NEW AGE

REVISED SECOND EDITION

Food Science

Sumati R. Mudambi
Shalini M. Rao
M.V. Rajagopal

NEW AGE INTERNATIONAL PUBLISHERS

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NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS
New Delhi · Bangalore · Chennai · Cochin · Guwahati · Hyderabad
Jalandhar · Kolkata · Lucknow · Mumbai · Ranchi
Visit us at **www.newagepublishers.com**

Published by New Age International (P) Ltd., Publishers

ISBN (10) : 81-224-2308-6

ISBN (13) : 978-81-224-2308-2

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NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS
4835/24, Ansari Road, Daryaganj, New Delhi - 110002
Visit us at **www.newagepublishers.com**

Preface to the Second Edition

It is a pleasure to present the second edition of the book on Food Science to our readers.

In this edition the focus of the book has been enlarged to meet the needs of students in universities studying food science as a part of their degree programme. It is also intended to meet the needs of students in a number of faculties in which it is a major, ancillary or an elective subject. These include Home Science, Food Science & Technology, Agriculture, Catering, Education, Arts and allied areas.

The contents in this edition have been revised on the basis of developments in the field, the changes in the curricula of universities and feedback from teachers and students. Thus the following four chapters have been added to improve the utility of the book—

- Basic Food Chemistry (Chapter 2)
- Food Acceptance & Sensory Evaluation of Foods (Chapter 7)
- Food-borne Diseases (Chapter 19)
- Food Laws & Food Standards (Chapter 20)

As in the earlier edition, the topics have been arranged in such a manner as to develop the subject matter in a sequence. The basic theory has been amply illustrated by giving examples of familiar Indian foods. Figures (44) and tables (47) have been used extensively to help the understanding of the subject.

It is hoped that the study of the subject matter will provide fundamental knowledge and understanding of Food Science to the students who may not carry the study further and that other students will find this to be an adequate foundation for advanced study.

It is hoped that the book will meet a felt need of students and teachers of the subject. Any suggestion for improvement of the book in subsequent edition from teachers and students will be very much appreciated for it evinces a shared interest in the study and development of this fascinating subject.

We gratefully acknowledge the permission given by our publishers New Age International to use some of the illustrations from the book *Fundamentals of Foods and Nutrition* co-authored by two of us, Dr S.R. Mudambi and Dr M.V. Rajagopal. We thank the V.A. & Mudambi Prakashan for permitting us to use some of the figures from the book *What's to Eat?* authored by one of us, Dr S.R. Mudambi.

Chinchwad, Pune

Sumati R. Mudambi
Shalini M. Rao
M.V. Rajagopal

Preface to the First Edition

It is a pleasure to present a book on Food Science to the students of junior and senior colleges. It is based on the syllabus prescribed by the Maharashtra Higher Secondary Board, Pune, for the first year of junior college. It will also be useful for students studying the first course in Food Science as a part of Home Science degree programme and those offering Food Science and Nutrition as an ancillary subject.

The topics have been arranged in such a manner as to develop the subject matter in a logical sequence. It is hoped that this will help the students to understand and grasp the subject matter with ease. The basic theory has been amply illustrated by giving examples of familiar foods. Figures and tables have been used extensively to help understanding of the subject. It is hoped that the study of the subject matter will provide fundamental knowledge and understanding of Food Science by the students who may not carry the study further and that others will find this to be an adequate foundation for advanced study.

The organization of the book is devised to facilitate effective learning experiences. Practical activities suggested at the end of each topic are directed toward heightening student interest and ensuring their understanding of the subject matter. Obviously the teacher can supplement the list as desired.

It is hoped that the book will meet a long felt need of teachers and students of the subject. Any suggestion for improvement of the book in subsequent edition from teachers and students will be very much appreciated for it evinces a shared interest in the study and development of this fascinating subject.

We are very grateful to Miss Shubha Murthy for her untiring help in preparation of the manuscript and valuable suggestions for its improvement. We gratefully acknowledge the permission given by our publishers Wiley Eastern to use some of the illustrations from the book *Fundamentals of Foods and Nutrition* co-authored by one of us (Dr S.R. Mudambi) with Dr M.V. Rajagopal.

Sumati R. Mudambi
Shalini M. Rao

Contents

1

Nature of Food Study

The basic function of food is to keep us alive and healthy. It is important to understand the composition of foods and changes that occur when foods are grown, harvested, stored, prepared, processed and eaten, so that foods can fulfill their basic function.

In recent years, the study of food has been accepted as a distinct discipline and is known as **Food Science**. The study of food science involves understanding the nature, composition and behaviour of food materials under varying conditions of storage, processing and use. Thus, it helps us to find answers to questions such as what is food, what happens to it when it is stored, processed, preserved, cooked and what determines its acceptability.

Food science embraces many disciplines. Chemical and biochemical methods are used to determine food composition. Knowledge of food composition helps us to use food intelligently to fulfill our nutritional needs. Retention of food quality and preservation of foods are based on food microbiology. The changes that occur in foods during preparation such as volume and texture are physical ones. Study of food acceptability is based on the understanding of sociocultural background. The principles of economics help us to manage food budget efficiently. Thus the basic sciences of physics, chemistry and biology are all involved as also the sciences of biochemistry and microbiology. In addition, one needs understanding of social sciences such as psychology, sociology and economics. Yet food science is more than the sum of these separate disciplines, because it is a subject with its own character.

There has been a tremendous increase in our population in the last twenty years. The gains of "Green Revolution" and "White Revolution" have been nullified in the process. The per capita availability of food has decreased in this period. There is an urgent need to conserve foods produced by reducing post-harvest losses to derive maximum benefit from foods produced. In practice, it means we must utilise all edible parts of plant and animal foods and **avoid wastage of food**, both at personal and institutional level.

Aim of Study of Food Science

The foods we eat are derived from plants and animals. Foods are a complex mixture of many different chemical components. Food components vary with the growth, maturation, harvesting or slaughtering, storage and handling of plant and animal parts used as food. There are further changes in the food components during food preparation and processing as a result of their interaction with one another, with the cooking medium and with the environment. The temperature at which the

food is cooked and the duration of cooking also bring about changes in the components of the food. The aim of the study of food science is to understand these changes and control them in order to obtain food preparation or products, which have desirable characteristics.

Food Science and Food Technology

The dividing line between food science and food technology is often blurred because food technology uses and exploits the knowledge of food science. The link between food science and technology is well illustrated in solving the foremost problem of feeding the world's rapidly increasing population. The problems inherent in deciding what foods meet the nutritional needs of people, the nutritional content of various foods, how to preseve and serve food with minimum nutritional loss, these form part of food science. But to use this information, it must be applied—foods must be grown, stored. processed, preserved and transported on a large scale and this is the area of food technology.

Food science embraces many sciences but a chemical approach to the subject is a natural and important one. Firstly, food materials are composed entirely of chemical compounds. Secondly, nearly all manufactured foods have "additives", which are chemical compounds. These may be added to improve colour, flavour, texture or other desirable qualities. Further, the changes that occur in food when it is processed, cooked, eaten and used by the body are chemical changes.

Understanding basic chemistry of foods is an essential part of the study of food science. Therefore, the second chapter is devoted to the revision of basic chemistry studied earlier.

Physico-chemical aspects of food help us to understand the nature and properties of food. For example, emulsions and emulsification are an important example of colloidal food systems. Milk and butter are good examples of natural emulsions. Physical conditions such as pressure and temperature have often decisive effects upon food systems and the rate of change, which occurs. All changes, which occur during food preparation are primarily physical ones.

Food is an essential pre-requisite of nutrition. Let us start our study by defining some of the words we would be using in the following pages.

Definitions

Food is that which nourishes the body. Only those substances which when eaten or drunk and absorbed by the body produce energy, promote growth, repair tissues and regulate these processes are *foods*. The chemical components of food, which perform these functions are called *nutrients* (Fig. 1.1). Some foods such as milk and cereals supply many nutrients while others such as sugar provide only one nutrient. The study of various nutrients, their functions, food sources and their utilisation by the human body and their effect on human wellbeing is called the science of *nutrition.*

Foods provide six types of nutrients—proteins, carbohydrates, fats, vitamins, minerals and water. In addition, the body also requires a continuous supply of oxygen. There are over 40 essential nutrients, which are supplied by the food we eat.

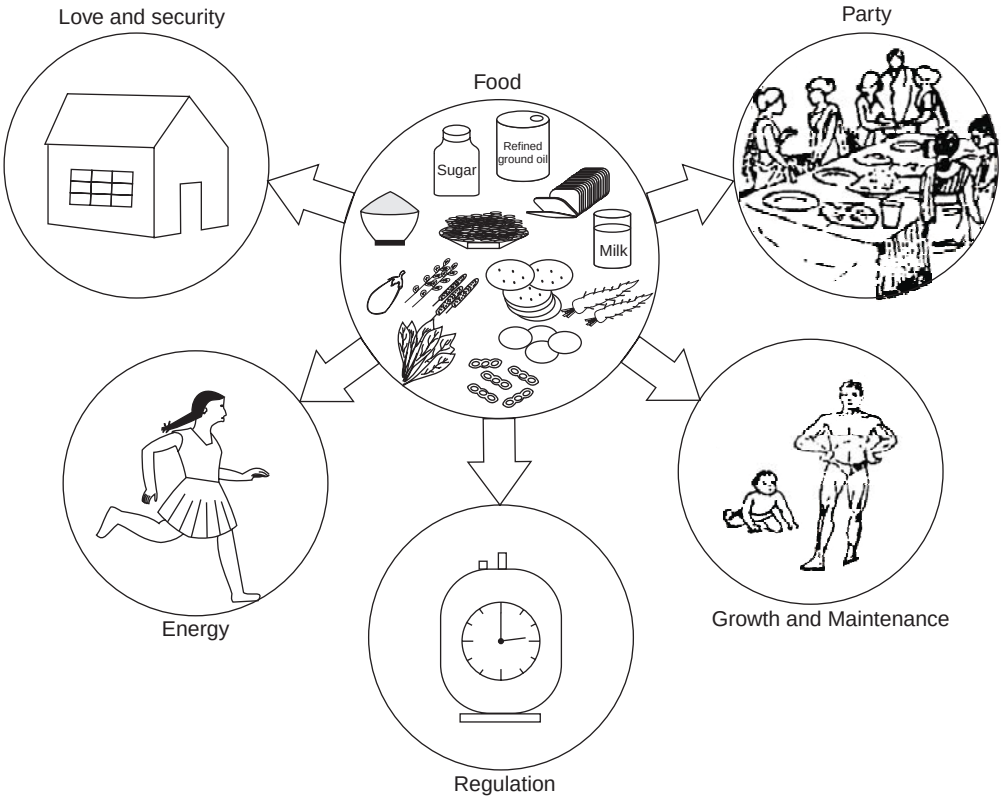

Fig. 1.1 Functions of Food

Malnutrition means an undesirable kind of nutrition leading to ill health. The *lack, excess* or *imbalance* of nutrients in the diet may result in malnutrition. It includes both *undernutrition* and *overnutrition.*

Undernutrition is a state of insufficient supply of essential nutrients to the body. Overnutrition is the result of excessive intake of nutrients, which disturbs normal body functions.

Deficiency of nutrients can occur if the supply of the nutrient is inadequate to meet the body's need or the nutrient supplied is not absorbed and is thus not available to the body.

The word *health* refers to the condition of the body. *Good health* indicates not only freedom from disease, but physical, mental and emotional fitness as well.

Nutrients are discussed from two points of view—their functions in the body and their chemical composition, which are closely related.

The main emphasis in later chapters will be on chemical composition.

Nutrients provided by food perform three basic functions in our bodies. Nutrients supply energy, provide materials for growth and repair of tissues, control and regulate the body processes.

Specific Nutrients in Foods and Their Functions

The foods we use daily include, rice, wheat, dal, vegetables, fruits, milk, eggs, fish, meat, sugar, butter, oils etc. These different foods are made up of a number of chemical components called *nutrients*. Nutrients are classified according to their chemical composition:

Carbohydrates are one of the three main classes of nutrients (carbohydrates, fats and proteins), which supply energy. Each gramme of carbohydrate supplies 4 kilocalories of energy to the body. Carbohydrates are formed in plants from carbon dioxide and water by photosynthesis using the energy of sun. Thus, solar energy is stored as chemical energy in the form of carbohydrates (starch, sugar) in the plant. Carbohydrates contain the elements carbon, hydrogen and oxygen. Starch is present mainly in cereals, pulses, roots and tubers. Sugar is found in fruits, sugar cane and sugar beet.

Table 1.1 gives food sources of major nutrients.

Oils and Fats occur as components of plant and animal foods. These are composed of glycerol and fatty acids. Fats and oils contain carbon, hydrogen and oxygen. But the amount of oxygen present in these is much smaller than in carbohydrates. Each gramme of oil or fat supplies 9 kilocalories of energy. Thus, these are a concentrated source of energy. Oils and fats are extracted from plants and animal sources and are used in food preparation and service.

Proteins are the third major nutrient present in foods. They are present in plant and animal foods, as can be noted from Table 1.1

TABLE 1.1 Food Sources of Major Nutrients

Nutrient	Source	Concentration (%)
1. *Carbohydrates*		
(a) Starch	Cereals, Pulses	60—80
	Roots, Tubers	10—20
(b) Sugar	Fruits	5—12
	Sugar	100
2. *Proteins*	Milk	3—4
	Pulses, Nuts	17—25
	Cereals	6—12
	Egg	13
	Flesh foods	15—26
3. *Fats and Oils*	Vegetable oils, Vanaspati ghee	100
	Butter	81
	Nuts and oilseeds	25—40
	Eggs and meats	13—20

Proteins vary in their composition and size from one species to another. Thus, there are literally thousands, of proteins found in nature. All the proteins contain the elements carbon, hydrogen, oxygen and nitrogen. Thus, the presence of nitrogen distinguishes proteins from carbohydrates and fats. Proteins are made up of smaller compounds known as amino acids.

Mineral elements form an important group of nutrients. The term *minerals* refers to elements other than carbon, hydrogen, oxygen and nitrogen, which are present in foods. Minerals include those elements, which normally form salts and are converted to ash on exposure to high temperature (about 550°C). Mineral elements include calcium, phosphorus, magnesium, sodium, chlorine, potassium, sulphur and many others.

Vitamins are organic compounds present in small amounts in foods, which must be provided to the body, to ensure normal growth and maintenance of the body. *Vitamins* include both fat-soluble ones such as A, D, E and K and water-soluble, vitamin C (ascorbic acid) and thiamin, riboflavin, niacin and others, which belong to the B-complex group.

Water The importance of water as a nutrient has been recognised only recently.

Water is an essential part of the body structure. It is a carrier of nutrients and regulator of a number of body functions. A major part of our need for water is met by the water we drink. A part of our need for water is met by the water in beverages such as tea, coffee, fruit drinks and juices and the water present in food preparations included in the meals.

All individuals need the same nutrients for the same body function. The only variation is in the amounts of each nutrient required according to age, size, activity etc. For example, though all persons need energy for work, a man who carries loads may need more energy than a man who works at a desk job.

Food Microbiology

Our knowledge and study of foods will be incomplete without understanding the role of microorganisms in food production. Microorganisms are minute living organisms, which vary in size from algae, which are just large enough to be seen by the naked eye (about 100 micron) to viruses, which are so small (about 0.1 micron) that these can be seen with an electron microscope only. The micro-organisms that are usually found in food are *moulds*, *yeasts* and *bacteria*. These occur mainly in soil, air, water and sewage. These enter animal and plant foods at various stages of production and storage. These multiply in food, if conditions are favourable.

The food we eat is a very good media for growth of microorganisms. As a result of their growth they may bring about changes in the food. Some of the changes are desirable. In fact a variety of food products are added to our menu as a result of microbial activity. For example, curds are formed from milk by the action of lactic bacteria, bread is fermented with the help of yeast. But it is also true that moist foods kept in a warm place spoil due to action of microorganisms. The presence of some microorganisms or the toxin they produce in food is known to be harmful to the consumer. Therefore, it is important to know the kind of microorganisms present and their mode of action in foods for effective use of food.

Moulds are microscopic form of plants made up of branching intertwined multicellular filaments, which do not contain any chlorophyll. They reproduce through formation of *spores* or seeds. These spores are light and can be carried considerable distances by air currents and in this way infect foods. Meat, cheese, sweet foods and preparations are especially likely to be attacked by moulds. They grow best at a pH of 4 to 6 and at a temperature of 30°C and as the temperature decreases so does the rate of growth. To ensure complete destruction of all moulds and their spores sterilization by heat is necessary.

Yeasts are unicellular microorganisms, which have spherical or ovoid cells. They reproduce by budding of these cells. Yeasts can also form spores, but these are far less heat resistant than the mould and bacterial spores. Yeasts are found on the surface of fruits and other foods which contain sugar. They can grow in varied conditions, namely quite low pH, high salt or sugar concentrations and in the absence of oxygen. Yeasts and yeast spores are easily killed by heating to 100°C.

Bacteria are the smallest form of plant life. They are spherical (cocci), rod-shaped (bacilli) or spiral in shape. They multiply by fission. When conditions are favourable, this fission may occur every 20 minutes. They grow most readily in neutral conditions and growth is generally inhibited by acids. Some bacteria however tolerate fairly low pH. For example, *Lactobacilli*, cause souring of milk with the production of lactic acid. Some bacteria will grow only in the presence of oxygen (aerobic), whereas others will grow only in its absence (anaerobic).

Bacteria grow best in their vegetative state within a given temperature range (25°–40°). All of them can be killed by exposure to a temperature near to 100°C and at this temperature, they are killed instantly. The heat resistance of bacterial spores varies from one species to another and with the pH of the surrounding medium. This aspect is considered in detail in the subsequent chapters. The commonest food spoilage organisms thus are the bacteria, which grow best at about normal body temperature and are found in soil, air, water and sewage.

Protozoa are very tiny one-celled organisms. These are widely distributed in lakes, ponds, streams and in moist soil rich in organic matter. Therefore, vegetables and fruits that have had contact with contaminated soil may be carriers of these. They may also occur in the intestinal tract and may cause amoebic dysentery.

Fermentation: Fermentation is the process of production of gas by microorganism, which brings about changes of volume and texture of the food product. Most food fermentations are brought about by the action of yeast. The most common example is the use of baker's yeast in preparation of bread. *Idli* and *dhokla* are the other examples of fermented foods.

