent. After the first crystallization of sucrose, the molasses is high in sugar and light in colour. After the final process, a dark and bitter product with a relatively high mineral content, called black-strap molasses, remains.
Maple syrup	<ul style="list-style-type: none"> It is high prized of all syrups used for culinary and table purposes. It is made by evaporation of the sap of the sugar maple to a concentration containing not more than 35 per cent water.
Honey	<ul style="list-style-type: none"> Honey contains about 17 per cent water and 82.5 per cent carbohydrate with small amounts of minerals and vitamins and enzymes. The carbohydrate portion of honey includes fructose (38 per cent) glucose (31 per cent), maltose (7 per cent) and sucrose (2 per cent). The colour of honey may vary from white to dark amber. The colour of fresh honey is related to its mineral content and is characteristic of its flowers- its source.
Jaggery	<ul style="list-style-type: none"> Jaggery is malty obtained from sugar cane though it can also be prepared from palm, date palm and coconut. Cane is crushed and coarse suspended impurities from the juice are removed by straining and then the juice is boiled. Chemical clarificants are used to flocculate colloids present in the juice. After clarification, the cane juice is boiled vigorously to 115-177 Celsius with constant stirring and then concentrated into thick, almost semisolid mass, which on cooling solidifies into jaggery.

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	<ul style="list-style-type: none"> • Generally good quality jaggery has a light colour, good flavour, hardness, crystalline structure and good keeping quality. It contains 65 to 85 percent sucrose, 10-15 per cent invert sugar and 2.5 per cent ash. Jaggery is peculiar to only Indian cookery. It does not easily crystallize because of invert sugar and it is very much preferred when non-crystalline candies are prepared. It is especially used when it is used as binder in the preparation of chikki (groundnut: jaggery in 1:1 proportion) and puffed rice balls. It is also used in making sweet pongal, payasamcoffee and kozhukattai. • Jaggery is preferred to sugar because it is rich in iron, gives colour, has a typical flavour, gives body or thickness and it is less expensive.
Caramel sugar	<ul style="list-style-type: none"> • Prepared from soyabean, tapioca or sago. • Caramel is a multi-use food additive as it enhances colour, flavour and sweetness to the product. • The brown colour of caramels results primarily from Maillard reaction. • Obtained from sugars when they are heated either dry or with certain additives or in concentrated solutions. • Caramel is polymeric in nature- containing about 143 volatile and non-volatile compounds. • Includes caramel, caramelen, caramelin methyl imidazole, furans fructose, glucose, alcohols, acids, aldehydes, esters, carbon dioxide and sulphur dioxide as breakdown products. • Used in brewing, vinegar making, blending of spirits like whisky, rum and wines as well as soft drinks. • Example: Used in biscuits, pickles, sauces and pastries.

The following chart describes various types of sugar along with their characteristics and uses.

Type	Characteristics	Uses
<ul style="list-style-type: none"> • Castor • Granulated • Cube • Icing • Golden syrup • Molasses • Diamond sugar • Rock sugar • Brown sugar • Sugar powder 	<ul style="list-style-type: none"> • Fine white crystals • Crystals of medium size • Crystals compressed to cubes. • Fine white powder with or without starch • Processed to a yellow syrup • Dark by-product of sugar • Small rectangular crystals • Big slabs • Contains molasses, glucose and fructose, pleasing and distinctive flavour. • Pulverised granulated sugar 	<ul style="list-style-type: none"> • Bakery • General sweetening agent • Tea service • Cake icings • Cooking and baking confectionery • Cooking and confectionery • Used with beetle nuts, confectionery. • Used on festive occasions • Baked products • Doughnuts, hard puris

Properties of Sugar Compounds

Let us discuss the property of sugar compounds:

- D-Glucose is a natural sugar commonly called as dextrose in confectionery industry.

- Corn syrup is produced by hydrolysis of corn starch in acidic medium at high temperatures.
- Molasses is the residue that remains after sucrose crystals have been removed from the concentrated juices of sugar cane or beet.
- Honey contains about 17 per cent water and 82.5 per cent carbohydrate with small amounts of minerals and vitamins and enzymes.
- Jaggery is preferred to sugar because it is rich in iron, gives colour, has a typical flavour, gives body or thickness and it is less expensive.

NOTES

Sugar Confectionery Production: Principles

Some of the principles of sugar production are as follows:

- Balance the recipe
- Prepare the ingredients
- Mix together the ingredients
- Boil the mixture until the desired temperature has been reached
- Cool
- Shape
- Pack

Check Your Progress

1. What are the uses of caramel sugar?
2. How is high fructose corn syrup manufactured?
3. What are the characteristics of good quality jaggery?

12.3 STAGES OF SUGAR COOKERY

We will in this section discuss the process of producing sugar.

Processing of Sugar

Processing stage	Equipment
Mix ingredients	Weighing and measuring equipment
Boil	Heat source
	Boiling pans
	Steam jacketed pans
	Thermometer
Cool	Table
Beat	Hand whisk or liquid mixer
Form/set	Starch mould cutting equipment
Pack	Waxed papers cellulose films aluminum foils or polythene bags
	Heat sealer
	Wrapping equipment

NOTES**1. Boiling**

The following are the three main ways by which the sugar solution is boiled:

- A simple open boiling pan.
- Steam jacketed pan (make the mixing and heating process more uniform, and lessen the possibility of localized over-heating).
- A vacuum cooker (used in large scale units).

2. Cooling

Boiling is followed by slight cooling before being shaped into desired product. The boiled mass is poured onto a metal, stone, or marble table with the purpose to cool the product uniformly. The table should be clean and free from split, as they may have dirt and microorganisms.

3. Beating

Beating involves reduction of crystal size in the process of crystallization as in the case of production of fudge; the supersaturated solution is poured onto the table, left to cool, and then beaten with a wood or metal beater.

4. Forming/setting

There are two main ways of forming sweets: cutting into pieces, or setting in moulds.

- Moulds may be as simple as a greased and lined tray; made from rubber, plastic, metal, starch, or wood; impressions are then made using wooden shapes; the mixture is poured into the impressions and allowed to set.
- Mixture is cut into desired shapes.

Crystallization

Crystallization refers to a process in which mass transfer of a solute from the liquid solution to a pure solid crystalline phase occurs. During the process of sugar, it takes place after the stage of evaporation. It is in this stage that the clarified sugar cane juice is boiled and most of the water is removed and leaves thick syrup. The *sugar* crystals and molasses are then separated in centrifugals.

Figure 12.1 show the stages of production of sugar.

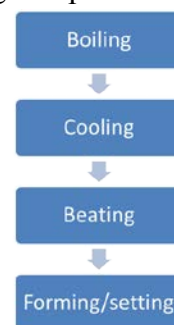


Fig 12.1 Process of Production of Sugar.

12.3.1 Crystalline and Non-Crystalline Candy

There are two different categories in which candies can be classified: crystalline and non-crystalline. Crystalline candy includes fudge and fondant, whereas non-crystalline candy consists of lollipops, toffee, and caramel. These crystalline versus non-crystalline characteristics are influenced by different ingredients as well as preparation techniques; for example, type of ingredients, rate of cooking, concentration of sugar, conditions of cooling, and degree of agitation, addition of interfering substances etc.