Food Poisoning

Food poisoning occurs when foods containing poisons of chemical or biological origin are eaten.

The characteristic symptoms are abdominal pain and diarrhoea, usually accompanied by vomitting, which follow 2-36 hours after eating such food. By far, the most common cause of food poisoning is the presence in food of harmful bacteria or toxins produced by them.

Most food poisoning incidents occur due to unhygienic practices and therefore these are *preventable.* Pathogens (disease producing bacteria) find their way into food through use of infected animal foods, infected food handlers, unclean equipment, household pest and water. The storage of prepared food at room temperature may accelerate multiplication of pathogens present.

Food poisoning can be prevented by strict adherence to cleanliness in purchase, storage, preparation, handling and service of foods as also use of appropriate temperature during processing and storage of leftovers.

Food Preservation

As mentioned earlier, microorganisms are present in the air, in dust, soil and sewage etc. They are infact so ubiquitous, that their presence in or on food is inevitable, unless special steps are taken to remove them. If food is to be kept in good condition for any length of time, it is essential that the growth of microorganisms be prevented. This can be done by either killing them and then storing the food in conditions, where further infection is impossible or by creating an environment which is not suitable for their multiplication. Table 1.2 lists methods of food preservation.

TABLE 1.2 Methods of Food Preservation

Sl.No.	Method	Principle	Examples
1.	Dehydration	Removal of water prevents growth and multiplication of microorganisms.	Dried foods such as cereals, pulses, nuts, oilseeds, papad, vermicelli, and milk powder.
2.	Chemical preservation	Preservatives kill or inhibit growth of microorganisms.	Salt, sugar, vinegar (pickles and sauces), potassium meta bisulphite (squash).
3.	Sterilization by heat[1]	Heat kills microorganisms. Food is stored in a sealed container and cannot be re-infected.	Canned milk, meat, fish, vegetables and fruits.
4.	Freezing or use of low temperatures	At very low temperature microbial growth is either retarded or prevented	Frozen foods, vegetables, fruits, meat, chicken, shrimp, pomfrets.
5.	Irradiation[2]	High potency radiations kill the microorganisms and pests	Irradiated potatoes, wheat etc. (prevents sprouting of potatoes, onions etc.).

Food preservation, which falls into one or both of the above categories, may be therefore considered as essential in the study of foods.

The principal methods of food preservation include, dehydration, treatment with chemical preservatives, sterilization[1] by heat, use of low temperatures and irradiation[2].

A basic knowledge of food hygiene, personal hygiene, kitchen hygiene and sanitation and the means of preserving food, so as to control food-borne illnesses is very essential. This will enable you to understand how microorganisms bring about changes in food, which affect the basic characteristics of the product. Sanitation at every stage of food handling, will ensure reduction in food spoilage and effect economy and thrift.

In Study of Food Science, the Objectives are:

1. To understand the functions of foods, which supply our nutritional and physiological needs.
2. To know how to select foods to meet our need for nutrients from available foods or basic food groups.
3. To understand the composition of food and the changes that occur during preparation, so that these changes can be controlled to prepare acceptable food products to meet our body's needs.
4. To learn the methods of food preparation which blend acceptability with retention of nutrients.
5. The economic management of food budget to meet family's needs efficiently.
6. Food preservation as an aid to increase variety and food availability.
7. Safeguarding the food supply through sanitary handling and preparation to avoid food-borne diseases.

Points to Remember

Significance of Food Food is essential for sustenance of life. Food usage has cultural, social, religious and regional significance, which forms a part of our food culture.

Food Availability Food is restricted due to increase in population.

Aim of Study of Food Science To understand the changes that occur in food composition at various stages of production and preparation, and control these so as to obtain a product, which has the most desirable colour, flavour, texture and taste.

To understand nutritive value of foods, and use this knowledge in planning of meals.

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1. *Sterilization*—Process, which renders the food free from microorganisms.
2. *Irradiation*—Exposure to radiation is generally used to sterilize various foods, as the radiations kill certain microorganisms.

Functions of Food To provide foods for *building*, *maintenance* and *repair* of body. To provide energy to the body for sustenance, work and other activities. To *regulate* activities in the body.

Specific Nutrients in Foods Include five groups of nutrients viz. carbohydrates, proteins, oils and fats, minerals, vitamins and water.

Food Microbiology Microorganisms from air, soil, water, equipment or personnel may be found in food. Some of these may be helpful, while others may be definitely harmful. Knowledge of their nature helps to take steps to prevent entry and growth of harmful ones and to control the action of helpful ones to obtain desirable products.

Food Preservation Helps to increase shelf-life of foods by controlling changes brought about by microorganisms, enzymes and autooxidation of foods.

Study Questions

1. Explain the aim of study of food science.
2. List three steps taken to improve the acceptability of food products.
3. What are the functions of food in the body?
4. Explain the terms food, nutrition, nutrients, undernutrition and malnutrition.
5. List the sources of starch, proteins and fat in your diet.
6. List the principal methods of food preservation.
7. Prepare charts to depict the following aspects of food study:
   (a) Foods prepared for guest meals, and for important festivals.
   (b) Steps taken to ensure acceptability of food preparation in your home.
   (c) Functions of food—please try to depict these in your own way.
   (d) Sources of the nutrients—carbohydrates, proteins, fats, minerals, vitamins and water.
   (e) Food preserves in your home, and the manner in which these are stored.

2

Basic Chemistry of Foods

Food consists of chemical components. Knowledge of basic chemistry is essential to understand the nature of food and the changes that occur in it. Therefore, it may be useful to revise the basic chemistry, studied in high school.

Atoms and Atomic Particles

Atoms are basic minute particles of elements. An atom is the smallest particle of an element capable of taking part in a chemical reaction. The element hydrogen has the smallest atom, which weighs 1.7×10^{-15} mcg. A microgramme is 1×10^{-6} g. It is difficult to record such minute weights. Hence atomic weights are relative weights of atoms, not absolute weights. Hydrogen, the lightest element was taken as one and the atomic weights of other elements were compared with it. Carbon atom was 12 times and oxygen 16 times the weight of hydrogen atom.

In recent times, carbon isotope of mass 12 has been selected as the standard for comparative purposes instead of hydrogen. For understanding food chemistry, the absolute atomic weight is not important, the basic concept is important. The data for elements important in food science is given in Table 2.1.

TABLE 2.1 Elements of Importance in Food Science

Name of element	Symbol	Atomic No.	Atomic weight
Hydrogen	H	1	1
Carbon	C	6	12
Nitrogen	N	7	14
Oxygen	O	8	16
Fluorine	F	9	19
Sodium	Na	11	23
Phosphorus	P	15	30
Sulphur	S	16	32
Chlorine	Cl	17	35.5
Potassium	K	19	39
Calcium	Ca	20	40
Iron	Fe	26	56
Iodine	I	53	127

When the elements are arranged in the order of increasing atomic weights, the number of the element in this series is called **atomic number**. Thus hydrogen, the lightest element has an atomic number of 1, helium 2, and so on. Over one hundred elements are now known, 92 are natural ones. Those elements with an atomic number of more than 92 are artificial man-made elements.

Components of Atom

Atoms are made up of smaller particles, three of the most important ones are proton, neutron and electron; their mass and charge are listed in Table 2.2.

Table 2.2 Atomic Particles

Name	Mass	Electrical charge
Proton	1	Positive
Electron	1/1840	Negative

Each atom has an equal number of protons and electrons, which carry equal but opposite charges, hence the atom as a whole is not charged.

The protons and neutrons occur together in nucleus (centre) of the atom. The number of protons in the nucleus of the atom are the same as the atomic number of the element. The atoms have diameters of 10^{-8} cm. The diameter of an atom is some ten thousand times that of its nucleus. The electrons are distributed in the space around the nucleus and are never stationary. The electrons are very minute particles; thus all material things are more than 99.9 per cent empty space. This is true of our bodies also.

Hydrogen is the simplest atom, with one proton in the nucleus and one electron in the first shell.

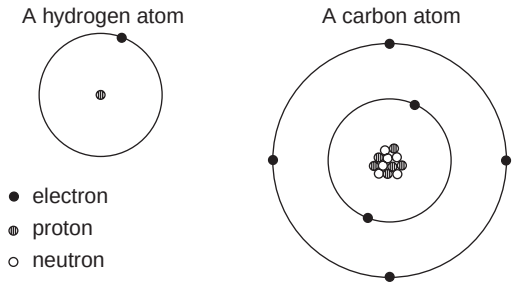


Fig. 2.1 Diagrammatic Representation of a Hydrogen Atom and a Carbon Atom

Carbon, with atomic number 6, has six protons and six neutrons in the nucleus (adding up to atomic weight of 12) and six electrons, two in the first shell and four in the second shell. The

identity of an element is decided by the number of protons in the nucleus and therefore by the number of electrons in the extra nuclear structure.

Isotopes Two atoms of the same element with same number of protons but different number of neutrons in their nucleus are called isotopes. Chlorine (35 and 37), oxygen (16 and 18) and nitrogen (14 and 15) have naturally occurring isotopes, but their concentration of the isotopes in nature is low.

Radioisotopes are the isotopes prepared by the bombardment of natural isotopes with atomic particles. These are unstable isotopes, which emit radiation and atomic particles and change into more stable form. The radiation and particles they emit are extremely harmful to living cells. Thus, radiotherapy is used to destroy the malignant cells of cancer.

Since World War II (1945), atomic explosions from atomic bomb or due to accident in nuclear plants have resulted in production of several radioisotopes of elements. These radioisotopes, when distributed by air currents, found their way into plants and animals and hence into the food. Isotopes of the same element have the same number of electrons and therefore enter into chemical reactions in the body, which are harmful to the body.

There are instrumental methods to measure the isotope concentration. Hence radioactive isotopes have been used in research to study the pathways of biological reactions in the body. Thus, utilization and metabolism of nutrients in the body has been studied by feeding isotopically labelled nutrients to animals. The elements most important in food science are hydrogen, carbon, nitrogen, oxygen, fluorine, sodium, phosphorus, sulphur, chlorine, potassium, calcium, iron and iodine.

Molecules

A molecule is formed by the combination of two or more atoms of an element. It is the smallest particle of an element or compound capable of a free (independent) existence. In forming a molecule, the atoms either share an electron or completely transfer one or more electrons from one atom to another to form the outermost shell. These electrons in the outermost shell are known as **valence electrons**.

Organic Chemistry

You may wonder why a special branch of chemistry, namely, organic chemistry is devoted to carbon compounds. There are two important reasons for this. Firstly carbon compounds are the products of living cells. Secondly, there are many more compounds of carbon known than any other element. In organic chemistry, a single molecular formula may represent different compounds, having different molecular arrangements.

TABLE 2.3 Differences between Inorganic and Organic Compounds

Inorganic compounds	Organic compounds
1. Exist as ions.	Do not exist as ions.
2. Have high melting points.	Have low melting points.
3. No vapour forms on boiling—boiling point is high.	On boiling some molecules escape as vapour. Boiling point is low.
4. Since the atoms exist as ions, they react instantly.	As they are not ionized, they do not react freely with other compounds.
5. A few carbon compounds are inorganic. These include Carbon Monoxide, Carbon Dioxide, Carbon Disulphide, Cyanides, Carbonates and Bicarbonates.	All the remaining carbon compounds are organic compounds which contain hydrogen and often oxygen. In additon, they may contain Nitrogen, Sulphur Phosphorus and the Halogens.

Hydrocarbons

Compounds of carbon and hydrogen are known as **hydrocarbons**. These do not occur in foods and are not nutrients. But it is important to study the chemistry of hydrocarbons as a base, before studying the chemistry of nutrients, which are more complex.

Hydrocarbons exist in nature as straight chain compounds of carbon and hydrogen or as cyclic compounds of carbon and hydrogen. The simplest straight chain compound is methane (CH_4) and cyclic compound is cyclohexane (C_6H_{12}). An important cyclic hydrocarbon which forms a base for several complex compounds occurring in foods is benzene (C_6H_6) in which alternate single and double bonds connect the six carbon atoms to form a hexagon. Ring structures which contain an element other than carbon are known as **heterocyclic compounds**. In nature, one finds a wide range of heterocyclic compounds e.g., vitamins.

TABLE 2.4 Important Classes of Organic Compounds

Class	Name of the functional group	Example
Alcohol	Hydroxyl group (OH)	CH_3OH Methyl Alcohol
Phenol	Hydroxyl group attached to a benzene ring	C_6H_5OH Phenol
Aldehyde	Aldehyde group(CHO)	CH_3CHO Acetaldehyde
		C_6H_5CHO Benzaldehyde
Ketone	Carbonyl group(CO)	CH_3-CO-CH_3 Acetone
Acid	Carboxyl Group(COOH)	CH_3COOH Acetic Acid
		C_6H_5COOH Benzoic Acid

Alcohols and Acids Occurring in Foods

In an alcohol, one of the hydrogen atoms of a hydrocarbon molecule has been replaced by a hydroxyl (OH) group. Most of the acids occurring in foods have a hydrogen atom in a hydrocarbon replaced by a carboxyl (COOH) group.

Alcohols and acids are important classes of organic compounds found in foods.

Alcohols

Simple alcohols are named according to the alkyl group they contain. For example, methyl alcohol (CH_3OH), ethyl alcohol or ethanol (C_2H_5OH), amyl alcohol ($C_5H_{11}OH$), and so on.

Alcohols containing three or more carbon atoms, e.g., propyl alcohol, can have isomers. Thus two propyl alcohols are—n-propyl alcohol ($CH_3CH_2CH_2OH$) and isopropyl alcohol $(CH_3)_2CHOH$.

Alcohols, which contain only one hydroxyl group are called **monohydric alcohols**. Those containing two hydroxyl groups are called **dihydric** and three hydroxyl groups, **trihydric alcohols**. Glycerol, an important constituent of fats and oils, is a trihydric alcohol.

Ethyl Alcohol Ethyl alcohol is referred to as alcohol, as it is a constituent of all alcoholic drinks. Alcoholic drinks are manufactured by the fermentation of fruits (mainly grapes) and molasses (a sugar syrup got as a by-product of sugar manufacture). Other cheap sources used to produce alcohol are barley, rice or roots such as potatoes.

Glycerol Glycerol is a trihydric alcohol, i.e., it contains three hydroxyl groups. It is the only important trihydric alcohol. It is a colourless, sweetish liquid and is also known as **glycerine**. It is an important component of fats and oils and will be discussed in that chapter.

Acids

Acids are the important constituents of foods. Acids have the following properties:

- Acids have a sour taste.
- Acids change the colour of some natural dyes (blue to red).
- Acids react with many metals.
- Acids react with bases to form salts.

Acidity and pH You may have studied the relationship of acidity and pH. Pure water is said to have a neutral pH, i.e., ionization results in production of equal number of hydrogen and hydroxyl ions. Thus, it has a pH of 7.0.

An acidic solution has a hydrogen ion concentration of less than pH 7.0 and an alkaline solution has a pH of more than 7.

A pH change of one is a ten-fold change in hydrogen ion concentration.

Inorganic acids are completely ionized in solution and are called *strong* acids.

Thus, 0.1M HCl has a pH a 1.0

Buffer Systems A buffer system is one that resists change in pH when small amounts of acid or alkali are added to it. A buffer system is formed by a mixture of a weak acid and its salt or a weak base and its salt.

A weak acid or a base is only partially ionized in solution; therefore, there is equilibrium between undissociated acid and its ions. Acetic acid, a component of vinegar, is a typical weak acid. Acetic acid of 0.1M strength is dissociated to only 1 per cent and has a pH of 3.

The pH values of some foods are given in Table 2.5.

TABLE 2.5 pH Values of Some Foods

Food	pH
Lime juice	2.3
Apples	3.0
Orange juice	3.7
Tomatoes	4.3
Potatoes	5.5
Spinach	5.4
Peas	6.0
Evaporated milk	6.0
Butter	6.2

The control of pH by buffers is very important in food processing as also in living bodies.

Carboxylic Acids Most of the acids found in foods are carboxylic acids. Carboxylic acids contain a carboxyl group –COOH. The carboxyl group is a combination of a carbonyl group (C=O) and a hydroxyl group (OH). Acetic acid is a typical carboxylic acid. Carboxylic acids are weak acids with pH between 2.2 to 3.0.

The carboxylic acids starting with acetic acid, are called **fatty acids** because some of the higher members of this series occur in fats in combination with glycerol.

The carboxylic acids important in food chemistry are:

Acetic acid	CH_3COOH
Propionic acid	C_2H_5COOH
Butyric acid	C_3H_7COOH
Caproic acid	$C_5H_{11}COOH$
Caprylic acid	$C_7H_{15}COOH$
Capric acid	$C_9H_{19}COOH$
Lauric acid	$C_{11}H_{23}COOH$
Myristic acid	$C_{13}H_{27}COOH$

Palmitic acid	$C_{15}H_{31}COOH$
Stearic acid	$C_{17}H_{35}COOH$

All the above acids are *saturated fatty acids*, which contain an even number of carbon atoms. The members of the above series, with lower molecular weights are liquids at normal temperatures and are miscible in water.

Acetic Acid is produced when alcohol is oxidized in the presence of a bacterial enzyme.

$$CH_3CH_2OH + O_2 \xrightarrow{\text{Enzyme in } \textit{Acetobacter}} CH_3COOH + H_2O$$

In fact, this is how vinegar, a dilute solution of acetic acid, is produced. The choice of raw material depends on the availability of an inexpensive source. It is malt in U.K., cider in U.S.A. and wine in France. In India, it is molasses. Vinegar is used in pickles and in salads.

Butyric acid is found in sour milk and butter, combined with glycerol. When butter gets rancid, butyric acid is released and gives it the unpleasant rancid smell. Stearic acid is a white wax-like solid, which is insoluble in water.

Unsaturated Acids When oils and fats are hydrolysed, some unsaturated fatty acids are released along with saturated fatty acids. As the name indicates, unsaturated fatty acids contain one or more double bonds. Unsaturated fatty acids have lower melting points than saturated ones containing the same number of carbon atoms. As the proportion of unsaturated fatty acids increases, the softness of fat increases.

Oleic acid, which occurs widely, derives its name from olive oil of which it is the principal acid. Oleic acid contains eighteen carbon atoms. The only double bond in its molecule occurs in the center of the carbon chain. It is called a *mono-unsaturated* fatty acid (MUFA) to indicate it contains only one (mono) double bond. Oleic acid is also the main acid present in human body fat.

It is an interesting fact that the majority of the unsaturated fatty acids obtained from oils and fats contain 18 carbon atoms. Linoleic and linolenic acid occur in linseed oil and hence their names start with "lin". These are two of the commonest unsaturated fatty acids. As you may note from formulas given below, linoleic acid contains two double bonds in positions 6 and 9; linolenic acid contains three double bonds in positions 3, 6 and 9.

Stearic acid, a saturated fatty acid, contains 18 carbon atoms. The differences in the structure of these four fatty acids are shown below:

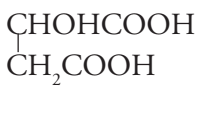
$CH_3(CH_2)_{16}COOH$	Stearic acid
$CH(CH_2)_7$ $CH{=}{=}CH(CH_2)_7$ $COOH$	Oleic acid
$CH_3(CH_2)_4CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	Linoleic acid
$CH_3CH_2CH{=}{=}CHCH_2CH{=}CHCH_2CH{=}CH(CH_2)_7COOH$	Linolenic acid

Dicarboxylic Acids, as the name indicates contain two carboxylic groups. *Oxalic acid* is the simplest one of these and contains simply two carboxyl groups joined together HOOC-COOH. Small amounts of oxalic acid are present in most fruits and vegetables. However, spinach, beet tops and rhubarb contain very large amounts of oxalic acid as calcium oxalate.

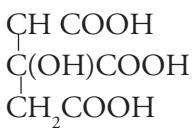
Hydroxy Acids are those acids, which contain both a hydroxyl (OH) and a carboxyl (COOH) group, and these behave both as an alcohol and as an acid. The most important hydroxy acid is *lactic acid* (hydroxy propionic acid). It is produced when milk sugar, lactose is hydrolysed by lactic bacilli to lactic acid. The same chemical change occurs in the preparation of fermented milk products such as curd (yoghurt), butter and cheese.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Enzyme from lactobacilli}} \underset{\text{Lactic acid}}{4CH_3CHOHCOOH}$$

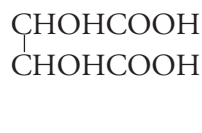
Malic Acid and Citric Acid are two acids commonly present in fruits. Both contain one hydroxyl (OH) group and two and three carboxyl (COOH) groups respectively. Tartaric acid, which contains two hydroxyl and two carboxyl groups, occurs less widely in fruits. Their structures are shown below:



Malic acid



Citric acid



Tartaric acid

Malic and citric acid are responsible for the flavour of fresh fruits. These acids are present in fruits as their potassium salts and also as free acids. Citric acid, as the name suggests, is the main acid of citrus fruits. It is also found in pineapples, tomatoes and most other summer fruits. Malic acid is found in grapes, unripe apples, plums and rhubarb. Tartaric acid is present in grapes and tamarind.

These acids are manufactured commercially for use in beverages, preserves and candies. One of tartaric acid salts is also used in baking powder.

Most of the citric acid and malic acid are absorbed and oxidized in the body; most of the tartaric acid is not absorbed in the body.

Acids act as food preservatives. Acids may be produced in foods during fermentation, or may be added to food to preserve them.

The acids and their salts added to foods lower the pH values and inhibit growth of microorganisms.

Points to Remember

Atoms and Atomic Particles An atom, the smallest particle of an element, is made up of three smaller particles—proton, neutron and electron.

Isotopes and Radio Isotopes Isotopes are the atoms of an element with different number of neutrons in the nucleus; radio isotopes, used in radiotherapy of cancer, are prepared by the bombardment of natural isotopes with atomic particles.

Molecule The smallest particle of an element or compound capable of free independent existence.

Organic Chemistry A special branch of chemistry devoted to the study of carbon compounds, which form the basis of most of the foods.

Alcohols Compounds containing one or more hydroxy groups, e.g., ethyl alcohol a constituent of all alcoholic drinks, glycerol, a trihydric alcohol, which is a constituent of all fats.

Organic Acids Organic acids contain one or more carboxyl groups and are important constituents of many foods, e.g., malic, citric and tartaric acids. Higher members of organic acids occur in fats, in combination with glycerol.

Study Questions

1. What are atoms? What are they made of? Explain the difference between an atom and a molecule.
2. Show diagrammatically the difference between a hydrogen and carbon atom.
3. Why it is important to study organic chemistry?
4. List the differences between inorganic and organic compounds.
5. What are alcohols? Why is it important to study the role of glycerol in foods?
6. Define pH and explain its significance.
7. What are organic acids? What is the difference between a saturated and unsaturated organic acids?
8. List the fatty acids important in foods. Write down their chemical composition.

3

Food as a Source of Nutrients

The foods we use daily include rice, wheat, *dal*, vegetables, fruits, milk, eggs, fish, meat, sugar, butter, oils etc. These foods are composed of chemical components called *nutrients*. The nutrients found in foods include carbohydrates, proteins, fats, minerals, vitamins, water and fibre.

Let us study these nutrients and understand their nature, classification, composition, structure sources and functions.

Carbohydrates

In the Indian dietary, about 65 to 80 per cent of the energy is supplied by carbohydrates. Carbohydrates contain carbon, hydrogen and oxygen. Carbohydrate means hydrate of carbon i.e., in the carbohydrate molecule, hydrogen and oxygen are present in the same proportion as in water and attached to the carbon. In this word, the suffix hydrate indicates that hydrogen and oxygen occur in carbohydrate in the same proportion as in water.

Classification and Structure Carbohydrates are classified chemically according to their molecular structure. The basic structural unit of carbohydrates is the sugar unit $C_6H_{12}O_6$.

Carbohydrates whose molecules consist of only one sugar unit are called *monosaccharides* (mono-one, saccharide—sugar containing). Glucose and fructose (fruit sugar) are examples of this class.

The *disaccharides* contain two sugar units in a molecule. Cane or beet sugar (sucrose), milk sugar (lactose) and maltose (malt sugar) are members of this class.

Carbohydrates made up of a long chain of many sugar molecules are called *polysaccharides* (poly-many). Among them are starches, glycogen, celluloses, plant gums and mucilages. The individual members of these classes differ in the type of small units they contain and in the way the units are linked together.

The size and shape of starch granules is a characteristic of the source of starch. It can be identified by its microscopic appearance by a trained person.

Most starch granules contain both *amylose* and *amylopectin* molecules. The relative concentration of these depends on the starch. Amylose molecules are straight chain polysaccharides. Chain lengths vary from 250 to about 350 glucose units. The long molecules appear to be coiled in an alphahelix. Amylopectin molecules are branched at carbon 6 on the glucose unit and the length of the linear units is only 25 to 30 units, but 1000 or more glucose units are combined in one molecule.

The ability of starch to absorb water, swell, form pastes and gel varies with the source of the starch. The ability of some starches to gel readily is believed to be related to their amylose component.

Pectin is the name given to a mixture of polysaccharides found in some fruits and roots. It can form gel in the presence of adequate sugar and acid. It is not affected by animal enzymes.

Food Sources: Carbohydrates are synthesized by plants and occur in several forms. Starch is found in plant seeds—such as cereals and pulses, and roots and tubers; sugar in fruits, honey, plant juice (sugarcane, beetroot, and palm) and in vegetables such as corn and peas. Cereals supply a large part of the carbohydrate (starch) in the Indian dietary.

The structural carbohydrates of vegetables and fruits are celluloses and other polysaccharides. These are the important sources of dietary fibre in the diet.

Sugar used in daily life is cane sugar or sucrose. It is used in beverages such as tea and coffee and also in preparation of sweets. It is one of the few pure manufactured foods used in the dietary. It provides energy only.

Functions: The main function of carbohydrates is to provide energy. Each gramme of starch or sugar gives four calories[1] to the body. In the Indian dietary, about 65 to 80 per cent of energy is supplied by the carbohydrates, mainly in the form of starch. Some of this energy is used as glucose to supply immediate energy needs of the body, a small portion is stored as *glycogen* (about 350 g) mainly in the muscles and liver; and any excess intake is converted to fat and stored as adipose tissue. Glucose is the source of energy for the central nervous system.

Another important function is to spare proteins for their main function of tissue building and maintenance. It is important to supply sufficient carbohydrates and fats to meet the essential energy needs of the body, otherwise proteins are metabolized to meet energy requirement of the body.

A third function is related to proper utilization of fat from the diet. It is said that fats burn in the flame of carbohydrates, indicating the need for major part of energy to be supplied in the form of carbohydrates.

Certain carbohydrates have special role in the body. *Lactose* aids the absorption of calcium. Ribose, a five carbon sugar, is a part of the important compounds DNA[2] and RNA[3].

Cellulose and other indigestible carbohydrates aid the movements of food through the digestive tract by their capacity to absorb water and help to maintain muscle tone.

Fibre Cellulose, hemicellulose and pectins, which are components of the skins of fruits, covering of seeds, and the structural parts of edible plants are usually referred to as 'Fibre'. Pectins which

1. Calorie is a unit of heat. It is the amount of heat needed to increase the temperature of 1 kg water by 1°C (from 14.0 to 15.0°C).
2. DNA—Deoxyribonucleic Acid, substance forming the genetic material in most organisms.
3. RNA—Ribonucleic Acid, molecules in cytoplasm which are involved with biosynthesis of proteins in the cell.

occur in ripe fruits have the ability to absorb water and to form gels. This property is made use of in the preparation of jams and jellies. Cellulose is insoluble in hot or cold water.

Fibre is not digested by the body. However, it is useful to the body. It helps in the elimination of intestinal wastes, stimulates peristaltic (rhythmic) movements of the intestinal tract by absorbing water and thus adding bulk to the intestinal contents. Lack of fibre in the diet could lead to constipation and other disturbances of the *colon*. This condition could be corrected by including foods containing whole grains cereals, fruits and vegetables in the diet.

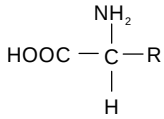
Proteins

Proteins are present in all living plant and animal tissues.

Composition Proteins, like fats and carbohydrates, contain carbon, hydrogen and oxygen. In addition they contain about sixteen per cent nitrogen, which distinguishes the proteins from carbohydrates and fats.

Proteins are more complex and larger molecules than carbohydrates and fats. Some proteins contain sulphur, phosphorus, iron or other minerals also.

Proteins are built from simpler compounds called *amino acids*. The amino acides contain a basic (amino — NH_2) and an acidic (carboxy1 — COOH) group in their molecules as indicated below:



The R may be a hydrogen atom or a more complex group, giving rise to variety of about 23 or more amino acids present in plant and animal proteins. Some of these amino acids cannot be synthesized in the body, but are *essential* for maintenance in human beings. These amino acids, which have to be supplied in the food are called *essential amino acids*.[1] The remaining amino acids, which can be synthesized from others in the body, are termed as *non essential amino acids*, because our body does not have to depend for their supply on the foods we eat.

Structure of Proteins: The structure of a protein molecule is dependent on the number and kind of amino acids present in it. The sequence of amino acids and the manner in which these are linked indicates the structure of the protein.

1. *Eight* amino acids needed by adults are—isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine (ILLMPTTV). *One* additional one needed by growing children is histidine.

Early experiments on protein quality were carried out with purified proteins. On the basis of these experiments, proteins were classified as complete, partially complete and incomplete proteins depending on their ability to maintain life and promote growth. Thus, animal proteins from milk, eggs and meat were all included in the list of complete proteins. *Gliadin*, one of the proteins from wheat was found able to maintain life, but lacked sufficient amounts of some amino acids necessary for growth. Therefore, it was reported to be partially incomplete protein. *Zein* one of the proteins from corn and gelatin are the examples of proteins, which are incapable of maintaining tissues or supporting growth. Therefore, these are totally incomplete proteins. However, later experiments with diets made up of mixed protein from plants sources were found to maintain life and support growth of animals. In view of these findings and the fact that human dietaries are not made up of purified single proteins such as gliadin, zein or gelatin, the classification mentioned above is not relevant and therefore, it is no longer used as it has no practical utility.

Biological Value of Protein is a measure of its quality or ability to support life. If a protein contains all the essential amino acids in the proportions needed by the body, it is said to have a high *biological value*. If a protein lacks sufficient amount of one or more essential amino acids, it is by itself unable to support life and is said to be of low biological value. Thus, biological value indicates the relative nutritional value of a protein.

Food proteins vary greatly in their amino acid composition. For example, animal foods such as milk, eggs, fish, poultry etc., contain all essential amino acids. But cereals are low in lysine and most pulses are low in methionine. However as cereals and pulses are normally consumed together with other foods such as vegetables, milk or curd, the lack in one food is supplemented by the other foods. In other words, various foods, when eaten together in a meal, complement each other and the biological value of protein mixture in the meal is much higher than that of the individual food proteins, when eaten separately.

Properties of Proteins: As mentioned above, proteins are synthesized from amino acids, which contain a basic and an acidic group. The presence of these basic and acidic groups in the constituent amino acids of proteins is responsible for their *amphoteric* nature. The ability of proteins to act as an acid or a base is referred to as its amphoteric nature. The amphoteric nature of proteins is very important from biological point of view, as it prevents sudden change of pH in the body. In food mixtures, these groups help to bind ions and change the texture, volume and appearance of the product.

Denaturation When proteins are exposed to heat, light and/or change in pH, structural changes occur. These changes in structure of proteins are known as denaturation. Denaturation leads to change in solubility of proteins. It may be reversible, if conditions which cause it are mild, but mostly the changes which occur are irreversible.

Coagulation Proteins coagulate on exposure to heat and/or change of pH. All proteins are first denatured and then coagulated by heat. The coagulation occurs between 65° and 90°C. Coagulation means curdling, formation of a mass, congealing or solidifying. For example, when egg is boiled or

scrambled, the egg proteins coagulate and a solid mass is formed from raw egg, which is a fluid. When milk is incubated with curd, the liquid milk is transformed to curd, due to coagulation of milk protein by the lactic acid formed.

The temperature of coagulation increases with addition of other ingredients. For example, when milk and sugar are added to egg to prepare egg custard, the coagulation temperature increases to 85° to 90°C, from 65° to 70°C, which is the temperature of coagulation of egg proteins.

If coagulation is gradual, as in the preparation of curd, the proteins bind water and hold it. This property of proteins is known as *hydration*.

When proteins are coagulated by the action of acid on hot milk, the protein (casein) coagulates and whey is formed. The liquid is known as whey and the coagulum as cottage cheese or paneer. Thus the nature of the product of coagulation is dependent on the agent used for coagulation, the intensity and period of exposure to heat. If coagulated protein is heated for a long period, it becomes tough and dry. Roasted meat, if heated at high temperature to doneness, is dry and tough to chew. Therefore, to obtain an acceptable product, it is important to monitor the time and temperature while preparing these protein foods.

Hydration of Proteins Proteins can form hydrates with water. This reaction is very important in food science. The protein molecule contains a number of groups, which contain a pair of unshared electrons and are therefore capable of attracting and binding the hydrogen of a molecule of water. The water molecule which has been bound, attracts another molecule of water, and thus aggregates of water can build up around each polar group on the protein molecule. The extent of hydration of a protein dispersion depends on concentration of protein, the pH, the temperature and the presence of other substances, which combine with water.

Gelatin when placed in cold water, swells, due to hydration. If it is heated, it dissolves. When cooled, it solidifies again. Thus the water is held in the network of swollen gelatin particles. Gelatin is useful as a gelling agent, a whipping agent in foam and as clearing agent in fruit juices, due to this property.

Emulsifying Agent *Emulsion* is dispersion of one liquid in another liquid. An emulsion is a heterogenous system made up of two phases. A substance which stabilizes an emulsion, is known as an *emulsifying agent*.

If oil and water are shaken vigorously, the two liquids are dispersed to form an *emulsion*. Such an emulsion is unstable, and in order to stabilize it, a third substance, called an *emulsifying agent* or *emulsifier*, must be added. Emulsifying agents are substances whose molecules contain both *hydrophilic* (water-loving) and *hydrophobic* (water-hating) groups.

Proteins act as emulsifying agents, because of their amphoteric nature. For example, in preparation of mayonnaise, eggs act as emulsifying agent.

Foaming Agent Formation of foam is necessary in some food preparations. Proteins when beaten are able to hold in air, and thus improve the texture and feel of the food. Ice-cream and lemon meringue are excellent examples of this property.

Gel Formation Gel formation is a very important process in food science. The changes that occur in food preparation such as stiffening of an egg, meat and milk cookery depends on gel formation. A gel displays the property of rigidity. A classic example is that of gelatin gel, which forms with as low a concentration as one per cent. When colloidal dispersions of large molecules are cooled, the viscosity increases and the mass attains some rigidity. This point is called *gel point*. Egg custard, gelatin gel, *Khandavi, Kharvas* (colostrum custard), puddings etc., are excellent examples of this phenomena.

Food Sources: Plants are the primary source of proteins, as they synthesize protein by combining nitrogen and water from soil with carbondioxide from the air. All animals and fish depend on plants to provide them proteins.

Pulses, nuts, oilseeds, milk and milk products, eggs, fish, poultry and meat are the good sources of protein in the diet. Cereals and their products provide 50 to 70 per cent of proteins in the Indian dietary. Food sources of proteins are presented in Table 3.1. As mentioned earlier, including two or more sources of proteins in each meal helps to improve the quality and utilization of proteins.

TABLE 3.1 Food Sources of Proteins

Food	Protein content per 100 g edible portion
Dals and pulses	17–28
Nuts and oil seeds (except coconut)	16–32
Milk	3–4
Egg	13
Fish, meat, poultry,	15–26
cereals	6–13
Vegetables — beans and peas	4–8

Functions: The principle functions of proteins in the body are as follows:

1. *Building* new tissues in growth stages of life, from conception up to adulthood, and after injury.
2. *Maintenance* of tissues already built and replacement of regular losses.
3. As *regulatory* substances for internal water and acid base balance.
4. *Formation* of enzymes, antibodies, some hormones and one of the B-vitamins.
5. *Formation* of milk.
6. *Energy supply*. Each gramme of protein supplies four calories to the body.