NOTES

Crystalline Candy	Non-Crystalline Candy
Includes fudge and fondant.	Includes lollipops, toffee, and caramel.
Procedure involves dissolving the sugar, concentrating the solution, supersaturating the solution, and controlled crystallization; heating crystalline candy to its final temperature is followed by cooling until a specific temperature and agitation or beaten in order to incorporate air thereby promoting the formation of many nuclei by redistributing ingredients, and it breaking up of large crystals.	Procedure involves addition of interfering substances like fat, milk solids, and acid, which keep sucrose crystals smaller in size; involving heating to a high degree so that the solution is viscous and the molecular movement is restricted-in order to inhibit crystal formation; no beating or agitation is involved to form nuclei for crystals

Check Your Progress

4. What is crystallization?
5. What are the three ways in which sugar solution is boiled?

12.4 ARTIFICIAL SWEETENERS

Artificial sweeteners, also known as sugar substitutes, possess a sweet taste such as that of sugar, but without the contributing to the calories usually consumed to cut calories in diet or manage diabetes. Sugar substitutes are food additives that are sweet hitherto contain appreciably less calories than sugar. These substitutes may be derivative from natural or synthetic sources.

Naturally occurring sugar substitutes comprise stevia and sugar alcohols.

Artificial sweeteners are characteristically calorie-free and at least 30 times sweeter than sucrose. The most common sweeteners are as follows:

- Saccharin
- Acesulfame-k
- Sucralose, aspartame
- Neotame
- Advantame
- Cyclamates

Disproportionate consumption of artificial sweeteners can cause detrimental side effects, however, including diarrhea and headaches.

In the following section, we will learn about the development of some of the artificial sweeteners.

NOTES

Saccharin

- It was developed in 1878.
- It is a coal tar derivative that is around 200-700 times sweeter than sucrose.
- It is commercially available as a white powder for use as a tabletop sweetener, and used in a variety of foods such as beverages, jams, and baked goods.
- Saccharin can cause allergic reactions, headaches, skin problems, diarrhea, and inhalation difficulties.

Aspartame

- It is composed of two naturally occurring amino acids (the building blocks of protein) - phenylalanine and aspartate.
- Aspartame has a zest comparable to sucrose, and also functions as a taste enhancer.
- Aspartame is 200 times sweeter than sucrose and has no aftertaste. After
- It is used in hard and soft candies, bakery products, nonalcoholic beverages and malt beverages.
- A packet of this sweetener is equivalent in sweetness to two teaspoons of sugar (32 calories), for just four calories.
- Aspartame is usually not recommended to people with phenylketonuria, a rare genetic disorder that prevents proper metabolism of phenylalanine, an essential amino acid.
- Contrary to other artificial sweeteners, which have no nutritional value, aspartame gives calories.
- It is because it can be used by the body like any other protein, but the amounts are so small that its caloric value is insignificant. Aspartame does not contribute to tooth decay.

Acesulfame-K

- Acesulfame-K is similar to aspartame in sweetening power but has a limited use in products such as chewing gums and dry beverage mixes.
- It is stable while heated and can be used in baking.

Sucralose

- Sucralose is the only alternative sweetener made from sugar.
- It is 600 times sweeter than sucrose.

- Sucralose is derived from sugar but cannot be absorbed by the human body, therefore contributing almost no calories.
- It is excreted in the urine practically unchanged
- Sucralose does not contribute to tooth decay.

Neotame

- Neotame is 7,000 to 13,000 times sweeter than sugar.
- It was approved for use as a general-purpose and contains phenylalanine.
- Neotame is rarely used in food.

Advantame

- This sweetener is chemically similar to aspartame, and it contains phenylalanine.
- It is 20,000 times sweeter than sucrose, as opposite to aspartame, which is only 200 times sweeter.
- It can be used in non-alcoholic beverages, chewing gum, and certain foods.

Cyclamates

- Cyclamates are 30 times sweeter than sugar, leave little aftertaste, and are heat stable.
- Study in rats show that in combination with saccharin it can act as cancer-causing agent.

Sugar Alcohols

- Sugar alcohols are sometimes used as a substitute for sucrose.
- The sugar alcohols that occur naturally in fruits are Mannitol, sorbitol, and maltitol are all.

Xylitol

- It is an intermediate product in the metabolism of carbohydrates in fruits and vegetables.
- Sugars have a typical ring structure, sugar alcohols do not.
- Sugar alcohols add bulk and texture to food such as hard candies.
- They do not contribute to tooth decay, so they are commonly found in chewing gum.

Stevia

- Stevia is 250 times sweeter than sucrose.
- It is processed from a compound found in the leaves of the stevia plant.
- Stevia has a bitter taste when consumed in high quantities and is shelf-stable when dry.

NOTES

NOTES

Uses of Artificial Sweeteners

The following are the main uses of artificial sweeteners:

- **Diabetes management:** Contrasting sugar, artificial sweeteners usually do not raise blood sugar levels since they are not carbohydrates. However, it is recommended to always check with your doctor or dietitian about using any sugar replacement if you have diabetes.
- **Weight control:** Artificial sweeteners have practically no calories which make them interesting to incorporate in weight loss diets. In addition, you need only a portion as compared to the normal table sugar. Nevertheless, the nature and amount of sweetener to be used needs to be confirmed with a doctor or a dietitian.
- **Preventing tooth decay:** Sweeteners also do not contribute to tooth decay, as they are not broken down to acid by bacteria in the mouth.

Common Sweeteners Approved for Use in India by FSSAI

The four most common artificial sweeteners used in food industry are: Aspartame, Acesulphame K2, Saccharin and Sucralose. Table 12.2 shows the most commonly used artificial sweeteners and their uses.

Table 12.2 Commonly used Artificial Sweeteners and their uses

Common Sweeteners Approved for Use in India by FSSAI	Properties	Uses
Aspartame	High-intensity, artificial, non-nutritive sweetener.	Used in variety of products like instant breakfasts, gelatin desserts, soft drinks, beverages, tabletop sweeteners, cereals, laxatives, tea beverages and sugar-free chewing gums.
Acesulfame Potassium	a calorie-free sugar substitute (artificial sweetener), also known as Acesulfame K ; 200 times sweeter than sucrose (table sugar), as sweet as aspartame, about 2/3 as sweet as saccharin, and 1/3 as sweet as sucralose.	Used in carbonated drinks, it is almost always used in conjunction with another sweetener, such as aspartame or sucralose.
Saccharin	Saccharin and its salts are the most common sweeteners.	Used in a variety of beverages, foods, cosmetics and pharmaceuticals.
Sucralose	Used in products that requires a longer shelf life.	Used in combination with, other artificial or natural sweeteners, such as aspartame, acesulfame potassium or high-fructose corn syrup.
Sugar Alcohols (sorbitol, Mannitol and Xylitol)	Provide lesser calories and are less sweet than sugar.	Mostly used to enhance commercial foods-labeled sugar free or no added sugar.

Check Your Progress

6. How is stevia processed?
7. What are the uses of saccharin?

NOTES

12.5 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Caramel sugar is used in brewing, vinegar making, blending of spirits like whisky, rum and wines as well as soft drinks.
2. High fructose corn syrup is manufactured from isomerization of high quality dextrose syrup which is catalyzed by enzymes.
3. Good quality jaggery has a light colour, good flavour, hardness, crystalline structure and good keeping quality. It contains 65 to 85 percent sucrose, 10-15 per cent invert sugar and 2.5 per cent ash.
4. Crystallization refers to a process in which mass transfer of a solute from the liquid solution to a pure solid crystalline phase occurs.
5. The following are the three main ways by which the sugar solution is boiled:
 - (a) A simple open boiling pan.
 - (b) Steam jacketed pan (make the mixing and heating process more uniform, and lessen the possibility of localized over-heating).
 - (c) A vacuum cooker (used in large scale units).
6. Stevia is processed from a compound found in the leaves of the stevia plant. Stevia has a bitter taste when consumed in high quantities and is shelf-stable when dry.
7. Saccharin is used in a variety of beverages, foods, cosmetics and pharmaceuticals.

12.6 SUMMARY

- D-glucose is a natural sugar commonly called as dextrose in confectionery industry.
- Corn syrup is produced by hydrolysis of corn starch in acidic medium at high temperatures.
- High fructose corn syrup is manufactured from isomerization of high quality dextrose syrup catalyzed by enzymes.
- Molasses is the residue that remains after sucrose crystals have been removed from the concentrated juices of sugar cane or beet.

NOTES

- Maple syrup is made by evaporation of the sap of the sugar maple to a concentration containing not more than 35 per cent water.
- The colour of honey may vary from white to dark amber. The colour of fresh honey is related to its mineral content and is characteristic of its flowers-its source.
- Jaggery is malty obtained from sugar cane though it can also be prepared from palm, date palm and coconut.
- Generally good quality jaggery has a light colour, good flavour, hardness, crystalline structure and good keeping quality.
- Jaggery is preferred to sugar because it is rich in iron, gives colour, has a typical flavour, gives body or thickness and it is less expensive.
- Boiling is followed by slight cooling before being shaped into desired product. The boiled mass is poured onto a metal, stone, or marble table with the purpose to cool the product uniformly.
- Beating involves reduction of crystal size in the process of crystallization as in the case of production of fudge; the supersaturated solution is poured onto the table, left to cool, and then beaten with a wood or metal beater.
- Moulds may be as simple as a greased and lined tray; made from rubber, plastic, metal, starch, or wood; impressions are then made using wooden shapes; the mixture is poured into the impressions and allowed to set.
- Crystallization refers to a process in which mass transfer of a solute from the liquid solution to a pure solid crystalline phase occurs.
- There are two different categories in which candies can be classified: crystalline and non-crystalline.
- Crystalline candy includes fudge and fondant, whereas non-crystalline candy consists of lollipops, toffee, and caramel.
- Artificial sweeteners, also known as sugar substitutes, possess a sweet taste such as that of sugar, but without the contributing to the calories usually consumed to cut calories in diet or manage diabetes.
- Sugar substitutes are food additives that are sweet hitherto contain appreciably less calories than sugar. These substitutes may be derivative from natural or synthetic sources.
- Disproportionate consumption of artificial sweeteners can cause detrimental side effects, however, including diarrhea and headaches.
- Saccharin can cause allergic reactions, headaches, skin problems, diarrhea, and inhalation difficulties.
- Aspartame is composed of two naturally occurring amino acids (the building blocks of protein) - phenylalanine and aspartate.

- Acesulfame-K is similar to aspartame in sweetening power but has a limited use in products such as chewing gums and dry beverage mixes.
- Artificial sweeteners have practically no calories which make them interesting to incorporate in weight loss diets.
- Sweeteners also do not contribute to tooth decay, as they are not broken down to acid by bacteria in the mouth.

NOTES

12.7 KEY WORDS

- **Beating:** It refers to a process which involves reduction of crystal size in the process of crystallization as in the case of production of fudge; the supersaturated solution is poured onto the table, left to cool, and then beaten with a wood or metal beater.
- **Maltodextrins:** It refers to a type of sugar compound which is prepared from corn starch by controlled enzymatic hydrolysis.
- **Molasses:** It refers to the residue that remains after sucrose crystals have been removed from the concentrated juices of sugar cane or beet.
- **Sugar Substitutes:** It refers to food additives that are sweet hitherto contain appreciably less calories than sugar.

12.8 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. How is corn syrup produced?
2. What are the uses of maltodextrins?
3. List the main uses of artificial sweeteners.
4. How is maple syrup prepared?
5. What are the factors on which colour of honey depends?
6. Why is jaggery preferred to sugar?
7. What are the most commonly used artificial sweeteners?

Long Answer Questions

1. Discuss the uses of various sugar related compounds.
2. Analyse the principles related to production of sugar.
3. Explain the stages of sugar cookery.
4. Differentiate between crystalline and non-crystalline candies.
5. Explain in detail the uses and effects of any four artificial sweeteners.

12.9 FURTHER READINGS

NOTES

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UNIT 13 FOOD ADDITIVES

Structure

- 13.0 Introduction
- 13.1 Objectives
- 13.2 Food Additives: Definition and Need
 - 13.2.1 Types of Food Additives
- 13.3 Packaging Material Contaminants
 - 13.3.1 Food Safety
- 13.4 Answers to Check Your Progress Questions
- 13.5 Summary
- 13.6 Key Words
- 13.7 Self Assessment Questions and Exercises
- 13.8 Further Readings

NOTES

13.0 INTRODUCTION

Food components are materials added to meals to retain flavor or enhance its taste, appearance, or different qualities. Some additives have been used for centuries; for example, keeping meals by pickling (with vinegar), salting, as with bacon, keeping sweets or the use of sulfur dioxide as with wines. With the creation of processed meals during the second half of the twentieth century, many extra components have been introduced, of each herbal and synthetic origin.

Food additives additionally encompass components that may be delivered to food not directly (called ‘indirect additives’) in the manufacturing process, through packaging, or for the duration of storage or transport.

The Government of India’s (GOI) Food Safety and Standards Authority of India (FSSAI) posted its comprehensive list of 11,000 food components used in more than a few meals categories. The new file was prepared on the groundwork of feedback obtained from several stakeholders.

In this unit, the concept of food additives and its types have been discussed in detail. The unit will also explain the importance of food safety and the guidelines given by Food Safety and Standards Authority of India (FSSAI) regarding the use of preservatives.

13.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the concept and importance of food additives
- Analyse the various types of food additives
- Explain the meaning of unintentional additives

- Discuss the guidelines by Food Safety and Standards Authority of India (FSSAI) for food safety

NOTES

13.2 FOOD ADDITIVES: DEFINITION AND NEED

Food additives are defined as substances which are added to the food to preserve flavour or to increase the taste or appearance of the food. Some of the commonly used additives are vinegar, salt, bacon, use of sulfur dioxide in wines and so on. They can also be used indirectly and are known as indirect additives.

Additives are added during the process of production and packaging of materials. It helps to maintain the nutritive value of food and improves the shelf life of the products. Food additives are needed to improve the keeping quality of food. It maintains the nutritional quality of a food. It also helps enhance the appeal of foods by improving consistency, texture and other sensory properties.

13.2.1 Types of Food Additives

We will in this section discuss the types of food additives.

Preservatives

The preservatives are the substances that interferes with the cell membrane of the microorganisms, their enzyme activity or their genetic mechanism.

Unintentional Additives: Food Contaminants

Codex Alimentarius defines ‘food contaminant’ as any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food or as a result of environmental contamination. The term does not include insect, fragments, rodent hairs and other extraneous manner.

Food Contaminants of Natural Origin**1. Biogenic amines**

The biogenic amines are biologically active compounds that are synthesized from amino acids. Food borne biogenic amines are most commonly synthesized by spoilage microorganisms and are usually considered to be potential toxins. Mammalian polyamines are a subgroup of the biogenic amines. They include putrescine, spermidine and spermine. Biogenic amines should not always be considered as potential toxicants but can also be non-hormonal growth promoters.

Vasoactive amines include histamine, which may be present in food in quantities capable of producing clinically apparent pharmacologic effects. The

prototype of these amines is histamine, the mediator of immediate allergic reactions triggered by foods and other allergens. Endogenous histamine is released from basophils and mast cells. Endogenous histamine can also be released by intrinsic histamine-releasing food components.

In addition to the release of endogenous histamine during allergic reactions, certain foods contain histamine produced by decarboxylation of histidine by enzymes produced by bacterial contamination of foods.