Deficiency: The deficiency of proteins and energy to a varying extent is one of the most common nutritional deficiencies in India. Children tend to have retardation of growth, and adolescents have

thin and lanky bodies, pregnant women gain insufficient weight and have babies, who are low in weight at birth, who may be at-risk.

Severe deficiency of proteins in early stage may result in development of *kwashiorkor* in small children. If severe protein deficiency is accompanied by lack of dietay energy, *nutritional marasmus* occurs.

Oils and Fats

The details of composition and classification of oils and fats will be discussed in Chapter-8-Oils and Fats.

Oils and fats are the most concentrated source of energy in our diet. Each gramme of oil or fat supplies 9 calories. They constitute an important part of our daily diet. It is reported in Diet Atlas of India that they supply 10 to 30 per cent of our energy needs.

Essential Fatty Acid: Vegetable oils contain linoleic and other poly-unsaturated fatty acids. Although some of these can be synthesized in the body, linoleic acid which is required for growth and maintenance of normal skin, cannot be synthesized in the body. Therefore, it has to be supplied in the diet and is termed *essential fatty acid* (EFA). Therefore, it is necessary to include sufficient vegetable oils, in the diet to meet body's need of essential fatty acid.

Food Sources: Oil and fats are obtained from plants and animal sources. The food sources of fats are listed in Table 3.2. Vegetable oils include those extracted from groundnut, sesame or gingelly, mustard, safflower, cotton seed, coconut and palm. Butter and ghee are animal fats, extracted from milk. These food sources contribute visible fat in our dietary.

Foods, which contain large amount of fat, are the sources of hidden fat in the dietary. These include nuts and oilseeds and animal foods such as milk, eggs, fish and meat.

TABLE 3.2 Food Sources of Oils and Fats

Food	Per 100 g	Calories per 100 g
Oil, vegetable cooking	100.0	900
Vanaspati	100.0	900
Ghee	99.5	895
Butter	81.0	729
Oilseeds and nuts	37.0–64.5	537–687
Coconut, fresh	42.0	444
Fatty fish (Hilsa)	19.4	273
Mutton, muscle	13.3	194
Eggs, hen	13.3	173
Liver, sheep	7.5	150
Milk, cow	4.1	67

Functions: Oils and fats are concentrated sources of energy. In addition, to supplying energy, oils and fats have several functions in the body:

(i) They carry fat-soluble vitamins (A, D, E and K) into the body and help in the absorption of these vitamins.
(ii) Vegetable oils are a source of essential fatty acid linoleic acid (Table 3.3) and monounsaturated fatty acid.
(iii) The subcutaneous layer of fat helps us to conserve body heat.
(iv) Fats act as cushion and protect vital organs of the body.
(v) Oils and fats greatly improve the palatability and satiety value of the foods.

TABLE 3.3 Oleic Acid and Linoleic Acid Content of Food Fats[1]

S.No.	Fat/Oil	MUFA (% Oleic acid)	PUFA (Linoleic acid content) g per 100 g
1.	Cotton Seed oil	17–25	50–54
2.	Maize (corn) oil	26–29	54–55
3.	Groundnut oil	47–60	20–30
4.	Ghee (butter fat)	33	3
5.	Coconut oil	5–6	2

1. Meyer, Lilian, *Food Chemistry,* Avi Publ., 1978.

Minerals

It is known that human beings require 14 different elements for health and growth. These include calcium, phosphorus, sodium, chlorine, potassium, magnesium and sulphur, which are present in appreciable amounts (0.5 per cent or more) the other iron, iodine, manganese, copper, zinc, cobalt and fluorine are found in traces.

Functions Minerals have several functions in the body. Body building minerals serve as structural constituents in the hard tissues of the body, such as the bones and teeth. They are the components of soft tissues (muscle, nervous tissue). They form a part of compounds essential for body functions (haemoglobin, thyroxine, insulin etc.)

Body Regulation Some minerals help to maintain acid-base balance and while others regulate water balance in the body. Some minerals are important in *transmission of nerve impulses*, while others are necessary for *muscle contraction* and *relaxation*.

Essential for Action of Enzymes Some metals are integral part of enzymes, while others function as cofactors of some enzymes.

The food sources and deficiency of calcium and iron are discussed as deficiency of other minerals is not very common.

Calcium and Phosphorus The minerals are needed in comparatively large amounts to help normal growth and development of bones and teeth. Breast-milk supplies these in sufficient amounts for the first six months of life.

The food sources of calcium are presented in Table 3.4. The best source of calcium is milk. Babies receive an excellent supply of calcium from their mother's milk. The milk of cows, buffaloes and goats is rich in calcium, so are milk products such as curd, paneer, khoa, cheese and milk powder. Other food sources are fish, sesame seeds (til), the millet ragi and dark green leafy vegetables.

TABLE 3.4 Sources of Calcium

Food	Calcium mg/100 g
Milk, cows	120
Milk, buffalo	210
Milk, goat	170
Skimmed milk powder	1,370
Whole milk powder	950
Khoa (mava)	650–990
Paneer (channa)	208–480
Cheese	790
Fish, fresh	40–1,600
Fish, dry	500–6,000
Sesame (til) seeds	1,450
Ragi (nachani)	344
Leafy vegetables, dark green	70–400

Deficiency of calcium may lead to poor bone and teeth formation. Severe deficiency may cause rickets in children and osteomalacia in adults.

Iron The iron requirement is met from the foetal store for the first three months. Iron is essential for the formation of haemoglobin, the red pigment in blood. Iron is the one mineral, which is found in insufficient amounts in the infant's diet when it is fed only milk. The following foods are good sources of iron (Table 3.5)

Eggs, liver and meat;

dal, leafy green vegetables,

and whole wheat flour, *bajra*, *ragi*, *pohe* (rice flakes)

TABLE 3.5 Sources of Iron

Food	Iron mg/100 g
Leafy vegetables, dark green	5–60
Whole wheat flour, rice flakes	10–20
Rice, jowar, bajra, ragi	3–6
Dals, pulses, tree nuts	5–10
Eggs, meat, liver	2–6
Other vegetables	2–5
Fruits	1–3

The lack of iron results in anaemia due to insufficiency of haemoglobin, the iron containing pigment in blood. Persons lacking iron get tired easily or feel faint due to inability of the body to carry sufficient oxygen to the cells for respiration.

Water

Water accounts for about 55 to 68 per cent of our total adult body weight. The percentage of water tends to decrease as we grow older. Thus, infants and children have a much higher amount of body water than adults. Fat persons have less water than lean ones. Water is an essential nutrient next in importance to oxygen. Deprivation of water even for a few days can lead to death.

Functions of Water Water is a universal solvent and is responsible for the movement of food from mouth to the stomach and is able to dissolve most of the products of digestion.

Further, it is a constituent of all body fluids. It helps to transport the products of digestion to the appropriate organs. For example, blood which contains 90 per cent water, carries carbondioxide to the lungs, nutrients to the cells, and waste nitrogenous material (urea, uric acid etc.) and salts to the kidneys. Urine, which contains 97 per cent water has all the waste material dissolved in it and the body is thus able to excrete soluble waste products of metabolism. Water is needed for many chemical changes that occur in the body. For example, the breakdown of sugar or fat, to simpler substances (hydrolysis) needs water as a medium and also as a reactant in the process.

Water acts as a lubricant and prevents friction between joints. When water from joints is lost, when one falls, the joints become stiff.

The body temperature is regulated through the evaporation of water from the skin and lungs (sensible and insensible perspiration).

Vitamins

Until the beginning of twentieth century, it was thought that a diet containing proteins, carbohydrates, fats, minerals and water was adequate to maintain life. But research conducted in the early part of that century proved that some vital factor was missing from the diet. This vital factor was given the name *vitamin*. Later it was found that there were more than one factor involved.

Now we know that vitamins are one of the six classes of nutrients supplied by food. They are required for normal growth and maintenance of all animal life. Vitamins are important for their regulatory and protective functions. Unlike most other nutrients, they are required in very small amounts. But it is necessary to provide these in the diet because many of them cannot be manufactured by the body. The lack of vitamins results in definite deficiency disorders which are specific for each particular vitamin.

These are essential for the maintenance of good health as they catalyse various body processes, which help to utilize all the nutrients supplied and regulate a number of functions in the body.

Vitamins are conveniently classified into two groups on the basis of their solubility (in fat or in water) into fat-soluble and water-soluble vitamins. Fat-soluble vitamins include A, D, E and K, and water-soluble vitamins include the B-group and vitamin C. Foods differ greatly in the amount and kinds of the vitamins they supply.

Fat-Soluble Vitamins Fat soluble vitamins include vitamins A, D, E and K. Fat-soluble vitamins can only be absorbed in the presence of fat. Therefore, the presence of some fat in the diet is essential for their absorption. Fat-soluble vitamins can be stored in the body and hence occasional intake of very high sources may help the body tide over periods of low intake. The requirement for fat-soluble vitamins may be met by intake of a precursor or the vitamin itself. *Precursor* is a substance which can be converted into the vitamin in the body. Not much of fat-soluble vitamins are lost in the normal cooking procedures.

Vitamin A (Retinol) Vitamin A has a number of varied functions in the body. It is necessary for growth and development. It helps to keep the skin and epithelial tissues healthy and resistant to infection. Vitamin A occurs in the retina of the eye, as a part of substance *rhodopsin* or *visual purple*. Visual purple is bleached in the presence of light and regenerated in the dark with the help of vitamin A. Vitamin A is needed in visual cycle, which enables a person to adjust to light of varying intensity. Thus, Vitamin A is needed for normal vision in light and darkness (night). The earliest symptom of Vitamin A deficiency is night blindness, the inability to see normally in dim light.

Other symptoms of Vitamin A deficiency which develop progressively are dryness of conjunctiva, xerosis of cornea and corneal infection, which if unchecked may lead to blindness.

In addition, severe deficiency of Vitamin A results in growth failure and skin changes (dryness, wrinkling, thickness).

Being fat-soluble, vitamin A is present only in the fat of animal foods, such as whole milk products, ghee, butter, egg yellow, liver etc. (Table 3.6).

A plant pigment (red-orange in colour) called *carotene* is converted to vitamin A in the body. Therefore, foods which contain carotene are indirect sources of vitamin A. Such foods include dark green leafy vegetables, such as amaranth, coriander, drumstick, radish leaves and spinach, and orange-yellow vegetables and fruits, such as carrot, pumpkin, papaya and mango. Be sure to include one of these in the daily diet.

Severe deficiency of vitamin A leads to growth failure, skin changes, infections of the eye and eventual loss of vision.

TABLE 3.6 Food Sources of Vitamin 'A'

Food	Vitamin A Mcg/100 g	Carotene Mcg/100 g
Liver (sheep)	6690	—
Eggs	360	600
Butter, ghee (cow's)	600–960	—
Refined oil, vanaspati	750	—
Milk	48–52	6
Leaves dark green	—	5000 and above
Leaves light green	—	750–2000
Yellow or orange vegetables and fruits	—	665–2740
Immature beans, peas capsicum, tomato etc.	—	80–595

Vitamin D Vitamin D is essential for the absorption of calcium and phosphorus from the digestive tract and deposition in the bones. Vitamin D is formed from a substance present in our skin, called *7-dehydrocholesterol*.

The infant needs to be exposed to sunlight to permit the synthesis of Vitamin D from the precursor in the skin. Since milk, human as well as cow's, is not a good source of Vitamin D, a small supplement is required for both breast-fed and bottle-fed infants. An additional intake of 200 IU per day is recommended by the I.C.M.R. This may preferably be given in the form of a water-soluble preparation.

Fish liver oil preparations are normally used as supplements for the supply of vitamins A and D. When vitamin supplements are used, feeding of excess of vitamin A and D should be avoided as they have toxic effect when taken in large doses for prolonged periods.

Without the presence of vitamin D, formation of strong and rigid bones is not possible.

Vitamin E Vitamin E is present in human tissues and it is necessary for normal metabolism. It is found to be widely distributed in foods. It is found in wheat-germ oil, in milk and in green leaves. Deficiency of Vitamin E in man has not been reported and so there is no recommended daily intake. Vitamin E, however plays an important role in the body as an antioxidant by protecting substances such as unsaturated fatty acids, carotene and ascorbic acid, which are easily oxidized.

Vitamin K Vitamin K is essential to ensure normal clotting of blood whenever there is bleeding. Green leafy vegetables are the principal dietary source of Vitamin K. Excessive intake of Vitamin K should be avoided.

Water-Soluble Vitamins Water-soluble vitamins consist of a large number of substances. These include ascorbic acid and the B-complex vitamins. Some of the water-soluble vitamins are partly lost in cooking procedures. This factor has to be kept in mind while meeting their requirements.

Vitamin B-complex A number of substances have been identified and grouped together under this heading.

At present there are eight well-defined B vitamins, collectively they are known as *vitamin B-complex*. These are thiamin, riboflavin, niacin, vitamin B-6, folacin, vitamin B-12, pantothenic acid and biotin. Of these, only three will be discussed—thiamin, riboflavin and niacin.

Food sources of these three B vitamins are presented in Table 3.7.

Thiamin was first isolated in 1926 from rice polishings.

Thiamin is necessary for catalyzing the oxidation of carbohydrates in the body. This reaction releases energy in the body. Therefore, the amount of thiamin required is dependent on the total calorie intake. Thiamin also helps in the normal functioning of the nervous system and the heart. It is essential for normal growth.

Nearly all foods, except sugars, fats and oils contain some thiamin. Plant sources include pulses, nuts, oilseeds and whole grains (Table 3.7). Leafy green vegetables and animal foods such as milk, eggs, fish and meat are fair sources. Most foods however, contain only a small amount of thiamin. It is, therefore necessary to consume a variety of foods to fulfill the daily thiamin needs.

TABLE 3.7 Food Sources of B-Vitamins

Food	Thiamin (Mg)	Riboflavin (per 100 g)	Niacin edible portion
Dals, pulses, oil seeds, nuts	0.24– 1.00	0.15– 0.97	2.0– 19.9
Cereals			
Whole	0.20– 0.98	0.10– 0.29	2.3– 4.3
Refined	0.06– 0.12	0.06	1.9– 2.4
Animal Foods			
Liver, sheep	0.06	0.01– 0.70	17.6
Pork	0.54	0.009	2.8
Other flesh foods & eggs	0.03– 0.18	0.09– 0.44	0.1– 6.8
Milk	0.05	0.10– 0.19	0.1
Vegetables			
Dark green leafy	0.01– 0.22	0.30- 0.47	0.2– 1.4
Peas & tender redgram	0.25– 0.32	0.01– 0.33	0.8– 3.0
Fruits	0.02– 0.33	0.01– 0.44	0.1– 1.6

Refining of cereals reduces the thiamin content. But parboiling of rice helps to conserve thiamin. Thiamin being water soluble, is also lost when the water in which cereals and pulses are cooked is discarded. Long cooking time also increases the destruction of thiamin. Under ordinary conditions, most of the thiamin losses occur due to solution and not because of heat inactivation. If cooking water is not discarded, only 10 to 30 per cent of thiamin is lost.

Riboflavin is a water soluble yellow pigment. It is less water soluble than thiamin, and more stable to heat. When in solution, the vitamin is destroyed on exposure to sunlight. For example, prolonged exposure of milk to direct sunlight may decrease the riboflavin content of milk drastically.

Riboflavin is essential for the growth of all animal and plant life. Like thiamin, the need for riboflavin by the body is dependent on the total energy intake.

Milk and milk products (such as curd, paneer) are rich sources of riboflavin. But there is no riboflavin in butter and ghee. Liver and kidney of animals and birds are good sources of riboflavin. Pulses, green leafy vegetables, eggs and meat contain a fair amount. Cereals, roots and fruits are poor sources. Table 3.7 presents the riboflavin content of some common foods.

Niacin Niacin is most stable of the B complex vitamins. Niacin functions as a component of enzymes that are involved in the break-down of glucose to release energy. It is necessary for growth. Since niacin is involved in the utilization of carbohydrates, its requirement is proportional to the total calories in the diet.

Meat is a rich source of niacin. So also are groundnuts. Cereals are a major source of niacin in the Indian dietary. Unrefined and parboiled cereals contain more niacin than refined ones. Milk, eggs, vegetables and fruits contains small amounts of niacin.

Ascorbic Acid (Vitamin C) The lack of ascorbic acid has long been known to cause a disease, called *scurvy* in humans. In olden days, sailors to whom fresh fruits and vegetables were not available for many days during long voyages at sea, developed this disease.

Ascorbic acid performs a number of important functions in the body. It is a part of the cementing material which holds body cells in place. It helps the body to build resistance to infection. It also helps in the absorption of calcium and iron.

Ascorbic acid is a labile nutrient. It is readily soluble in water and is easily oxidized. Losses can occur due to solution, oxidation and destruction on heating. The loss of ascorbic acid in normal food preparation varies from 5 to 35 per cent. It is comparatively stable in acid medium.

To minimize cooking losses, special care has to be taken during preparation. This is discussed in Chapters 9–10.

Amla is one of the richest sources of ascorbic acid. Citrus fruits like orange, lemon, grape fruit are excellent sources (Table 3.8). Guava, cashew apple and drumsticks have a high ascorbic acid content. Leafy vegetables such as amaranth, drumstick leaves, cabbage are readily available sources of the vitamin. Sprouted pulses such as Bengal gram and green gram are good sources.

The functions and sources of the nutrients discussed so far are summarized in Table 3.9.