An example of the mentioned discussed mechanism is **scombroid poisoning**, which is one of the three most common illnesses associated with seafood consumption. It is food borne illness that results from consuming decayed or spoiled fish. It is the second most important type of sea food poisoning. Other biogenic amines such as putrescine and cadaverine may play a synergistic role with histamine by inhibiting the histamine detoxifying enzymes, diamine oxidase and histamine N-methyl transferase. While allergic reactions affect only susceptible individuals, contamination of foods with histamine will cause symptoms in all individuals exposed to enough amounts of the food involved.

The most frequently encountered **symptoms** are rash, nausea, diarrhea, flushing, sweating, and headache. Typically, induction period and duration of the illness are short. The severity of the symptoms can vary considerably with individual sensitivity to ingested histamine, but it can be severe for the elderly and the persons who are immuno-compromised.

2. Alkaloids

They are nitrogen containing heterocyclic compounds which occur mainly in plants as salts of common carboxylic acids such as citric acid, oxalic acid acetic, maleic and tartaric acids. They also occur as fumaric, benzoic, aconitic and veratric acid. They are amines that produce an alkaline solution in water. That is why they are known as alkaloids.

They are important in pharmacological activities. They are normally used as analgesics, anti-malarial, antispasmodics. They also play an important role in the treatment of hypertension, mental disorders and tumors. The alkaloids are extracted from plant by extraction with organic solvents. The major alkaloids are:

1	Ornitnine	Tropane Pyrrolidine Pyrrolizidine
2	Tyrosine	Benzyl-iso-quinoline
3	Tryptophane	Indole Quinoline
4	Pyridine	Pyridine
5	Lysine	Quinolizidine Piperidine

NOTES

Classification of alkaloids:**NOTES**

S. no.	Types of alkaloids	Examples
1	Monocyclic	Nicotine
2	Bicyclic	Atropine Cocaine Quinine
3	Polycyclic	Reserpine Vinblastine Strychnine Lysergic acid

‘**Sanguinarine**’ is a toxic alkaloid that causes Epidemic Dropsy. Epidemic dropsy is caused by consuming mustard oil contaminated with argemone seed oil. Argemone mexicana is a weed that produces seeds similar appearance to mustard seeds. FSSAI rules under A.17.06 specify negative test for argemone oil.

In dropsy, watery fluid collects in the cavities or tissues of the tissues of the body and causes swelling. The disease starts with gastro-intestinal disturbances and irregular fever with rashes appearing on the exposed parts of the body. Heart failure leads to death in the untreated cases. A diet rich in vitamin B-complex and proteins should be prescribed during recovery and convalescence.

3. Phenolic Compounds

These consist of large number of molecules of heterogeneous nature.

Table 13.1 Classification of Phenolic Compounds (J B Harborne, 1980)

S. No.	Group	Examples	Plants	Function
1	Anthocyanes Chalcones Aurones Yellow flavonoids Flavones	Cyaniding-3,5-diglucosid	<i>Rosa</i>	Flower pigments
		Coreopsin	<i>Coreopsis tinctoria</i>	
		Aureusin	<i>Anthirrhinum majus</i>	
		Gossypetine-7-glucoside	<i>Gossypium</i>	
		Apigenin-7-glucoside	<i>Bellis perennis</i>	
2	Anthocyanins Isoflavones chalcones	Petunidin glucoside	<i>Atropa belladonna</i>	Fruit pigments
		Osajin	<i>Maclura pomifera</i>	
		Ocanin	<i>Kyllingi</i>	
3	Quinines Phenols Hydrocinnamic acid	Juglon	<i>Juglans regia</i>	Allelopathic substance
		Hydroquinone	<i>Arctostaphylos</i>	
		Ferulic acid	<i>Adenostoma</i>	
4	Quinones Tannins Flavonols	Juglon	<i>Carya ovata</i>	Protection against pest
		gallotannine	<i>Quercus robur</i>	
		Quercitine-glycosids	<i>gossypium</i>	

5	Isoflavones Phenolcarboxylic acids Dihydrochalcones	Luteon	Lupinus	Fungicide
		Protocatechunic acid	Allium	
		phloideine	Malus	
6	Stillbens Phenylanthrenes Isoflavones Pterocarpanes Phenylpropanoids Fucocoumarins	Reservatrol	Arachis hypogea	Phytoalexins
		Orchinol	Orchis	
		Vestitiol	Lotus	
		Pisatin	Pisum sativum	
		Conyferyl alcohol	Linum	
		Psoralen	Petroselinum crispum	

NOTES

Most of the phenolic compounds are flavonoids. The most important class of flavonoids and their biological significance as described by a British chemist, J B Harborne (1980), is tabulated below:

Table 13.2 *Flavonoids and their Significance.*

S. No.	Class	Biological significance
1	Anthocyanins	Red and blue pigments
2	Chalcones	Yellow pigments
3	Aurones	Yellow pigments
4	Flavones	Cream coloured pigments of flowers
5	Dihydrochalcones	Bitter tastes by some groups
6	Proanthocyanidines	Astringent substances
7	Catechins	Show properties similar to those of tannins
8	Isoflavones	Oestrogen effect, toxic to fungi.

4. Protease Inhibitors

Trypsin-inhibitor is an example of protease inhibitor. Trypsin-inhibitors are found in most of the lentils and legumes, potatoes, sweet potato and sunflower.

The most widely known case of negative impact on health is by the pulse *Lathyrus sativus* or kesari dal. An unusual amino acid, named, beta oxyabylamino alanine (BOAA) is isolated from kesari dal. The symptoms include an altered gait of the affected persons and exaggerated knee and ankle jerks.

Under FSSAI rule 44-A, sale and use of kesari dal or flour or any of the products mixed with any other dal, flour or product is strictly prohibited.

5. Phytates

The phytates are present in cereal grains and some lentils. Phytates are usually present in a bound form with potassium, calcium or magnesium. Phytates are usually present in a bound form with potassium, calcium or magnesium. They have adverse effects on the availability of zinc, calcium or magnesium and iron, because they form insoluble complexes with these minerals.

NOTES

Many individuals, especially Indians do consume more than enough iron-rich foods, yet they tend to be anemic or iron deficient. The Indian diet consists of sufficient quantities of cereals which contains sufficient quantities of iron. This iron found binds with the phytates as iron-phytate and that is why it cannot be absorbed by the body. This bond between iron and phytates can be broken by overnight soaking of the cereal in water.

6. Crop contaminants and naturally occurring toxic substances

Under FSSAI rule 57-A, 'crop contaminant' means any naturally occurring substance not intentionally added to food, but which gets added to articles of food in the process of their production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacturing, processing, preparation, treatment, packing, packaging, transport or holding of articles of such foods as a result of environmental contamination. This rule states that no food shall, contain aflatoxin in excess of 0.03 mg/kg.

According to FSSAI the following naturally accruing substances are permitted in the following quantities in any article of food:

Naturally occurring toxins	Maximum limit in food
Agaric acid	100 ppm
Hydrocyanic acid	5 ppm
Hypericine	1 ppm
Saffrole	10 ppm

The natural toxins and their effects on various types of food can be tabulated as follows:

S. No.	Toxins	Foods affected
1	Avidin	It is an antivitamin that is present in egg white. It makes the biotin present in the egg white unavailable to the body.
2	Antivitamin K	It is found in green leafy vegetables
3	Antivitamin D	Soyabean (raw)
4	Thiaminase	Fishes (fresh water)
5	Aflatoxins	Peanuts, legumes, nuts (the fungus grows well under humid conditions and produces aflatoxins)
6	Allyl iso-thiocyanate	Mustard seeds
7	Capciacin	Capsicum
8	Cyanogenetic compounds	Bitter almonds, apple seeds, beans
9	Erucic acid	Mustard oil
10	Fluorine	Water, sea foods
11	Gossypol	Cotton seed
12	Goitrogenic compounds	Cabbage
13	Haemagglutinins	Soyabeans
14	Lead	Spices, flavourings, food colors, processed foods etc.
15	Myristicin	Nutmeg and mace
16	Nitrates	Fertilizer-contaminated water
17	Oxalic acid	Spinach, amaranth and green leafy vegetables
18	Phalloidine	Mushrooms
19	Solanine	Potatoes
20	Trpsin inhibitors	Kesari dal

Environmental Contaminants

a) Pesticide Residues

Codex Alimentarius defines ‘**Pesticides**’ as any substance intended for preventing, destroying, attracting, repelling, or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds or which may be administered to animals for the control of **ectoparasites**. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent, or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. The term normally excludes fertilizers, plant and animal nutrients, food additives and animal drugs.

Codex Alimentarius defines ‘**Pesticide residues**’ as any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products and impurities considered to be of toxicological significance.

Common pesticides that are seen as food contaminants are **Organochlorines** and **Organophosphate pesticides**. In our country, the three commonly used pesticides are:

- HCH
- DDT
- Malathion

These account for 70 per cent of the total pesticides consumption in our country.

In our country, weeds account for around 33 per cent of crop losses, followed by plant diseases contributing to 26 per cent crop losses and insect pests contributing to 20 per cent of losses. The consumption pattern of pesticides is, however, just the reverse. The total consumption of pesticides in the country is as follows:

- 80 per cent (as insecticides)
- 16 per cent (as herbicides)
- 2 per cent (as fungicides)

In our country, the estimated figures of crop wise consumption of pesticides are:

- Cotton around 45 per cent
- Paddy around 22 per cent
- Jowar around 9 per cent
- Wheat around 7 per cent
- Fruits and Vegetables around 7 per cent

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Rule 65 under Part XIV: Insecticides and Pesticides of FSSAI Rules lays down specific restrictions on use of insecticides and prescribes tolerance limits of various insecticides in various food items.

NOTES

Explanation- For the purposes of this rule—

The term, 'insecticide' shall have the meaning assigned to it in the Insecticide Act, 1968 (46 of 1968).

Unless otherwise stated:

1. Maximum levels are expressed in mg./kg on a whole product basis.
2. All foods refer to raw agricultural products moving in commerce.

b) Heavy Metals

Common heavy metals that can be toxic are given below:

Arsenic

The sources of exposure are as follows:

1. Air pollution
2. Antibiotics given to commercial livestock
3. Certain marine plants
4. Chemical processing
5. Coal-fired power plants
6. Defoliants
7. Drinking water
8. Drying agents for cotton
9. Fish
10. Herbicides, pesticides and insecticides
11. Meats (From commercially raised poultry and cattle)
12. Metal ore smelting
13. Seafood (fish, mussels, oysters)
14. Wood preservatives

Cadmium

The sources of exposure are as follows:

1. Air Pollution
2. Art Supplies
3. Bone Meal
4. Cigarette Smoke

5. Food (Coffee, Fruits, Grains, And Vegetables Grown In Cadmium-Laden Soil)
6. Meats (Kidneys, Liver, Poultry)
7. Refined Foods
8. Freshwater Fish
9. Fungicides
10. Highway Dusts
11. Incinerators
12. Mining
13. Nickel-Cadmium Batteries
14. Oxide Dusts
15. Paints
16. Phosphate Fertilizers
17. Power Plants
18. Seafood (Crab, Flounder, Mussels, Oysters, Scallops)
19. Sewage Sludge
20. Softened Water
21. Smelting Plants
22. Tobacco and Tobacco Smoke
23. Welding Fumes

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Lead

The sources of exposure are as follows:

1. Air pollution
2. Ammunition (shot and bullets)
3. Bathtubs (cast iron, porcelain, steel)
4. Batteries
5. Canned foods
6. Ceramics
7. Chemical fertilizers
8. Cosmetics
9. Dolomite
10. Dust
11. Foods grown around industrial areas

NOTES

12. Gasolin
13. Hair dyes and rinses
14. Leaded glass
15. Newsprint and colored advertisements
16. Paints
17. Pesticides
18. Pewter
19. Pottery
20. Rubber toys
21. Soft coal
22. Soil, solder
23. Tap water
24. Tobacco smoke
25. Vinyl 'mini-blinds

Mercury

The sources of exposure are as follows:

1. Air pollution
2. Batteries
3. Cosmetics
4. Dental amalgams
5. Diuretics
6. Electrical devices and relays
7. Explosive
8. Foods (grains)
9. Fungicides and insecticides
10. Fluorescent lights
11. Freshwater fish (especially large bass, pike, and trout)
12. Mining
13. Paints
14. Pesticides
15. Petroleum products
16. Saltwater fish (especially large halibut, shrimp, snapper, and swordfish)
17. Shellfish
18. Tap water

Nickel

The sources of exposure are as follows:

1. Appliances
2. Buttons
3. Ceramics
4. Cocoa
5. Cooking utensils
6. Cosmetics
7. Coins
8. Dental materials
9. Food (chocolate, hydrogenated oils, nuts, food grown near industrial areas)
10. Hair spray
11. Industrial waste
12. Jewelry
13. Medical implants
14. Metal refineries
15. Metal tools
16. Nickel-cadmium batteries
17. Orthodontic appliances
18. Shampoo
19. Solid-waste incinerators
20. Stainless steel kitchen utensils
21. Tap water
22. Tobacco and tobacco smoke
23. Water faucets and pipes
24. Zippers

NOTES**Chromium**

Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials. Low-level exposure can irritate the skin and cause ulceration. Long term exposure can cause kidney and liver damage, and damage to circulatory and nerve tissue. Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium.

Copper

Copper is an essential substance to human life, but in high-doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation. People

with Wilson's disease are at greater risk for health effects from overexposure to copper. Copper normally occurs in drinking water from copper pipes, as well as from additives designed to control algal growth.

NOTES

Check Your Progress

1. What are biogenic amines?
2. What are the uses of alkaloids?
3. State any one effect of chromium.

13.3 PACKAGING MATERIAL CONTAMINANTS

There are three major groups of materials used to package food which are as follows:

1. Flexible
2. Semi-rigid
3. Rigid

Flexible materials include paper (laminated and waxed) and plastic films. Aluminum foil, paperboard and formed plastics are in the semi-rigid category. Metal, glass and thick plastic are considered rigid materials. Though a large variety of packaging materials are currently used for food packaging, the prevention of contamination of food by the packaging intended to protect it is the object of constant research and regulation.

Migration of additives

Some of the additives used in plastics are more likely to migrate than others. The main concern in the past has been in connection with plasticizers, which are used to improve the flexibility of some packaging materials. They are used in a range of plastics but particularly in polyvinyl chloride (PVC) films. As the tendency for plasticizers to migrate increases at higher temperatures, only those plastics specifically designed to withstand high temperatures should be used. Many plastic containers containing processed food may appear to perform satisfactorily in the microwave or oven, but their migration levels at high temperature may not necessarily have been tested. This applies particularly to those food containers used to package chilled or frozen foods, for example, ice cream containers, which are not designed to be exposed to high temperatures. Further, since migration is more likely to occur into hot fatty foods, glass containers are suitable choice for heating these products.

Taint and Odour

While paper and board materials may transmit taint or odour to a food, plastics have a much greater potential to do this. These taints may be residual monomer,

for example, styrene. This is probably the compound usually responsible when consumers detect a 'plastic taste' in food. Further, most food packaging is printed and a number of the components of the ink may cause unpleasant flavours in food if the manufacture of the packaging material is not carefully controlled. Many common plastics are also not effective barriers to strong odours. Odours from food such as garlic or onion can easily pass through plastic film and taint other food.