TABLE 3.8 Food Sources of Ascorbic Acid

Food	Ascorbic Acid mg/100 g
Amla	600
Guava	210–310
Cashew Fruit, Drumstick Leaves	180–220
Capsicum	137
Leafy Vegetables	10–135
Citrus Fruits	30–63
Papaya, Pineapple, Tomato	25–55
Other Vegetables and Fruits	5–95

TABLE 3.9 Nutrients: Functions and Sources

Nutrient	Its functions	Food sources
Carbohydrates	To supply food energy To help body to use other nutrients.	Cereal products including rice, chapati, bread, bhakri, pohe, rawa, maida; potatoes, corn, yam, sugar, syrup, jam, honey, jaggery, dried fruits, bananas.
Proteins	To retain body structure and composition. To build and reapair all tissues in the body. To help form antibodies to fight infections. To form enzymes, hormones to regulate body processes. To provide food energy.	Milk, curd, lassi, cheese, dals, dry beans, peas; Groundnut, other nuts, and oil seeds. Eggs, fish, poultry, meats, breads, cereals; other grain products.
Fats	To supply food energy in concentrated form. To supply essential fatty acids To aid transport and absorption of fat-soluble vitamins.	Cooking fats and oils; ghee, butter, cream, vanaspati; bacon, other meat fats.
Minerals		
Calcium	To build bones and teeth. To help clotting of blood.	Milk, curd, cheese, fish, fresh and dry (small), ragi, sesame seeds,

(Contd)

Nutrient	Its functions	Food sources
	To help the muscles and nerves to react normally	Amaranth, leaves of colocasia, chawli, drumstick, fenugreek and radish.
Iron	To form haemoglobin, a pigment in the blood, responsible for respiratory enzymes	Eggs, shellfish, poultry, meat-liver, heart, kidney, dark green leafy vegetables, whole cereal products, ragi, bajra, dals, dry beans
Vitamins		
Vitamin A	To help growth and development To help keep the skin and mucous membrane healthy and resistant to infection To protect against night blindness	Dark green and yellow vegetables, amaranth, chawli, radish tops, spinach, fenugreek, carrot, mango, papaya, ghee, butter, eggs, liver.
Thiamin	To maintain the appetite and keep the nervous system healthy To help release energy for use of the body	Whole wheat products, dals, parboiled rice, fresh peas and beans, eggs, poultry, milk, pork, liver, heart, kidney.
Riboflavin	To help cell respiration; Essential for growth To help keep clear vision To help maintain the skin smooth around mouth and nose	Milk, curds, cheese, milk products, liver, poultry, eggs, fish, cowpeas and other pulses, colocasia, radish tops, sitaphal
Niacin	To help growth To help release energy	Groundnuts, liver, brewer's yeast, pork, meat, prawns, pulses, seeds.
Vitamin C	To make cementing substance to hold cells together and to strengthen walls of blood vessels to help resist infection To help healing of wounds To help absorption of iron	Amla, guava, cashew apple, drumstick leaves, cabbage, radish tops, amaranth, orange, musambi, grape fruit, pummelo, tomato.
Vitamin D	To help absorption to calcium To help build strong bones and teeth	Sunlight fish, fish liver oils, butter, eggs
Water	To retain body structure and composition To help digest and absorb food To regulate body temperature To help regulate body pH	Water Beverages, such as tea, coffee, juices, sherbets, buttermilk, lassi, coconut water

Points to Remember

Carbohydrates Composed of carbon, hydrogen, oxygen. Include starch and sugar.

Functions To supply energy, to help body to use other nutrients.

Food Sources Cereals, roots and tubers, sugar, jaggery, banana.

In Foods Starches absorb water, swell, form pastes and gel. Sugar used to sweeten foods.

Proteins Composed of carbon, hydrogen, oxygen, nitrogen.

Functions To build, maintain and repair tissues.

Food Sources Plant and animal. Plant sources are dals, pulses, nuts and oilseeds. Animal sources are milk, eggs, fish, poultry and meat.

In Foods Proteins denature and coagulate on exposure to heat, change in pH. Gelatine absorbs water, swells and forms a gel when cooled. Act as emulsifying and foaming agents.

Fats Composed of carbon, hydrogen and oxygen.

Functions Supply energy, essential fatty acids, and fat soluble vitamins.

Food Sources Oil and oilseeds, ghee, nuts and meat fats.

Minerals

***Calcium** Functions* To build bones and teeth.

Food Sources Milk, fish, ragi, amaranth.

Iron

Functions To form haemoglobin.

Food Sources Green leafy vegetables, organ meat, whole cereals.

Vitamins

Vitamin A Functions It helps in growth and development of the body, maintains healthy skin and normal vision.

Food Sources Dark green leafy vegetables (spinach), yellow-orange fruits (mango), ghee, eggs, liver.

Thiamin Functions Maintain normal appetite, healthy nervous system, helps release energy from carbohydrate.

Food Sources Whole cereal products, eggs, poultry, milk and its products.

Riboflavin Functions Helps cell respiration, maintains smooth skin around mouth and nose.

Food Sources Milk and its products, eggs, fish, colocasia, pulses, liver.

Niacin Functions Helps growth and release of energy.

Food Sources Groundnuts, liver, pulses.

Vitamin C Functions Makes cementing substance to hold cells together, healing of wounds, increases absorption of iron.

Food Sources Citrus fruits, *amla*, guava, green leafy vegetables, papaya, tomato.

Vitamin D Functions Helps absorption of calcium, helps build strong bones and teeth.

Sources Sunlight helps form vitamin D in skin, fish, fish-liver, oil, butter.

Water Functions retains body structure and composition, helps digest and absorb food. Regulates body temperature and pH.

Sources Water, beverages.

Fibre Functions Add bulk to diet, prevents constipation.

Sources Whole cereals, green leafy vegetables.

Study Questions

1. List the different nutrients supplied by foods.
2. (a) What elements are carbohydrates made of?
   (b) List the kinds of dietary carbohydrates and their sources.
3. How are carbohydrates important to the body?
4. How are proteins different from carbohydrates and fats?
5. (a) What are Essential Amino Acids?
   Why are they said to be essential?
   List the different essential amino acids.
   (b) What is biological value of a protein?
   (c) List three different combinations of foods which have a high biological value.
6. What are the effects of heat on protein?
   Are some of these desirable in foods?
   Discuss these with examples.
7. What is hydration of proteins? How is this important in foods?
8. List the functions of proteins in the body.
9. What is a dietary deficiency of energy and protein called?
10. What is an essential fatty acid?
11. List the important functions of fats.
12. List the sources of calcium in your diet.

13. What are the functions of water?
14. List three important dietary sources of the following vitamins:
    (a) Vitamin A,
    (b) Thiamin,
    (c) Riboflavin,
    (d) Niacin,
    (e) Ascorbic acid.
15. What is Fibre? How is it important in the diet?

4

Basic Food Groups and their Nutrient Contribution

We meet our nutrient requirements in many ways. A wide variety of foods and meal patterns are found among the people of the world. Some eat two meals a day, while others find four or more meals best suited to their way of living. There is a wide variation in the types of animal foods included in the dietaries around the world. In India, the animal foods universally accepted are milk and milk products and these are included in all regions in the meals. There is a wide variation in the acceptance of other animal foods. Some eat eggs, but not fish and meat; yet others accept eggs, fish and poultry, but there are some reservations about the acceptance of pig and cattle meat.

A number of pulses and legumes are used in the meals of all regions and therefore, are a very important source of protein in the Indian dietary.

Each day our body needs a supply of a number of nutrients to carry out its activities efficiently. A lot of research has been carried out meticulously to determine the amounts and kinds of nutrients needed for good health. The recommended allowances (RDA) for Indians set up by the Indian Council of Medical Research is the product of these efforts. The RDA imply an addition of amount (safety factor) to the estimated requirement to cover for both the varation among individuals and the lack of precision in the estimated requirement. The latest RDA for Indians are presented in Table 4.1.

The nutritional requirement of a person depends on the following four factors:

Age An adult, who has larger body and increased activity, needs more total energy than a child.

Sex Males require more calories than females due to bigger body size and higher BMR.

Physical Work Persons engaged in hard physical work need more calories and B-vitamins than those engaged in sedentary work.

Physiological stress Requirement for nutrients is increased during periods of physiological stress such as pregnancy, lactation and recovery from illness.

Food Composition Knowledge of food composition is necessary to enable us to plan a diet, which meets our nutritional needs. Over 650 Indian foods have been analysed to determine their nutrient content. It is interesting to note that there are inherent similarities in groups of foods depending on the part of the plant or animal and their genetic origin. The average composition of various foods in Table 4.2, gives nutrients at a glance.

TABLE 4.1 Recommended Dietary Allowances for Indians—1989

Group	Particulars	Body wt	Net energy	Protein	Fat	Calcium	Iron	Vitamin A		Thiamine	Riboflavin	Nicotinic acid	Pyridoxin	Ascorbic acid	Folic acid	Vitamin B_{12}
								Retinol	β-carotene							
		(kg)	(Kcal/d)	(g/d)	(g/d)	(mg/d)	(mg/d)	(μg/d)	(μg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(mg/d)	(μg/d)	(μg/d)
Man	Sedentary work		2425							1.2	1.4	16				
	Moderate work	60	2875	60	20	400	28	600	2400	1.4	1.6	18	2.0	40	100	1
	Heavy work		3800							1.6	1.9	21				
Women	Sedentary work		1875							0.9	1.1	12				
	Moderate work	50	2225	50	20	400	30	600	2400	1.1	1.3	14	2.0	40	100	1
	Heavy work		2925							1.2	1.5	16				
	Pregnant woman		+300	+15	30	1000	38	600	2400	+0.2	0.2	+2	2.5	40	400	1
	Lactation															
	0–6 months	50	+550	+25						+0.3	+0.3	+4				
	6–12 months		+400	+18	45	1000	30	950	3800	+0.2	+0.2	+3	2.5	80	150	1.5
Infants	0–6 months	5.4	108/ kg	2.05/ kg		500				55 μg/kg	65 μg/kg	710 μg/kg	0.1	25	25	0.2
	6–12 months	8.6	98/ kg	1.65/ kg				350	1400	50 μg/kg	60 μg/kg	650 μg/kg	0.4			
Children	1–3 years	12.2	1240	22			12	400		0.6	0.7	8			30	
	4–6 years	19.0	1690	30	25	400	18	400	1600	0.9	1.0	11		40	40	0.2–1.0
	7–9 years	26.9	1950	41			26	600	2400	1.0	1.2	13	1.6		60	
Boys	10–12 years	35.4	2190	54			34			1.1	1.3	15				
Girls	10–12 years	31.5	1970	57	22	600	19	600	2400	1.0	1.2	13	1.6	40	70	0.2–1.0
Boys	13–15 years	47.8	2450	70			41			1.2	1.5	16				
Girls	13–15 years	46.7	2060	65	22	600	28	600	2400	1.0	1.2	14	2.0	40	100	0.2–1.0
Boys	16–18 years	57.1	2640	78			50			1.3	1.6	17				
Girls	16–18 years	49.9	2060	63	22	500	30	600	2400	1.0	1.2	14	2.0	40	100	0.2–1.0

Source: Gopalan C., B.V. Rama Sastri and S.C. Balasubramanian 1991, *Nutritive Value of Indian Foods*, National Institute of Nutrition, ICMR, Hyderabad 500 007, India.

TABLE 4.2 Nutrients in Food at a Glance[1]

(Approximate Group Values per 100 g Edible Portion)

Foods	Moisture	Calories	Protein (g)	Vit. A value (mcg)	Vit.C (mg)
Cereals-rice wheat bajra, jowar	10	340	7 to 12	—	—
Dals (pulses)[2]	10	340	17–25	—	—
Milk[3]	85	70	3	48	—
Egg	85	70	13	960	—
Meat, fish poultry	75	100–190	18	Some	—
Leafy and yellow-orange vegetables	90	20	2	> 1, 800	>30
Fruit rich in vit. C	85	50	1	Some	50
Ghee	0	900	—	750[3]	—
Oils	0	900	—	—	—
Sugar	0	400	—	—	—

1. For specific values, consult *Nutritive Value of Indian Foods* ICMR 1991.
2. Rich source of iron and B-complex.
3. Rich sources of calcium and riboflavin.

In order to use above information to plan adequate meals for people, the foods are classified into *basic food groups*; on the basis of the major nutrients present. The practical tool devised to guide food selection to meet nutritional needs is termed *food guide* (Fig. 4.1). The food guide is based on basic food groups.

As you know, food availability and meal patterns vary from one country to another. Therefore a food guide for one country, such as the Basic Four used in the USA, is not suitable for use in India, where meal pattern, food availability and cost are different. This is one of the reasons for developing a food guide for India.

Food Guide for Selecting an Adequate Diet

All the foods we use in our daily meals are divided into five groups in the food guide for India. This is presented in Table 4.3. The food groups are chosen because of the specific nutrients contributed by each to the total diet. Foods have been assigned to the groups on the basis of their composition. The Food Guide is designed to direct selection of foods and quantities consumed to meet the RDA, thus forming the foundation of an adequate diet.

As you may observe, the first column in the table indicates the food group, the third column specifies the amount in one serving, and the last column indicates the minimum number of servings

to be taken to meet your nutritional needs. If sufficient amounts of foods from each of the five groups are included in the day's diet, the nutrient requirements of the body will be met. Such a diet is a balanced diet, as it meets the person's nutritional needs.

Let us study each food group in detail, so that we can use the food guide as a practical tool. The food guide is presented pictorially in Fig. 4.1.

TABLE 4.3 Food Guide based on Basic Five Food Groups[1, 2, 3]

Food group	Foods included	Size of serving	Suggested no. of servings
1.	**Cereals and Breads** The staples-rice, wheat, bajra, jowar, maize, ragi and their preparations	25 g	9–16
2.	**Protein Foods**:		
	Dals, legumes, nuts and oilseeds	25 g	
	Milk and milk products	150 g	3–5
	Eggs	1 No.	
	Fish, poultry, meat	30 g	
3.	(a) **Protective Vegetables and Fruits** All green leafy vegetables, orange, yellow vegetables and fruits	50–75 g	1–2
	(b) **Vit. C rich Vegetables and Fruits**: Amla[4], guava drumstick, orange, papaya, mausambi etc.	50–75 g	1–2
4.	**Other Vegetables and Fruits** All the remaining vegetables such as fruit vegetables, gourds, immature beans & peas, potatoes, onions etc. Fruits such as bananas, melons, sapota, grapes, apples, etc.	50–75g	3 or more
5.	**Oils, Fats, Sugars**		
	Oils, ghee, butter, *vanaspati*	5 g	5 or more
	Sugar, jaggery, murabbas, syrups	5 g	5 or more

1. Adapted from ICMR Special Report Series 1991.
2. Mudambi, Sumati R., *Food for Fitness, Nutrition Education* 2, SNDT Univ. Publication, 1971.
3. Mudambi, Sumati R. & M.V. Rajagopal, *Fundamentals of Foods and Nutrition*, New Age International (P) Limited, New Delhi 1990, pp. 24-5.
4. Only 10 g will suffice.

Group 1: Cereals & Breads

The first food group includes preparations of cereals and millets, which are the staple foods in India. These foods provide more than half our body's daily need for energy and proteins. In addition,

if the whole grain or its flour is used in the preparation, these foods can be a valuable source of thiamin (one of the B vitamins) and iron. Seeds of plants are richer in thiamin than all other portions of the plant. Cereals are valued therefore, for providing thiamin and some iron in the dietary.

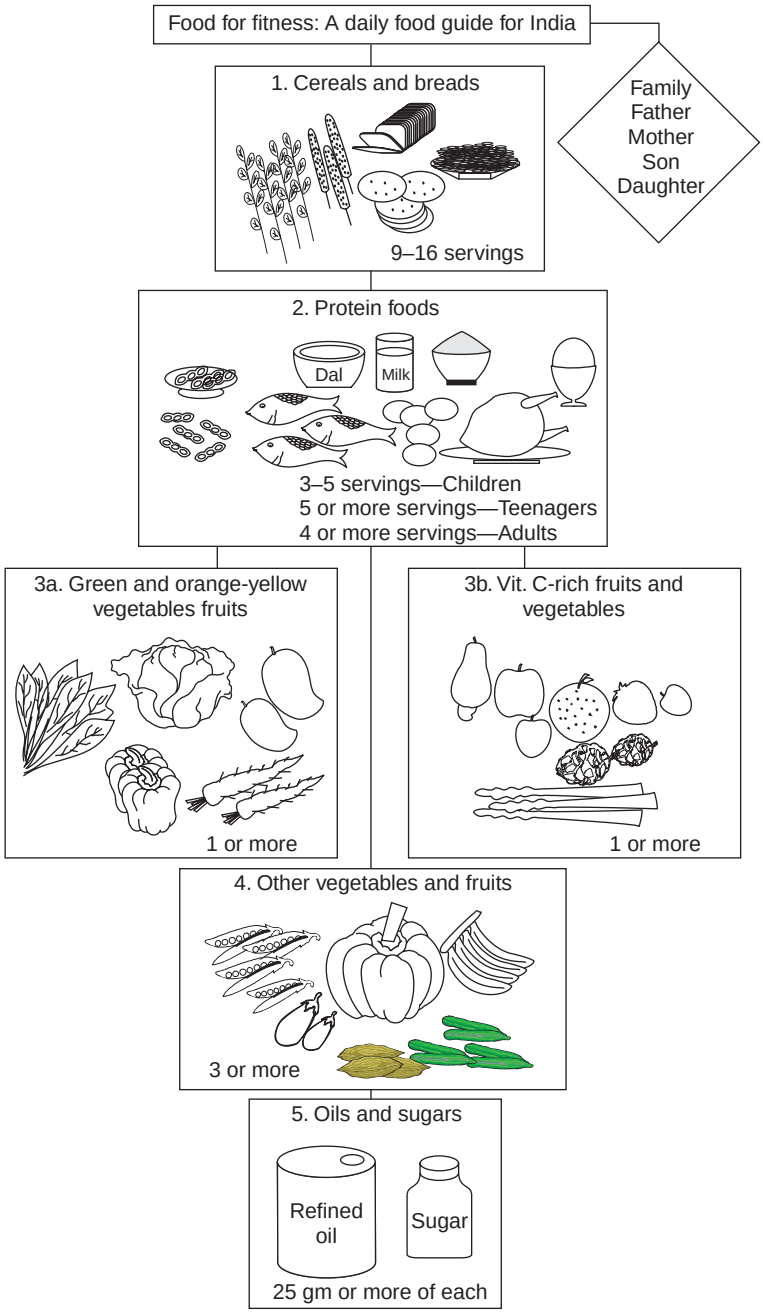


Fig. 4.1 Food Guide based on Basic Five Food Groups

The foods in the group include rice, wheat, *jowar, bajra, makka* (maize or corn), ragi or *nachani*, and cereal products such as *rawa* (*suji* or semolina), rice flakes (*pohe, aval*), *senvaya* (vermicelli) etc. (Fig. 4.2).

Serving Size One serving of these foods is any preparation made from 25 g of any cereal or millet. This is equal to half a katori of cooked rice, one medium chapati, two phulkas, two or three puries, half a medium roti or bhakari, two slices of bread, two tablespoons of rice flakes (dry, not soaked), or two tablespoons of ready-to-eat cereal.

Suggested Number of Servings A sedentary person may need about ten servings. Those who need more servings of foods in this group are:

- Teenagers.
- Expectant mothers (latter half of pregnancy) and nursing mothers.
- Persons involved in heavy physical work such as lifting and carrying heavy loads, agricultural work, pulling *rikshaw* etc.
- Players who practice for hours games such as badminton, tennis, squash, *hututu, khokho*, etc.
- Persons whose hobbies involve intense physical exertion for some hours each day.

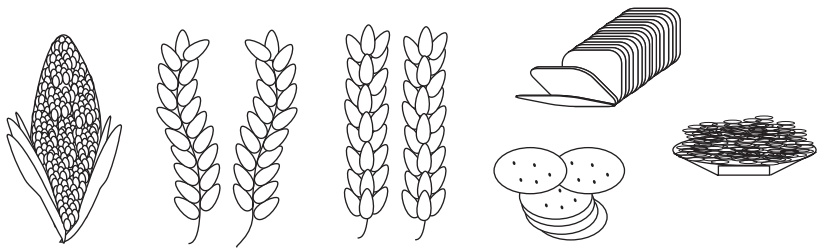


Fig. 4.2 Group 1—Cereals & their Products

Expectant mothers, in the latter half of pregnancy, need two servings more than their normal intake, while nursing mothers may need four servings more than their normal intake.

Group 2: Protein Foods

This group includes important plant protein sources such as dals and pulses (Fig. 4.3). Animal protein foods included in this group are milk, eggs, fish, poultry and meat (Fig. 4.4). A third or more of our protein requirement is met by these foods. These foods are not only good sources of proteins, but also of minerals and vitamins. *Dals*, eggs, and meat are the good sources of iron. In addition, milk is a very good source of calcium and riboflavin. Milk, eggs and liver are rich in vitamin A. These foods also supply part of our requirement of the B vitamins. The foods in this group are varied in their composition. Therefore, the serving size of these foods varies as given below:

Dals and whole legumes or pulses	25 g
Milk and milk preparations	1 medium cup or 150 ml
Egg (medium size 50–52 g)	1 No.
Fish, meat and poultry	25 to 30 g

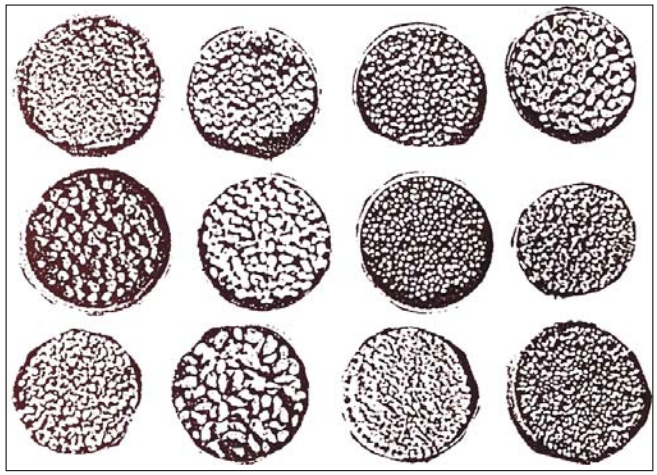


Fig. 4.3 Group 2—Plant Protein Foods

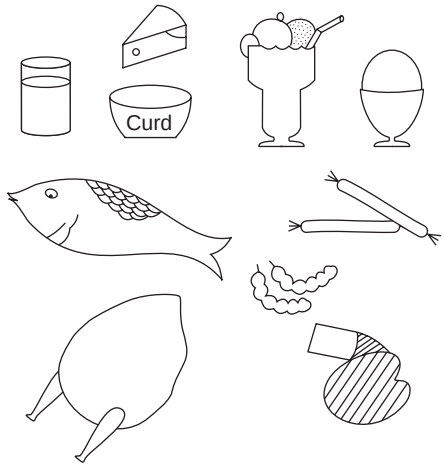


Fig. 4.4 Group 2—Animal Protein Foods

One serving of each of these foods provides about 5 to 6 grammes of protein.

Suggested Number of Servings The number varies with the person's age and body size. For example, an adult woman may need 3 servings, whereas a teenager may need 5 servings.

Group 3: Protective Vegetables and Fruits

This group consists of two major types of vegetables and fruits—(a) Yellow-green vegetables and fruits and (b) Vitamin C-rich vegetables and fruits.

(a) *The Yellow-green Vegetables and Fruits*

Foods in this group are a rich source of beta-carotene (a precursor of Vitamin A). Dark green leafy vegetables supply some iron, calcium, vitamin C and fibre also. This group includes all the *dark green* leafy vegetables such as amaranth, coriander leaves, radish tops, fenugreek, spinach etc., and *light green* leafy vegetables such as cabbage, onion tops and *deep yellow* vegetables and fruits such as carrots, orange, cantaloup, mango, apricots, cape goose-berries, papaya etc. (Fig. 4.5).

Half a katori or 50-75 g of cut vegetables or chopped fruit may be counted as a serving unit. In the case of fruits, such as, oranges and mangoes, one fruit may be counted as a serving unit. One serving unit of this group supplies about half or more of a day's need for vitamin A. If a good source of beta-carotene and vitamin C is included, one serving may meet the need for both the vitamins.

(b) *Vitamin C-Rich Vegetables and Fruits*

This group is made up of foods which are rich sources of vitamin C and fibre. These include amla (Indian gooseberry), bor, cashew apples, guavas, drumsticks, cabbage, citrus fruits (such as oranges, sweet limes, grape fruits etc.) mangoes, papaya, pineapple, tomato, strawberries etc. (Fig. 4.5).

Half a katori of fruit or 50-75 g of vegetable, or a portion as ordinarily served such as one orange or a slice of papaya is counted as a serving unit. Choose at least one serving from this group to meet vitamin C requirement.

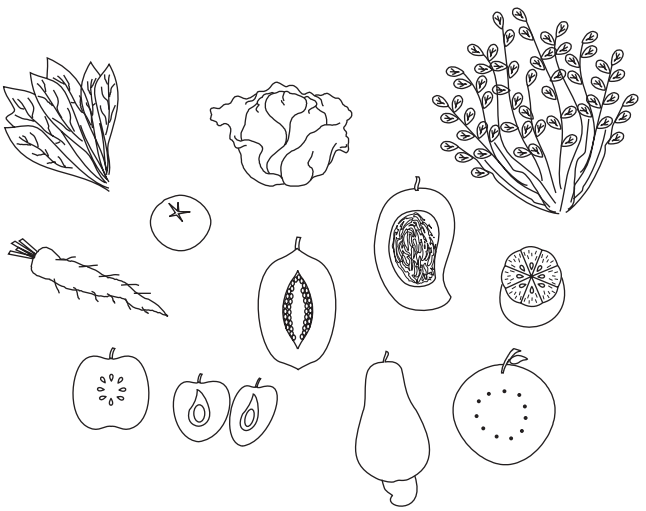


Fig. 4.5 Group 3(a) and (b) Protective Vegetables and Fruits

Group 4: Other Vegetables and Fruits

These foods provide small amounts of minerals and vitamins. These foods also add bulk to our diet. The fibrous tissues which are not digested help to move the food through the digestive tract and regulate excretion of body wastes.

All the vegetables and fruits which are not mentioned in group three are included in this group. These include:

Brinjals, cucumber, pumpkin, bhindi.

All gourds-ash, bottle, snake and ridge gourd etc.

All immature beans and peas, beetroot, radish and yam etc., and Fruits—apples, bananas, melons, grapes, berries etc. (Fig. 4.6).

Half a katori or 50-75 g of vegetables or fruit may be taken as one serving unit. An intake of at least three or more servings of this group is recommended per day.

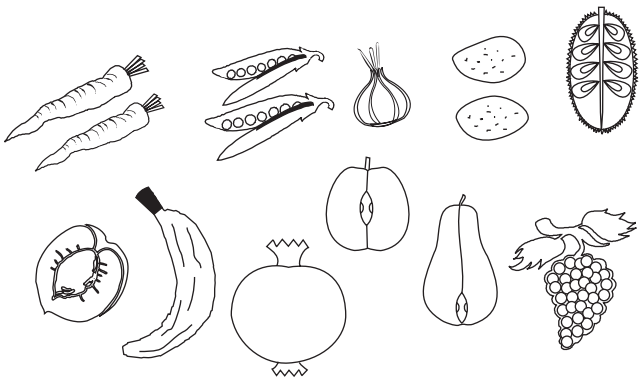


Fig. 4.6 Group 4—Other Vegetables and Fruits

Group 5: Oils, Fats and Sugars

Foods in this group are mainly a source of energy; sugars are a readily available source, whereas fats and oils are a concentrated source of reserve energy (Fig. 4.7).

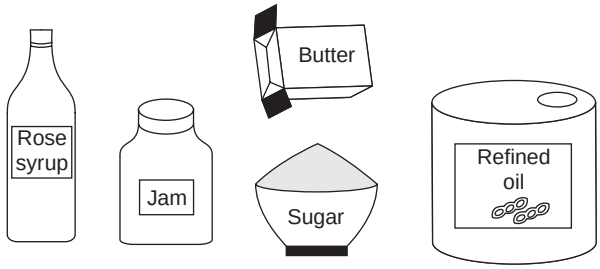


Fig. 4.7 Group 5—Sugars, Oils and Fats

Sugar is pure, refined sucrose extracted from sugarcane or sugar beet. All sugar preparations such as syrups, jams, jellies are included in this group. Jaggery is an extract from sugarcane but is not refined and contributes the minerals, which it contains to the dietary.

Some sugar is used to sweeten our daily foods and beverages. About 25 g will suffice to sweeten three cups of tea/coffee or a glass of sherbet. There is no need to recommend a minimum amount, as sugar is not a necessity in nutritional planning.

Oils and fats improve palatability of foods when used as seasoning or dressing. Apart from the flavour, texture and satiety these give, they are important in assimilation of fat soluble vitamins in the body. Ghee and butter are rich in vitamin A. Most of the hydrogenated fats are fortified with vitamin A. Use of these thus helps to meet a part of the day's need for vitamin A.

Oils include all vegetable oils such as groundnut, seasame, coconut and mustard. Fats include ghee, butter, margarine as well as hydrogenated fats such as the different brands of vanaspati.

A minimum level of fat in the diet is necessary to facilitate absorption of fat-soluble vitamins in the diet.

Suggested Number of Servings Since it is not an essential component in nutritional planning, there is no recommended amount for sugar.

Generally, four to five servings a day of fats and oils is suggested. We must include about 10 g or two servings of vegetable oil to meet our need for essential fatty acids. The remaining servings needed can be taken as ghee, butter, or *vanaspati*.

The total amount of oils and fats in the diet will vary with our total energy needs and our energy intake from the other food groups. We must remember that high fat diets are harmful to our health. Therefore, the ICMR Advisory Committee (RDI, 1991) suggested that the intake of dietary fat be 20 per cent or less of the total calorie intake for adults and 25 per cent for young children.

In summary, how much do we need of these foods? The answer is simple: only as much as is required to meet our nutrient and energy needs and to make the food palatable.

Nutrient Density

Several investigators are individually studying ways to develop an easy-to-use index of nutritive quality of individual foods. One of these is **nutrient density**. It is the ratio of the percentage of the recommended allowance of the nutrient to the percentage of the energy requirement in a serving of the food. For example, a serving of cow's milk (150 ml) provides 100 kcal, 180 mg calcium and 2.9 mg of riboflavin Table 4.4. The nutrient density is calculated as follows:

TABLE 4.4 Nutrient Density

	Energy (Kcal)	Calcium (mg)	Riboflavin (mg)
RDA (man)	2400	400	1.40
Milk — 1 serving	100	180	0.30
Percentage of RDA from milk	5	45	21
Nutrient density		9.0	4.2

Thus, milk is an excellent source of calcium, as it provides 45 per cent of the RDA in one serving and of riboflavin (21 per cent of RDA); while it accounts for only 5 per cent of RDA for energy. Thus, the nutrient density of calcium in milk is 9.0 and in riboflavin 4.2.

Practical Aspects of Food Selection

While you select foods from each food group, pay attention to the practical aspects of so that you get the most nutrients for each rupee spent for food.

The use of the daily food guide may prove to be an asset in nutritional planning and evaluation

The points to remember in using this guide are:

1. Choose *at least the minimum number of servings* from each of the food groups.
2. Make choices *within* each group according to suggestions given above. Foods within each group are similar but not identical in food values.
3. Try to include *at least one food* from group one in each meal.

It may be noted that there are a large number of foods in each group. Thus, it is possible to choose foods that are acceptable from each group to meet nutritional needs.

A choice can be made from the numerous sags, *palebhaji* or *Keerai* available. It makes little difference from the nutritional point of view whether the vitamin A precursor is supplied by spinach or amaranth or any other leafy vegetable. It is important to include *sufficient* foods from each group; the particular food chosen and the way in which it is cooked and seasoned, is a matter of individual choice.

The food guide is useful in meeting the needs of different members of the family. For example, teenagers can use more units from group one, two and five to meet protein needs for growth and their high energy requirements.

It may be noted that *cost is not related to the nutritive value* of foods. It is normally related to availability and season. For example, inexpensive fruits such as amla and guava supply a lot of vitamin C, but apples which are costly, are poor source of this vitamin.

The food groups emphasize intake of variety of foods. It reminds us of the large number of foods in each group that we can choose from. It is advisable to use moderation in the amount of foods eaten from any group so that all groups can be included in sufficient amounts.

A number of snacks are offered and eaten at tea, social meetings or get-togethers. The term snack is applied to a wide variety of foods, which are eaten between meals. The choice of these foods is also important in meeting one's nutritional needs.

Points to Remember

Purpose To enable you to plan nutritionally adequate meals.

Basic Food Groups are formed on the basis of food composition, meal pattern, food costs and availability.

The five basic food groups provide:

1. *Cereals and breads* half of daily need for energy and proteins, some iron and thiamine also.
2. *Protein foods* dals, pulses, milk, eggs, fish provide protein, calcium, iron, A and B-vitamins.
3. *Protective vegetables and fruits* beta-carotene, vitamin C, iron and fibre.
4. *Other vegetables and fruits* some protein, minerals and vitamins.
5. *Oils, fats and sugars* provide energy, *oil* — essential fatty acids and *ghee* — vitamin A.

How to use the food guide

1. Choose at least the minimum number of servings from each group.
2. Make choices within each group.
3. Use seasonal vegetables and fruits, which are rich in nutrients and are available at reasonable cost.

Study Questions

1. (a) Why have the Basic Food Groups been developed?
   (b) On what basis have the Basic Food Groups been developed?
   (c) List the different Basic Food Groups. State three foods that belong to each Food Group.
2. (a) What are different nutrients required by the body?
   (b) Which food groups meet these nutrient requirements?
3. (a) Record your food intake of yesterday. Classify the foods items in your menu into the Basic Food Groups.
   (b) Did your menu contain foods from all the Basic Food Groups?
4. (a) What is a Food Guide and what does it do?
   (b) Why are Food Guides particular to each country?

5. (a) What does a Balanced Diet mean?
   (b) Why is it important to eat a Balanced Diet?
   (c) Was the meal that you ate yesterday a balanced one?
   (d) If not, then how would you modify it, to make it a balanced meal?
6. What practical points will you keep in mind when you plan a balanced diet?

5

Food Preparation and Processing Techniques

Food processing and preparation is an essential part of meeting the nutritional needs of people. It is not enough that food be nutritious, it must be pleasing in appearance and taste so that it is eaten with relish. Excellent food processing and preparation is a very important pre-requisite of food acceptance. It is necessary to acquire the ability to process, prepare and serve food, which is not only nutritious, but also acceptable to the consumer.

The science of food processing and preparation is based on the understanding of physical and chemical changes that occur during processing and preparation. Further, these need to be manipulated to obtain the best product in terms of nutritional quality and acceptance.

This knowledge can be used to combine food ingredients in diverse ways to prepare innumerable products with delicate flavours, textures, and colour, which delight the senses. Thus, food preparation is both a science and an art. Food preparation is very much a part of the culture of the region. Each region has its own methods of blending flavours to bring about acceptable combinations.

Reasons for Cooking Foods

Most foods are acceptable only when they are cooked. Except for some fruits and vegetables, most of the food we eat is cooked. Even the tea or coffee or milk we take in the morning and the bread taken with it involves processing and preparation. For centuries we have nurtured this art of food processing and preparation. Let us examine the reasons for cooking food.

One of the foremost reasons for cooking is that it improves taste. Cooking does improve the taste of as simple a food as rice. It also makes the food more palatable. The sight of a raw potato may not even attract a hungry person but the sight of potato chips allures us to sample a few even when we are not hungry. Thus, cooking helps to enhance the taste and flavour of food and makes it more appetising.

A number of desirable changes occur in foods during processing and preparation. For instance, vegetables become soft. Starchy foods like cereals and *dals* take up water, swell and soften. Cooked potato is softer than raw potato. Rice and *tur dal* become soft on cooking.

Food preparation is very much a part of the culture of the region. Each region has its own methods of blending flavours to bring about acceptable combinations. Spices and condiments are added to the food and the food is simmered until the flavours blend. Some foods are also seasoned

with heated oil in which some of the spices are fried. These steps help to blend the flavours of the ingredients and thus enhance the acceptability of the product. For example—tea masala and crushed ginger are allowed to simmer in water before making masala tea.

As cooking involves heating of foods, many microorganisms are destroyed, during the course of cooking. This renders the food safe for eating. For example, boiling milk results in killing pathogens like tubercle bacilli if these are present; spoilage organisms are also killed by heating milk. Therefore, heated milk keeps longer than unheated milk. Some of the toxins present in the foods are rendered inactive at the cooking temperature. Thus, cooking helps to remove heat-labile toxins.

Cooking food helps to provide unlimited variety in the menu. Thus, with the same raw foods it is possible to provide innumerable dishes, which makes eating a pleasure.

Cooked food is easily chewed and swallowed. It is easily acted on by digestive juices. This makes its passage through the digestive tract smooth. In this manner, cooking improves the digestibility of food.

Preliminary Treatment of Foods

Only clean food is hygienic and palatable. Food should be washed to remove surface dirt. Each food needs to be handled carefully to ensure removal of adhering dirt without damaging its form and structure, and causing loss of nutrients.