Recycled Plastic and Paper

The use of recycled packaging materials, other than metals and glass, after the consumer has used them is potentially a problem because of contamination from a variety of sources. Since there are no controls on the treatment procedures or uses to which these materials have been put, there is no control over the type of contaminants which may be present. Consequently, the adoption of a Code of Practice by the packaging industry would be the most appropriate way to deal with the use of recycled materials in any form of packaging.

13.3.1 Food Safety

The Food Safety and Standards Authority of India (FSSAI) has laid down some guidelines regarding the use of preservatives. These are as follows:

Definition of preservative: Preservative means a substance which when added to food, is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food.

- Addition of Class I preservatives in any food is not restricted, unless otherwise provided in the rules.
- Use of more than one Class II preservatives prohibited. No person shall use in or upon a food more than one class II preservative.
- Preservation by Antioxidants: According to FSSAI, an antioxidant is a substance which is added to food to retard or prevent oxidative deterioration of food.
- No anti-oxidant other than lecithin, ascorbic acid and tocopherol can be used, except the following is the quantities mentioned:

Ethyl gallate-----	
Propyl gallate	
Octyl gallate or mixture thereof	0.01 Percent
Dodecyl gallate----	
Ascrobyl Palmitate	0.02 Percent
Butylated hydroxyl anisole(BHA)	0.02percent
Citric acid	
Tartaric acid	
Gallic acid	0.01 Percent
Resin Guaiac	0.05 percent
Tertiary butyl hydro quinone (TBHQ)	0.02 percent

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NOTES**Use of anti-oxidants in some food products:**

Food product	Anti-oxidants	Amount
Rasgollas and vadas (dry mixtures)	BHA	0.02% on the basis of fat content
Flavouring agents	Mentioned in the above table	Not exceeding 0.01%
Butter and ghee	BHA	Not exceeding 0.02%
Fat spread	BHA and TBHQ	Not exceeding 0.02% by weight on fat basis
Ready to eat breakfast cereals	BHA	Not exceeding 0.005% (50 ppm)
Ready to drink infant milk substitute	Lecithin and ascorbyl palmitate	Upto maximum limit of 0.5gm/100 (lecithin) and 1 mg /100ml (ascorbyl palmitate)
Vitamin D preparations	Above mentioned anti-oxidants	Not exceeding 0.08%

Rights of the consumers

According to the Consumer Protection Act (1986), the rights of the consumer are as follows:

- Right to be protected against marketing of goods and services which are hazardous to life and property.
- Right to be informed about the quality, quantity, potency, purity, standard and price of goods and services so as to protect the consumer against unfair trade and practices.
- Right to be assured, wherever possible, access to variety of goods and services at competitive prices.
- Right to be heard and to be assured that consumers' interests will receive due consideration to appropriate forums.
- Right to seek redressal against unfair trade practices and unscrupulous exploitation of consumers.
- Right to consumer education.

A food borne diseases outbreak is only possible if the foods are not properly handled and subjected to various types of contaminants. These contaminants can be natural origin like biogenic amines, alkaloids, phenolic compounds, protease inhibitors and phytates. The substances like avidin and agaric acid are toxins that originates from crops. Apart from these natural contaminants there are certain contaminants that may enter the food form the environment due to unhygienic practices. Such contaminants may include pesticide residues, certain heavy metals like arsenic. The contaminants of the biological origin include the pathogenic microorganisms and the toxins produced by them.

The entry of the contaminants leads to serious disease outbreaks such as botulism, which is caused by the pathogenic bacteria, *Clostridium botulinum*. Such serious outbreaks occur because of improper storage and preparation of food. The food may get infected by the microorganisms even during their storage. For proper storage of food, the temperature and moisture of the storage area should be such that does not permit the microbial growth. If the factors that favour the growth of microorganisms in food are controlled the spoilage of food can be prevented.

The spoilage in food is observed either because of the spoilage causing microorganisms or other reasons. The microorganisms responsible for causing the spoilage of food are bacteria, yeasts and molds. The growth of microorganisms in food largely depends on the pH of the food stuffs. The bacteria have more affinity for non-acidic foods like meat and meat products and vegetables. On the contrary, yeast and mold prefer acidic foods like fruits and pickles.

The shelf life of the food can be increased by preserving the food. Thus, spoilage of food can also be prevented. There are various methods of preserving the food. Foods have been preserved since ancient times by means of pickling and blanching boiling. The various modern and advanced methods of preservation have also been introduced; with improve in the technology. These methods increase the shelf life of the foods along with preserving their nutritional values and tastes. These methods have also increased the availability of fruits and vegetables throughout the year. The new technologies make the food safer, but their usefulness and safety must be demonstrated if they are to be accepted by the consumers. It is also the responsibility of the food manufacturing and food service industry to make the consumer aware of the food presented by them. They should also abide with rules and regulations laid down under the various government acts.

Check Your Progress

4. How has FSSAI defined preservatives?
5. What is the main reason for spoilage of food?
6. How can we increase the shelf life of the food?

13.4 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. The biogenic amines are biologically active compounds that are synthesized from amino acids.
2. The following are the uses of alkaloids:
 - a) They are important in pharmacological activities.
 - b) They are normally used as analgesics, anti-malarial, antispasmodics.

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- c) They also play an important role in the treatment of hypertension, mental disorders and tumors.
3. Chromium can irritate the skin and cause ulceration. Long term exposure can cause kidney and liver damage, and damage too circulatory and nerve tissue.
4. Preservative means a substance which when added to food, is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food.
5. The main reason for spoilage in food is observed either because of the spoilage causing microorganisms or other reasons.
6. The shelf life of the food can be increased by preserving the food. Thus, spoilage of food can also be prevented. There are various methods of preserving the food. Foods have been preserved since ancient times by means of pickling and blanching boiling.

13.5 SUMMARY

- The preservatives are the substances that interferes with the cell membrane of the microorganisms, their enzyme activity or their genetic mechanism.
- Codex Alimentarius defines ‘food contaminant’ as any substance not intentionally added to food, which is present in such food as a result of the production, manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food or as a result of environmental contamination.
- The biogenic amines are biologically active compounds that are synthesized from amino acids.
- Biogenic amines should not always be considered as potential toxicants but can also be non-hormonal growth promoters.
- Vasoactive amines include histamine, which may be present in food in quantities capable of producing clinically apparent pharmacologic effects.
- Endogenous histamine is released from basophils and mast cells. Endogenous histamine can also be released by intrinsic histamine -releasing food components.
- Scombroid poisoning, is one of the three most common illnesses associated with seafood consumption. It is food borne illness that results from consuming decayed or spoiled fish.
- Alkaloids are nitrogen containing heterocyclic compounds which occur mainly in plants as salts of common carboxylic acids such as citric acid, oxalic acid acetic, maleic and tartaric acids. They also occur as fumaric, benzoic, aconitic and veratric acid.

- ‘Sanguinarine’ is a toxic alkaloid that causes Epidemic Dropsy. Epidemic dropsy is caused by consuming mustard oil contaminated with argemone seed oil.
- Trypsin-inhibitor is an example of protease inhibitor. Trypsin-inhibitors are found in most of the lentils and legumes, potatoes, sweet potato and sunflower.
- The phytates are present in cereal grains and some lentils. Phytates are usually present in a bound form with potassium, calcium or magnesium.
- Codex Alimentarius defines ‘Pesticides’ as any substance intended for preventing, destroying, attracting, repelling, or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds or which may be administered to animals for the control of ectoparasites.
- Codex Alimentarius defines ‘Pesticide residues’ as any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide.
- Rule 65 under Part XIV: Insecticides and Pesticides of FSSAI Rules lays down specific restrictions on use of insecticides and prescribes tolerance limits of various insecticides in various food items.
- Chromium is used in metal alloys and pigments for paints, cement, paper, rubber, and other materials.
- Chromium often accumulates in aquatic life, adding to the danger of eating fish that may have been exposed to high levels of chromium.
- Copper is an essential substance to human life, but in high-doses it can cause anemia, liver and kidney damage, and stomach and intestinal irritation.
- Flexible materials include paper (laminated and waxed) and plastic films. Aluminum foil, paperboard and formed plastics are in the semi-rigid category. Metal, glass and thick plastic are considered rigid materials.
- The use of recycled packaging materials, other than metals and glass, after the consumer has used them is potentially a problem because of contamination from a variety of sources.
- FSSAI has defined preservative as a substance which when added to food, is capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food.
- According to FSSAI, an antioxidant is a substance which is added to food to retard or prevent oxidative deterioration of food.
- A food borne diseases outbreak is only possible if the foods are not properly handled and subjected to various types of contaminants.
- The spoilage in food is observed either because of the spoilage causing microorganisms or other reasons.

NOTES

- The shelf life of the food can be increased by preserving the food. Thus, spoilage of food can also be prevented.

NOTES

13.6 KEY WORDS

- **Alkaloids:** It refers to nitrogen which contains heterocyclic compounds which occur mainly in plants as salts of common carboxylic acids such as citric acid, oxalic acid acetic, maleic and tartaric acids.
- **Preservatives:** It refers to substances that interferes with the cell membrane of the microorganisms, their enzyme activity or their genetic mechanism.
- **Pesticide Residues:** It refers to specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide.
- **Food Contaminant:** It refers to any substance not intentionally added to food, which is present in such food as a result of the production, manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food or as a result of environmental contamination.

13.7 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. How is endogenous histamine released?
2. State the main cause of scombroid poisoning.
3. What are the types of mammalian polyamines?
4. What is the disease caused by 'sanguinarine'?
5. Name the most common pesticide food contaminant.
6. State any one effect of copper on human health.

Long Answer Questions

1. Explain the food contaminants of natural origin.
2. Discuss the importance of phenolic compounds.
3. Analyse the environmental contaminants present in food.
4. Identify the three main commonly used pesticides in India.
5. What are the ways in which heavy metals can be contaminated? Discuss in detail.

13.8 FURTHER READINGS

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UNIT 14 FOOD TECHNOLOGY

NOTES

Structure

- 14.0 Introduction
- 14.1 Objectives
- 14.2 Genetically Modified Foods: An Introduction
 - 14.2.1 Production and Nutritive Value of Genetically Modified Foods
- 14.3 Answers to Check Your Progress Questions
- 14.4 Summary
- 14.5 Key Words
- 14.6 Self Assessment Questions and Exercises
- 14.7 Further Readings

14.0 INTRODUCTION

Genetically modified (GM) food is defined as food which is produced from animals and plants whose DNA has been altered with the help of genetic engineering. The US Department of Agriculture (USDA) and the Food and Drug administration (FDA), however, favor the use of the term genetic engineering over genetic modification as being more precise; the USDA defines genetic modification to include ‘genetic engineering or other more traditional methods.’

According to the World Health Organization, ‘genetically modified organisms (GMOs) can be defined as organisms (i.e. plants, animals or microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and/or natural recombination. The technology is often called ‘modern biotechnology’ or ‘gene technology’, sometimes also ‘recombinant DNA technology’ or ‘genetic engineering’. ... Foods produced from or using GM organisms are often referred to as GM foods.’

In a meta-analysis, most of the studies showing genetically modified foods in a positive light were renowned to have a disagreement of interest. The scientific population is concerned about industry limits on testing of genetically modified seeds. Moreover, there is concern that revenue may be responsible the adoption of genetically modified crops.

In this unit, the concept of GM foods and its three main generations have been discussed. The production and nutritive contents of such foods have been explained.

14.1 OBJECTIVES

After going through this unit, you will be able to:

- Discuss the concept of genetically modified foods

- Identify the three main generations of GM foods
- Explain the production of GM foods
- Analyse the nutritive content of GM foods

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14.2 GENETICALLY MODIFIED FOODS: AN INTRODUCTION

A few centuries back, when individuals began to live in a civilized manner, they started choosing better plants for development and better creatures for reproducing, at first accidentally also, later purposefully. More than a huge number of years, agriculturists created plants with alluring attributes, for example, increased resistance to infection, superior organic product, and more outstanding healthful substance. Technological and innovative advances have consistently enhanced farming.

Conventional farming techniques include change of qualities of plants in order to produce seeds which is better in qualities. Be that as it may, the farmer chooses for qualities in a way by choosing parent plants with the attractive characteristics; there is no coordinate control at the DNA level because the revamping of the hereditary material happens in an irregular manner. Interestingly, hereditary designing prompts exceedingly focused on exchange of genes. Since, the essential structure of DNA is indistinguishable in all living things, researchers can take at least one particular quality from any creature, including plants, creatures, microscopic organisms, and infections, and embed them into the genome of another creature. This procedure is called recombinant DNA technology.

Generations of Genetically Modified (GM) Crops

Genetically modified (GM) crops are grouped into three ‘generations’, in view of the target of the characteristic that is being introduced in it. The following are the three generations of crops:

1. **First generation:** Original GM crops are developed from seeds that have been inferred with the assistance of biotechnology to increment creation of yields. These seeds have particular qualities to make them resistant to herbicides, bugs, infections, and so forth. The following yields are not essentially unique in relation to the customarily developed products as far as appearance, taste, what’s more, sustenance. For example, herbicide resistant soybean, insect resistant maize, and so on.
2. **Second generation:** GM crops have new qualities to increase the advantages for customer, for example, increased levels of protein, changed or more beneficial fats and altered sugars. Models of such yields incorporate rice with a larger amount of beta-carotene, tomatoes with larger amounts of carotenoids, maize with expanded Vitamin C, soybean with enhanced composition of amino acid, and potatoes with higher calcium content.

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3. **Third generation:** GM crops are in the exploration pipeline. These plants may have attributes that can give expanded capacity to oppose abiotic stress, for example, elevated temperatures, or saline soils. Different attributes may give medical advantages. One more target might be to make ‘pharma plants’ to help deliver dynamic pharmaceutical products. Recombinant antithrombin is the primary human biologic medication got from the drain of goats that have been hereditarily designed to create human antithrombin in their milk.

Benefits of Genetically Modified Crops

GM foods are produced on account of some apparent advantages to the producers and the consumers. The World Health organization (WHO) and US Department of Agriculture (USDA) have described exhaustive advantages of GM foods. The following are some of the advantages which are discussed as follows:

- **Insect resistance:** Agrarian biotechnology has been utilized to make the plants insect resistant. Bug resistance is accomplished by presenting the quality for toxin generation from the bacterium *Bacillus thuringiensis* (Bt). This poison is as of now utilized as an insecticide spray what’s more, is viewed as safe for human utilization. Plants that create this toxin subsequently require bring down amounts of outer insecticides. Such hereditary alteration can make the harvest creation less expensive and more reasonable, and additionally make insect control more secure. Moreover, there is diminished contamination of the groundwater and nature from pesticides, which benefits ranchers, makers, and consumers.
- **Herbicide resistance:** Biotechnology is likewise used to create herbicide-safe products, for example, soybean, cotton, and corn, which lessen cost furthermore, ecological effect. Herbicide-safe products diminish or on the other hand dispense with the requirement for preventative use of herbicides also, for herbicides with more noteworthy danger. Herbicide resistant crops likewise require less working of soil and in this manner protect topsoil from erosion. Herbicide-resistance is accomplished by the acquaintance of a bacterial quality along with the ability of protection from some herbicides.
- **Disease resistance:** Plants can likewise be designed to combat ailment superior to regular yields. Comparative research is being directed to make plants, for example, potatoes, squash, tomatoes, and different harvests sickness resistant.
- **Dietary Improvements:** Hereditary designing would now be able to deliver nutritiously enhanced plants and longer enduring plants, and plants with lower levels of natural occurrence of toxicants.
- **Safety and Risk Assessment:** The following chart will help you to analyse the benefits of GM crops in areas of safety and risk assessment.