Preliminary treatment of food includes washing, cleaning, peeling, cutting, slicing, cubing, grating, soaking, germinating, fermenting, roasting, grinding or some other step.

These procedures have to be carefully planned for each food so that the natural flavour and texture are retained. Table 5.1 lists the type of preliminary treatments of various foods prior to preparation.

TABLE 5.1 Preliminary Treatment of Foods

Preliminary treatment	Foods
Washing	Vegetables, fruits, whole grains
Peeling, cutting, slicing, grating, cubing	Vegetables and fruits
Pounding/milling/grinding	Cereals, legumes, spices, nuts
Soaking	Rice, *dals*, legumes
Fermenting	Cereals, *dals* and their mixtures
Germinating	Cereals and legumes
Roasting	Whole cereals, legumes, nuts, semolina, spices etc.
Mixing	All ingredients in preparations
Kneading	Flours for breads, *chapatis*, *puri*, etc.

The pre-preparation steps mentioned above need to be carried out in such a manner that nutrient loss is minimised. For example, While washing rice and dal to remove external dirt, care must be taken not to scrub the grain, which may lead to unnecessary loss of water-soluble nutrients.

Vegetables and fruits must be cut into even pieces, which are symmetrical and convey a sense of order. Some fruits darken on cutting and peeling, e.g., apples. It may not be necessary to peel these. It is advisable to cut such fruits just before use (Fig. 5.1).

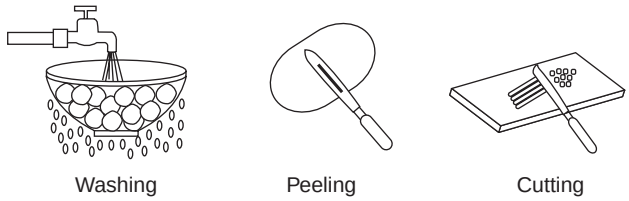


Fig. 5.1 Steps in Food Preparation

Vegetables and fruits need to be drained after washing, to reduce spoilage. Soaking rice, *dal* and whole legumes before cooking may result in reduced cooking time and improved texture.

In short, care and planning in preliminary handling is essential to prepare an acceptable finished product. Poor preliminary treatment cannot be corrected later.

Seasoning

Some foods require no seasoning. Others are improved by addition of small amounts of seasoning materials. The purpose of seasoning is to enhance the flavour of the food and to make it more delectable. Seasoning should be used judiciously so that it blends with the food flavour and is not excessive.

Food Preparation Techniques

Good food preparation requires understanding of the composition and structure of food and the changes that take place during preparation. Basic principles must be observed for each group of food products to obtain good results. Skill in handling foods is acquired by applying knowledge of cooking principles. Some techniques are more difficult to master than others; e.g., making an attractive salad is easier than preparing vegetable cutlets.

In addition, good equipment used scientifically helps to achieve good results in food preparation (Figs. 5.2, 5.3, 5.4). Knowledge of the correct recipe, which indicates the proportion of various ingredients and the order and method of combining these helps to ensure a good product. As books which give basic proportions and recipes of Indian dishes are few, one has to record one's own recipes and improve or modify them to create variety.

The magic ingredient in food preparation is imagination. It is the ability to visualise the effect of change in ingredients on the recipe in terms of flavour, texture and colour. As in any other art practice is essential but the practice must be intelligently directed. To acquire food preparation skills, one must carefully observe those professionals, who are proficient and learn from them and get opportunities to handle food. The chance to organise and prepare dishes for parties at home, for

the class and for friends help to develop one's skills and creative abilities. It must be remembered that foods are most palatable and nutritious when served soon after preparation.

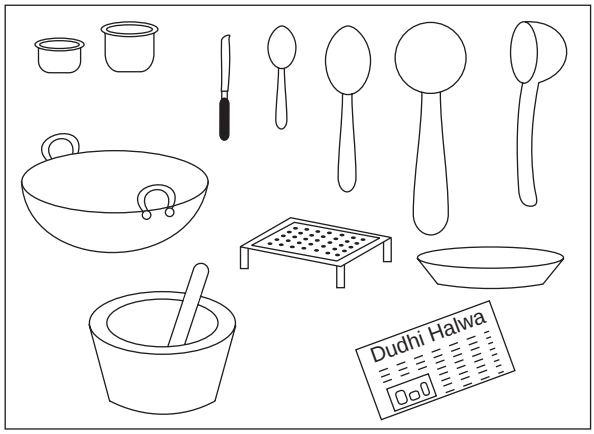


Fig. 5.2 Food Preparation Equipments

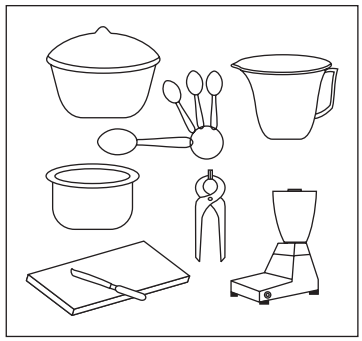


Fig. 5.3 Food Preparation Equipments

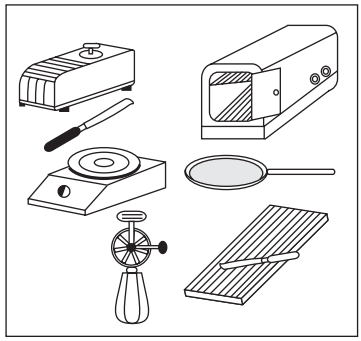


Fig. 5.4 Food Preparation Equipments

It is necessary to visualize how the foods combine and blend in terms of colour, flavour and texture. Pleasing combinations increase the appeal of a meal. Here again, one can make innumerable combinations from the same ingredients if one uses one's experience and imagination.

Each food item can be prepared into several different dishes. The methods of cooking of these items, however, are not many. The method used depends on the kind of product desired and the ingredients available.

It is necessary to retain or produce desirable appearance, colour, texture, flavour, odour and moisture in the course of preparation. It is important that as far as practicable, nutrients should be retained. To achieve these ends, it is necessary to understand the methods used in the preparation of food.

Choice of Fuel

Before we proceed with discussing the methods of cooking let us try to understand how heat energy, which is necessary for all form of cooking, is produced. The heat for cooking is usually generated by the use of kerosene, gas, electricity, diesel (for ovens), solar heat, microwaves, charcoal, wood or sawdust as fuel. The choice of fuel depends on the availability and the comparative cost of various fuels. Ease with which the fuel ignites and is put off and safety in use are also important considerations in the choice of fuel. Fuels, which can be converted into heat energy without production of offensive by-products and leave none or minimum residue, are preferred as they are economic and convenient to use.

By these criteria, the fuels may be listed in the order of preference as follows: solar heat, cooking gas, electricity, kerosene, charcoal, sawdust and wood. In practice, two more factors may affect our choice—availability and cost.

Medium of Cooking

The methods of cooking can be classified on the basis of the medium used for heat transfer. The media normally used are water as such or in the form of steam, oil and air. (Table 5.2)

TABLE 5.2 Classification of Cooking Methods

No.	Medium	Name of the cooking method
1.	Water	(i) Boiling (ii) Simmering (iii) Stewing
2.	Steam	(i) Steaming (ii) Pressure cooking
3.	Fat	(i) Deep fat-frying (ii) Shallow frying or pan frying
4.	Air	(i) Roasting (ii) Baking (iii) Broiling (iv) Grilling (v) Puffing
5.	Combination	Braising—roasting and then cooking in water. Any two methods coming together from above four groups.

Water

Water is the most commonly used medium of cooking. Boiling, simmering and stewing are methods in which moist heat is used. Many of the foods are cooked by using a combination of these methods. (Fig. 5.5)

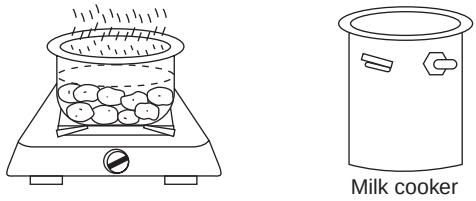


Fig. 5.5 Boiling

Boiling Water sufficient to just immerse the food (in case of vegetables) and twice the volume in case of rice and other cereals, is taken in a vessel and brought to boil. Sometimes salt may be added to the water at this stage. The food is washed, cut and added to the boiling water. Once the food has been brought to a boil, it is simmered till done. The temperature of boiling water is usually 100°C and when it simmers, the temperature may range from 85 to 90°C.

If the food is boiled continuously for a long time, the structure and therefore, the texture is adversely affected and the loss of heat-labile nutrients is extensive. It also results in fuel wastage, and should be avoided. Soups, broths, *dals* and curries are prepared by boiling.

Simmering is usually done after the food has been brought to a boil first. Simmering and poaching are used to cook food by immersion in a liquid maintained just below the boiling point (85–90°C) so that bubbles form slowly and collapse below the surface.

Milk preparations such as *Kadhi, Kheer* are prepared by simmering. Eggs are poached at 85°C in milk, water or cream. The liquid, just enough to cover the broken egg on the pan, is added to the pan and brought to a boil. Salt and pepper may be added to the milk or water. The egg is broken and added to the boiling liquid in the pan, and the temperature regulated so as to bring it down to a simmer.

Stewing refers to simmering food in a small quantity of liquid. The temperature of stewing is the same as that of simmering. The food is stewed when the finished product is intended to contain a small amount of liquid. Most of the vegetables and meats are prepared by this method.

Foods cooked with water as the medium are heated by transfer of heat energy from the fuel through the container to the water. Water is heated both by conduction and convection currents. The time needed for cooking the food is thus dependent on the amount of food being cooked, the material, thickness and size of the container and the efficiency of the fuel used.

If the food is cooked in just enough water, it is necessary to reduce the heat, keep a watchful eye and remove the food from the stove as soon as it is done to avoid burning the bottom layer of the food.

The cooking of food with water as a medium will be affected by the quantity of dissolved substances in it, because the boiling point of water is elevated in the presence of solutes. At high

altitudes water boils at a lower temperature than at sea level, and therefore, cooking may take a longer time than at sea level.

Steaming of food also involves the use of moist heat. When food is cooked in water vapour with or without pressure it is said to be steamed. The water vapour is produced from water placed at the bottom of the pan. Some of the products that are prepared by steaming are *idli, khaman-dhokala, modak* etc. (Fig. 5.6)

Pressure Cooking When steam under pressure is used the method is known as pressure cooking and the equipment used is known as a pressure cooker. As the temperature is elevated quickly in the food cooked with steam under pressure, the cooking period is reduced as also the loss of heat-labile nutrients. In this method, heat is transferred from the steam to the food; the steam condenses on the cold food and heat is released. Condensation of the steam occurs until the food reaches the temperature of steam (100°); then the condensation decreases and steam pressure is built up in the pressure cooker, to the point desired.

Rice, *dal*, some pieces of meat, potatoes and other roots and tubers, and various types of beans, and peas and some gourds are cooked in the pressure cooker.

Steam cooked foods are light, fluffy and easy to digest. As the period of cooking is reduced, the loss of heat-labile nutrients is minimised and there is saving of fuel and time. As the steaming of food does not need constant attention as in simmering or stewing, the time saved can be used for other activities such as preparing salad, chapati or dessert.

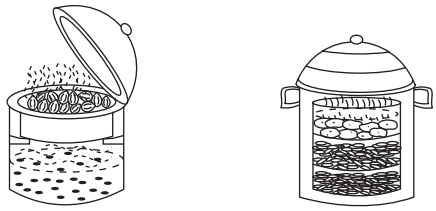


Fig. 5.6 Steaming

Oil or Fat

Oil or fat is used as a medium of cooking in *pan-frying* and deep fat frying. Pan-frying or shallow frying is the cooking of food in a slightly greased pan, e.g., *dosai*, *thalipeeth*, fried egg, pancake, *puda* etc. The heat is transferred mainly by conduction to the food. Only a thin layer of mix or thin pieces of food are cooked in this manner. The food must be turned from one side to another to ensure complete cooking (Fig. 5.7).

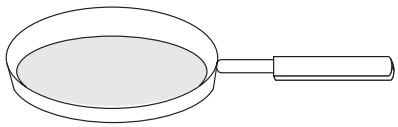


Fig. 5.7 Shallow Fat Frying

Deep fat frying is similar to boiling. The fat is heated by conduction of heat from the frying pan; the heat is then distributed by convection currents through the fat. The food is cooked very quickly by this method as the fats can be heated to much higher temperatures than boiling water. Therefore, it needs constant and careful attention. The temperature of frying varies from 180–220°C depending on the oil or fat used as a frying medium and food preparation being made. It is important to choose fats with high smoking temperature as the frying medium. Fats and oils should not be heated to the smoking point[1] as at this temperature, the fat starts decomposing, and is not suitable for frying foods (Fig. 5.8).

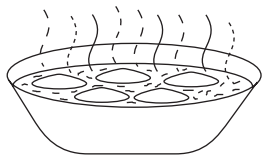


Fig. 5.8 Deep Fat Frying

Frying imparts a special flavour and texture to the foods making it tender or crunchy. There is an increase in the energy value of the food when it is fried. The high temperature used destroys any pathogens present on the surface. These foods are not digested quickly, due to the fat absorbed in frying. This method is not suitable for tough cuts of meat. It is used to make *puries*, *pakoras*, *samosas*, *chips*, *cutlets* etc.

Air (Dry Heat)

Methods in which air is used as a principal cooking medium include roasting, toasting, baking broiling, grilling, parching and puffing.

Roasting and toasting means to cook food by dry heat without covering it. Food is roasted or baked on heated metal, on stones or under hot coals, in hot ashes or in an oven.

Foods prepared by this method include chapati, roti, nan, and other unleavened breads, potatoes, sweet potatoes, other tubers, jowar, corn, paddy, groundnuts, cashewnuts, walnuts, pistachios etc.

Baking is also cooking by dry heat in an oven or oven like appliance. Baking pans and trays of various shapes and designs, covered and uncovered, are used for baking bread, biscuits, cakes etc. The food placed in the oven to bake or roast may be partially cooked by dry heat, by the convection current of hot dry air and conduction of heat from the container to the food and partially by moist heat.

Hot sand baths are used in baking on top of the stove. In this improvised method, the baking dish is placed in the sand bath, which is then covered to prevent loss of heat. Bread, cakes, pies,

1. Smoking point of fat is the temperature at which decomposition starts with emission of blue smoke, which is irritating.

pastries are the examples of baked products. The temperatures attained in different methods are given in Table 5.3

TABLE 5.3 Temperatures of Cooking

Method of cooking	Approximate temperature
Simmering/stewing	85–90°C
Boiling/steaming	100°C
Pressure cooking	100–112°C
Baking	160–205°C*
Deep fat frying	180–220°C

* The temperature attained by the food is only about 95°C.

Broiling or grilling refers to cooking of food by exposing it to direct heat. The food is cooked in part by contact with the hot broiler (conduction) and partially due to the radiant heat energy. Grilled sandwiches are an example of this method of cooking.

Microwave

One of the latest methods of cooking is the use of the microwave oven. It is a quick and an economical methods, as it saves up to 75% of energy as compared to conventional electric stove.

Household models of microwave ovens have an electrical input of about 1000 Watts. Foods are heated by molecular friction obtained by the use of a magnetron. A magnetron needs a very high voltage of about 3000 volts. Safety features are built in to ensure that the consumer does not come into contact with this high voltage and radiation. A special diode, capacitor and a high voltage transformer are essential for feeding this high voltage to the magnetron. At this high voltage, the electrons are affected by magnetic and electric fields and produce a microwave length radiation of about 2450 MHz. These microwaves generated from the magnetron tube bombard the food. They cause the water molecules to rotate at the same frequency millions of times a second. This agitation creates *molecular friction* which heats up the food. This friction may cause substantial damage to the surrounding molecules. Recent research shows that microwave oven cooked food suffers severe molecular damage. When eaten, it causes abnormal changes in human blood and immune systems. Hence scientists believe that microwave cooking may not be good for health. Some scientists believe that microwave cooking may not be good for health because of the molecular damage to the food. While microwave ovens produce a wavelength of energy in one narrow frequency of the energy spectrum, energy from the sun when used for heating operates in a wide frequency spectrum and does not damage the molecules.

Metal containers cannot be used for cooking in the microoven, as the waves are reflected from the metal surface and thus cannot cook the food. Only special grade plastic or glass containers can be used, which permit the action of microwave to occur.

Solar Cooker

Solar cooker is a fine example of the use of an unconventional form of energy for cooking. Heat from sunlight is utilized for cooking the food.

The solar cooker consists of a big metal box which has a double glass cover with adjustable screws. The box has a flap on the top which has a mirror embedded into it. The inside of the box is painted black. When the flap is open, the rays of the sun are reflected through the mirror into the box.

The food containers are prepared in the same manner as is done in a pressure cooker. Thus, rice and *dal* are washed and required amount of water is added. The containers are placed inside the box and the glass cover is closed. These containers are also painted black on the outside to absorb the heat from the sun's rays. The screws on the glass cover are tightened. The top flap is adjusted to permit sun rays to reflect on the main box. The cooking process begins. It takes about two hours to cook rice, *dal* and vegetables. Chicken or meat may require longer cooking time.

Dry foods such as rawa, groundnuts can be roasted in solar cooker, using aluminium trays. Cakes can be baked after preheating the box.

Microwaves from the sun also help in heating the food. But the energy from the sun operates in a wide frequency spectrum and other forms of energy are also used for heating. The food is cooked without causing any molecular damage.

The main advantage of this method is that there is no expense involved in cooking. It can only be used when there is **bright** sunlight. The only disadvantage is it needs a long time for cooking.

Combination of Methods

Many food preparations are made by using a combination of methods. When we roast semolina before putting it in boiling water for preparing *upma* or season vegetables with oil and spices and then add water, two cooking media—air and water, fat and water are used. It may be noted that many food preparations are made by using more than one method of heat transfer.

Points to Remember

Main reasons for cooking food—

To improve taste, texture and blend flavours
To make it easy to digest
To render it safe for eating
To provide variety in the menu

Preliminary treatment of foods—

Includes washing, cleaning, peeling, cutting, slicing, cubing, grating, soaking, germinating, fermenting, roasting, grinding.