Environmental Effects

- This includes are the persistence of the gene after the GMO has been harvested, and the potential for gene instability, biodiversity loss, or increased use of chemicals in agriculture.

Allergenicity

- Potential to cause allergic reactions in general; this risk is comparable to the risks associated with traditionally grown foods.
- To prevent such allergenicity, the transfer of genes from commonly allergenic foods is discouraged unless it can be proven that the protein produced by the introduced gene will not be allergenic.
- Introduction of an entirely new protein that did not previously exist in the food chain.
- Assessment of potential allergenicity to novel proteins is more difficult because of the lack of definitive tests to determine such risk.

Gene Transfer

- It is the transfer of genetic material from GE foods to the cells of the human body or the bacteria in the intestinal tract. DNA from ingested food is not completely degraded by digestion and small fragments of DNA from GM foods have been found in different parts of the gastrointestinal tract probably resulting in horizontal gene transfer due to absorption of DNA fragments by gut microflora or somatic cells lining the intestinal cells.
- The uptake of GM DNA into the cells of the gastrointestinal tract will not have any biological consequences because this DNA will be degraded in the cells. However, it is not clear if people with gastrointestinal diseases will be able to fully degrade this GM DNA.

Outcrossing

- The movement of genes from GM plants to traditional plants or related species in the wild is known as "outcrossing."
- If GM plants are grown in proximity to related plants there is a potential for exchange of the new traits via pollens.

Pleiotropic and Insertional Effects

- A single gene can be responsible for or affect more than one phenotypic characteristic. This is called pleiotropy.
- Introduced genes in GM foods could potentially silence the existing genes, change expression of genes, or turn on genes that were previously not expressed.
- Transgenic genes could interact with existing genes and biochemical pathways of plants in unpredictable ways and lead to production of toxic compounds. Genes only account for a portion of the control on the biochemical processes of an organism; there are other levels of controls.
- Thus, the results of GE can be unpredictable and the GM products unstable. It is important that the entire transgenic food, not just the single protein, be tested for toxicity.

Increase in Anti-nutrients

- Anti-nutrients are substances that interfere with the utilization of nutrients.
- The insertion of a new gene may lead to an increase in the existing levels of anti-nutrients.
- For example, GM soybean has been shown to increase anti-nutrients.
- In sheep and cattle, heat-stable anti-nutrients such as phytoestrogens, glucinins, and phytic acid have been found to cause infertility, allergic reactions, and decreased availability of phosphorus and zinc, respectively.

NOTES**14.2.1 Production and Nutritive Value of Genetically Modified Foods**

We will in this section discuss the production process of genetically modified foods and its nutritive content.

Production of GM Foods

In the production of genetically modified foods, genetically engineered organisms are tested in the laboratory. It is recommended to add one or more than one gene to genome of the organism. However, the most common procedure is to add or decrease the number of copies in a gene.

If the desired strains are producer, the producer then applies the same in a field which is known as 'field testing'. It involves the process of cultivating the plants in a controlled environment and in a field. If the results are successful, then the producer requests for regulatory approval so as to grow the crop at a large-scale.

After the approval, specimens such as breeding pairs, cuttings and seeds and so on are cultivated and given to the farmers. The farmers then cultivate the crops.

According to the USDA, the number of field releases for genetically engineered organisms has grown from four in 1985 to an average of about 800 per year.

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Nutritive Value of GM foods

The main nutrients found in GM foods are as follows:

- Rich in amino acids and protein-biofortification of cassava
- Rich in provitamin A and carotenoid biofortification of sweet potato, maize and wheat.
- Iron-biofortification of beans, legumes and rice.
- Zin-biofortification of maize and wheat.

Check Your Progress

1. How are original GM crops developed?
2. State any one use of herbicide-safe products.

14.3 ANSWERS TO CHECK YOUR PROGRESS QUESTIONS

1. Original GM crops are developed from seeds that have been inferred with the assistance of biotechnology to increment creation of yields. These seeds have particular qualities to make them resistant to herbicides, bugs, infections, and so forth.
2. Herbicide-safe products diminish or on the other hand dispense with the requirement for preventative use of herbicides also, for herbicides with more noteworthy danger.

14.4 SUMMARY

- Conventional farming techniques include change of qualities of plants in order to produce seeds which is better in qualities.
- Be that as it may, the farmer chooses for qualities in a way by choosing parent plants with the attractive characteristics; there is no coordinate control at the DNA level because the revamping of the hereditary material happens in an irregular manner.
- Since, the essential structure of DNA is indistinguishable in all living things, researchers can take at least one particular quality from any creature, including plants, creatures, microscopic organisms, and infections, and embed them into the genome of another creature.

- Genetically modified (GM) crops are grouped into three ‘generations’, in view of the target of the characteristic that is being introduced in it.
- Original GM crops are developed from seeds that have been inferred with the assistance of biotechnology to increment creation of yields.
- GM crops have new qualities to increase the advantages for customer, for example, increased levels of protein, changed or more beneficial fats and altered sugars.
- GM crops are in the exploration pipeline. These plants may have attributes that can give expanded capacity to oppose abiotic stress, for example, elevated temperatures, or saline soils. Different attributes may give medical advantages.
- Recombinant antithrombin is the primary human biologic medication got from the drain of goats that have been hereditarily designed to create human antithrombin in their milk.
- GM foods are produced on account of some apparent advantages to the producers and the consumers.
- Agrarian biotechnology has been utilized to make the plants insect resistant. Bug resistance is accomplished by presenting the quality for toxin generation from the bacterium *Bacillus thuringiensis* (Bt).
- Biotechnology is likewise used to create herbicide-safe products, for example, soybean, cotton, and corn, which lessen cost furthermore, ecological effect.
- Hereditary designing would now be able to deliver nutritiously enhanced plants and longer enduring plants, and plants with lower levels of natural occurrence of toxicants.
- In the production of genetically modified foods, genetically engineered organisms are tested in the laboratory.
- According to the USDA, the number of field releases for genetically engineered organisms has grown from four in 1985 to an average of about 800 per year.

NOTES

14.5 KEY WORDS

- **Anti-Nutrients:** It refers to substances which interfere with the utilization of nutrients.
- **Biotechnology:** It refers to an area of agricultural science which involves the use of scientific tools and techniques, including genetic engineering, molecular markers, molecular diagnostics, vaccines, and tissue culture, to modify living organisms: plants, animals, and microorganisms.

NOTES

- **Conventional farming:** It refers to a type of farming which uses synthetic chemicals and fertilizers to maximize the yield of a particular crop or set of crops, which are typically genetically modified.
- **Genetically Modified Foods:** It refers to foods which is produced from organisms that have had changes introduced into their DNA using the methods of genetic engineering.

14.6 SELF ASSESSMENT QUESTIONS AND EXERCISES

Short Answer Questions

1. What are the main nutrients found in GM foods?
2. Define the term 'field testing'.
3. What are the three generations of GM crops?
4. Write a short note on recombinant DNA technology.
5. What are the various conventional farming techniques?

Long Answer Questions

1. Discuss the production of GM foods.
2. Explain the advantages of genetically modified foods.
3. Analyse the role of genetically modified foods in the existing times.

14.7 FURTHER READINGS

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