Methods of food preparation—

(a) With water or steam
(b) In oil or fat
(c) With dry heat
(d) Microwave
(e) Solar cooker
(f) Combination of methods

Study Questions

1. What are the main reasons for cooking food?
2. What are the different preliminary treatments given to foods before they are cooked?
3. What are the different methods of food preparation?

6

Effect of Preparation and Processing on Food Components

A number of changes occur in the food components as a result of preparation. It is necessary to understand and manipulate the changes to obtain an acceptable food product.

The major constituents of food are carbohydrates, proteins, fats and their derivatives and water. In addition, a number of inorganic mineral components and a diverse group of organic substances are present in very small amounts in foods. These include pigments, flavour components, vitamins, acids, enzymes, etc. Let us consider their properties and the changes that occur in these components during handling, cooking and processing.

Carbohydrates

Starch, sugars, pectins, gums, celluloses and hemi-celluloses are the important carbohydrates found in food.

Starches are the major component of cereals, millets, *dals*, roots, tubers and sago. Starches are bland in taste, not readily soluble in cold water but absorb water when soaked in hot water. When starch granules are added to cold water, a temporary suspension is formed, the starch tends to settle out as soon as the mixture is allowed to stand.

When dry starch is mixed with warm or hot water, the part which comes in contact with water becomes sticky and the starch granules cling together in lumps. Heating does not help to separate the granules, because once formed the lumps stay intact. If one of these lumps is broken open, raw starch is found inside.

Lump formation can be prevented by mixing starch with a little cold water before introducing it into the hot water; roasting a little before addition of hot water or addition of a little fat, helps to separate the starch granules and allows them to gelatinise separately. The starches take up water, swell and burst on cooking. When a starch and water mixture is heated, it becomes translucent and forms a paste. This change is accompanied by a change in viscosity. This property is used when starch is used as a thickener in soups, starch puddings and other preparations. A gel is formed at a higher concentration of starch, e.g., puddings. The water is held in a physical bond by the starch.

The change in texture, colour and physical state, which occurs when starch is heated in water, is known as *gelatinisation* of starch. In roots and tubers, the presence of starch, which absorbs the water during cooking, results in retention of size.

Sugars About 5-11 per cent are present in ripe fruits, malted beverages and in milk. Sucrose, the sugar we use in food preparations is one of the pure, manufactured (extracted) foods we use daily. It is manufactured from sugarcane or sugar beet. Sugar is sweet and is usually used in foods for its sweetening power. Sugar dissolves in water and when heated this solution easily forms a syrup. When the solution is supersaturated and cooled, crystallisation occurs. This is the process used to prepare sweets such as *laddus*, candies etc.

When a high concentration of sugar is used, it acts as a preservative by binding moisture, e.g., preserves such as murrabbas, jams and jellies. In the presence of acids, the sugar (sucrose) is partially hydrolysed to form glucose and fructose, which is known as *invert sugar,* which is more soluble than sucrose. If sugar is heated beyond its melting point it caramelises or browns. The caramel formed has a bitter, astringent flavour. Sugars are readily fermented by microorganisms, thus causing spoilage of food products containing it.

Pectins and gums are responsible for holding the plant cells together. These are found in fruits and vegetables in a very small amount. Pectins and gums form colloidal solution when extracted in hot water and contribute to the viscosity of the product to which they are added. Therefore, these are used as thickeners and stabilisers in food preparation and processing. Pectins form gels in the presence of an appropriate amount of sugar and acid, e.g., fruit jellies.

Amla, guava, citrus fruits, papaya and apples contain pectin as soluble fibre. These fruits can be used to make fruit jellies. It is reported that pectin can lower total cholesterol and low-density lipoproteins in the blood.

Celluloses and hemicelluloses, the fibrous parts of vegetables and fruits are not soluble in cold or hot water. These soften as the water trapped in their tissues is released and used in cooking or processing. Thus there is a decrease in volume, especially of leafy vegetables. Celluloses are not digested by man even after cooking but as it has the capacity to bind moisture, it is helpful in smooth movement of the food through the digestive tract.

Proteins

Egg, fish, poultry and meat are good examples of protein foods. In *dals* and pulses, the presence of a large amount of starch (50–60 per cent) masks the reactions of proteins during preparation.

The effect of preparation on food proteins can be clearly observed in egg, fish, poultry and meat, as these contain mainly proteins, water and variable amounts of fat.

All proteins are first denatured and then coagulated by heat. The coagulation occurs between 65° and 90°C. The temperature of coagulation increases with the addition of other ingredients. For example, egg proteins coagulate at 65°–70° C but egg custard coagulates at 85°–90° C. Cooking results in softening of proteins in foods such as eggs, fish, poultry, meat, as water is bound in the process of coagulation. If the coagulated protein is heated further, it loses moisture and becomes dry and rubbery. Therefore it is important to monitor the temperature and time while preparing these foods.

Proteins are precipitated by change of pH, e.g., addition of lemon juice to milk to prepare *paneer*. Proteins bind water, if the coagulation is gradual, e.g., addition of lactic inocculum results in the formation of solid curd from liquid milk.

Oils and Fats

Milk, eggs, meat, oilseeds are foods, which contain fat. When foods containing fat are heated, the fat has a tendency to separate from the food. For example, heating milk results in the fat layer floating on top, while in cooking meat fat is released as drippings. When milk is curdled to prepare curd, the cream layer is always on top of the curd.

Oilseeds are extracted to obtain pure oil, and butter is clarified in the manufacture of ghee (butter fat). Oils and fats are used as a cooking medium. Since these have a higher boiling point than water, the food is cooked quicker in fat, than in water.

Some fat is absorbed during frying, the amount depends on a number of factors such as the composition and consistency of the food being fried, the temperature used and the nature of the fat used for frying. Fried foods have a higher energy value as compared to the same foods prepared by other methods such as boiling or baking. Fats which are solid (congeal) at room temperature, soften on heating, but do not have a sharp melting point. When heated beyond its boiling-point, a fat smokes (*smoke point*), then flashes (*flash point*) and lastly it catches fire (*fire point*). If the fat is heated for a long time, it browns and thickens. These changes are accompanied by changes in flavour, which may not be acceptable. Therefore, effort should be made to minimise these changes in food preparation.

Fats and oils are used to prepare food emulsions with water and air. Stabilisers such as proteins, gums, starches, finely ground spices, in small amounts, are used to stabilise these emulsions.

Fat has a *shortening power*, i.e., its presence between (protein and starch) layers makes the product crunchy (e.g., baked goods); its presence in meats tenderises it.

Fats and oils become *rancid* by the action of air (oxidised), water (hydrolysis) and enzymes. These changes must be minimised, so that the foods in which fat is used remain acceptable.

These is no loss of minerals in the normal cooking procedures. If cooking water is discarded, some (a small fraction of) water-soluble minerals may be lost.

Vitamins

As we know, thiamin and vitamin C are the two vitamins, which are most affected by cooking. The losses may occur due to dissolved nutrients being discarded and destruction due to exposure to heat in cooking. The amount lost depends on a number of factors.

Thiamin in partly lost in solution and is also destroyed by heat. Some thiamin loss occurs when rice and *dal* are scrubbed and washed repeatedly prior to cooking. Being soluble in water, if the cooking water is discarded some thiamin is lost. The losses of thiamin in normal cooking vary from 10 to 25 per cent.

Vitamin C is the most labile vitamin. It is water soluble, is easily oxidised and is also affected by heat. Washing vegetables after cutting, exposing cut vegetables to air for long periods before cooking and/or serving, result in the loss of a part of the vitamin C present. The average cooking or processing losses range from 30 to 35 per cent. Therefore, cooking procedures, which minimise the loss of vitamin C, result in conserving all other nutrients.

Pigments

Colour of food has much to do with its acceptance and enjoyment.

Vegetables and fruits contribute a variety of colours to the dietary. The plant pigments *chlorophyll* (green leafy vegetables), *carotenoids* (yellow-orange carrots), *flavonoids* (white potatoes) and *anthocyanins* (red beetroot) are present singly or in combination in plant foods. These may be affected by the method of preparation. The soluble pigments such as anthocyanins may leach in the cooking water and changes may occur due to the effect of heat and pH (acidity). The properties of plant pigments are summarised in Table 6.1. Understanding these may help us to retain the colour of vegetables and fruits during preparation.

When milk is heated slowly it browns a little due to the reaction of sugar (lactose) with amino acids. This change, is accompanied by flavour changes, which are enjoyed when these are very slight; if excessive, these are not liked. Similarly caramelisation of sugar, slight browning of starch in roasting, bring about colour changes, which are liked when these are slight, but not when these are excessive and give the dark brown colour of burnt food.

Some colour changes, which occur during food preparation are undesirable and efforts are made to minimise these. For example certain fruits and vegetables such as some varieties of apples and brinjals brown when cut surfaces are exposed to air. Efforts made to avoid exposure of the cut surfaces to air include—brinjals are cut into water, apples are covered with sugar and or lime juice, fruit salad is served with custard.

Table 6.1 Properties of Plant Pigments

S.No.	Food source	Name of pigment	Colour	Soluble in	Effect of prolonged heat	In presence of	
						acid	alkali
1.	Rice potato	Flavones flavanols	White or yellowish	Water	May darken	White	Yellow
2.	Beetroot	Anthocyanin	Red	Water	Little	Bright red	Reddish purple
3.	Leafy vegetables	Chlorophyll	Green	Fat	Olive green	Olive green	Intense green
4.	Carrot Mango Tomato	Carotene Xanthophyll Lycopene	Yellow-orange red	Fat Fat Fat	May darken	No change	No change

Flavour Components

Sugars, mineral salts, organic acids and salts are the flavour components found in fruits and vegetables. In addition, salt, sugar, acids, herbs and spices are used in food preparation to modify or enhance the natural flavour of foods during preparation.

Salt is the most widely used seasoning in food preparation. When used in pickles, it draws out the water from the fruit or vegetable and binds it in solution. Organic acids used in food preparation are lemon juice (citric acid), vinegar (acetic acid), tamarind extract (tartaric acid), and cocum extract. Tomato juice and mango pulp are also used in preparations for the acidity these contribute. Some of these extracts contribute thickness as well as acidity to the product. Some of the organic acids slow down bacterial action, and therefore, are used as preservatives in pickles. Lactic acid produced in milk, coagulates milk proteins to form curd and cheese. This change is accompanied by a change in flavour and texture.

Oxidants and Antioxidants When food is exposed to air, oxygen from the air acts as an oxidant, and changes occur that are mostly undesirable. For example, when cut surfaces of vegetables and fruits are exposed to air, vitamin C is partially lost due to oxidation, the surface become brown in colour, fats and oils become flat and then rancid. The metals, copper and iron act as catalysts in such oxidations. Therefore, these metals are not suitable for use in food preparation or processing.

Some natural substances such as vitamin E, lecithin, some sulphur containing amino acids act as antioxidants. These inhibit or prevent oxidation of fats and oils and other substances during storage and preparation. For example, vitamin E is found in some oils and prevents rancidity in these.

Enzymes are organic catalysts and control a number of reactions in vegetables and fruits. Ripening of fruits as well as over-ripening is controlled by enzymes. When fruits and vegetables are cooked or exposed to heat, e.g., blanching of vegetables before freezing, enzymes are inactivated. Purified enzymes are used to modify texture of foods. For example, papain is used to tenderise meat and rennin is used to coagulate milk protein in cheese making.

Retention of Nutritive Value During Preparation

It is important that all efforts should be made to retain the nutritive value of foods, during preparation. Another important objective in food preparation is to make food that is enjoyed by those who eat it. It is important to ensure that while retaining the nutritive value of the food, palatability is not sacrificed. It's good to remember that the food can provide nutrients to the body *only* after it is eaten. For example, some loss of thiamin (a vitamin of the B-complex) occurs when beans are cooked. But as we do not relish uncooked beans, we do cook beans and try to take care in the preparation to ensure that the loss is minimal. Thus, we cook beans in just enough water to avoid loss of nutrients in the cooking water. We cook beans for the minimum time required. We can reduce cooking time by using a pressure cooker. We can prepare the food just before serving, so that reheating before serving, is avoided.

Some simple rules for retaining nutritive value and flavour are given below:

1. Wash vegetables before cutting.
2. Cut vegetables just before cooking and introduce cut vegetables into boiling water, if it is cooked in water.
3. Use just enough water for cooking, if the vegetables or other foods are to be served as such.
4. Cook foods until just done and serve immediately.
5. When preparing soups, the slowest cooking ingredient should be added first, followed by addition of other ingredients, which cook in shorter time. For example, meat needs longer time and hence can be cooked half-way before adding vegetables, which need much less time. This procedure helps to avoid overcooking of the vegetables.
6. Spices and other flavour ingredients should be added in the oil used for seasoning, as the flavour compounds, which are soluble in fat, are thus easily dispersed in the preparation with the oil or fat.
7. Vegetables and salads should be prepared just before serving.
8. Use of acid foods, such as lime juice, tomatoes, vinegar or yogurt as dressings in salads prevents loss of vitamin C, because it is stable in acid medium.
9. Fruits are best eaten as they have been customarily eaten in tropics. Bananas are eaten right after peeling. Oranges are usually sucked after peeling. Grape fruit is usually peeled and eaten. Mangoes are sucked to get the juice. In this manner of eating, no loss of vitamin C occurs, as the fruit is not much exposed before eating.

Effects of Cooking on Microbial Quality of Food

As cooking involves heating of foods, many microorganisms are destroyed during the course of cooking. This renders the food safe for eating. For example, boiling milk results in killing pathogens like tubercle bacilli if these are present; spoilage organisms are also killed by heating milk. Therefore heated milk keeps longer than unheated milk. Some of the toxins present in the foods are rendered inactive at the cooking temperature. Thus, cooking helps to destroy heat-labile toxins.

Points to Remember

Changes occurring during cooking of food—

(a) ***Carbohydrates***
Starches absorb water, swell and thicken when cooked with water.
Sugars used as a syrup to prepare crystallised sweets, invert sugar formed in the presence of acid.
Pectins and Gums used as stabilisers and thickeners.
Celluloses and Hemicelluloses soften and shrink on cooking.

(b) ***Proteins*** denature and coagulate on heating. Soften due to water bound during coagulation. Excessive heat makes the protein dry and rubbery.

(c) ***Oil and Fats*** separate from the food on heating. When used as frying medium, they are absorbed by the food with increase in energy value. Excessive heat results in the fat smoking (smoke point). With stabilisers and water form emulsions. Have shortening power. Can become rancid on storage.

(d) ***Vitamins Minerals*** Heat labile vitamins are lost during cooking as heat is applied. Water soluble vitamins are lost if water in which food was cooked is discarded. Exposure of cut vegetables before cooking (oxidation) or washing after cutting brings about loss of vitamins. When cooking water is discarded minerals are lost.

(e) ***Pigments*** Anthocyanins may leach in cooking water. Some pigments are not affected (carotenoids), Chlorophyll turns olive green due to excessive heat and in acid pH.

(f) ***Flavour Components*** Salt is widely used–draws out the water from the food. Citric acid, acetic acid, tartaric acid can be used to acidify foods. Vitamin E and lecithin act as antioxidants.

Study Questions

1. Discuss the changes that occur in starch during food preparation. Give examples to illustrate the changes you describe.
2. Write short notes on:
   (a) Invert sugar,
   (b) Pectin,
   (c) Smoke-point,
   (d) Plant pigments,
   (e) Caramel,
   (f) Flavour components.
3. List the changes that occur in proteins during food preparation with examples to illustrate the change.
4. Discuss the steps which help to retain nutrients during food preparation. Which are the nutrients easily lost during food preparation?
5. How will you prevent the nutrient losses from the following foodstuffs:
   (a) Green leafy vegetables
   (b) Milk
   (c) Meats and eggs
   (e) Citrus fruits

7

Food Acceptance and Sensory Evaluation of Foods

We spend a number of hours each day to plan, purchase, prepare and enjoy food. A large part of our income is utilised to purchase food for the family. Therefore, it is important to understand personal preferences in food for without attention to the sensory aspects of food, there can be no true enjoyment of it. Let us consider the factors which affect our food acceptance.

Colour in Food

Colour affects our acceptance of food. It is said, we eat with our eyes, because the first impression of food is formed by its appearance, which includes colour, shape and aroma. The initial attraction or rejection of food depends on its looks. Most of our acceptance or rejection of food depends on its looks. Most of our traditional colour concepts affect our reaction to food. For example, we associate orange-yellow colour with ripe mangoes, red colour with ripe tomatoes and green colour with leafy vegetables. A green orange or a light coloured tomato looks unripe or anaemic and does not attract us.

The colour of food is one way to judge its quality. For example, a green colour is associated with unripe fruit such as mango or orange, a brown banana is thought to be spoilt. In food purchase, colour is used as an important criteria of quality. For example, mature ripe alfonso mangoes have orange-yellow colour. Hence, if the colour is pale or darkened, the chances are the fruit is immature or stale. But colour is not always a true indicator of quality. Some varieties of oranges have a green colour even when these are mature, while orange coloured fruit may have sections, which are not juicy.

It is observed that fruit preserves and vegetable pickles darken during storage. Such darkening is caused by oxidative changes. These changes can be minimised by reducing the oxygen in the top of the container by heat before sealing it. The presence of traces of metals such as iron, tin and copper, in foods also causes darkening and needs to be avoided.

Colour added to foods Since colour affects food acceptance, it is added to food products during processing to improve its acceptance. Fruit preserves, cheese, butter, icecream, cakes, confections and candies are some of the food products that have such addition of colour. When we buy these products, it is important to select appropriate delicate colour to ensure attractive, acceptable appearance.

Colouring materials used in foods belong to two groups—natural colouring material and synthetic coal-tar dyes. After extensive testing, it has been found that only some of the coal-tar dyes can be safely used in foods, and these have been certified. Some of these are used in carbonated beverages and fruit preserves.

Some of the natural colouring matters, which we use in food preparation, are turmeric and saffron. In addition to these, other/natural colouring substances used in food preparations are annato, betain, caramel, carotene and chlorophyll.

Texture in Foods

Each food has a particular texture that we associate with it. Thus, well-cooked rice is soft, potato wafers are crisp and cucumber slice has a crunchy texture. We learn about food texture very early in our eating experience.

A variety of qualities are included in texture, such as, crisp, soft, hard, sticky, elastic, tough, gummy or stringy. If there is change in the accepted, characteristic texture, we find the food unacceptable. Thus, we reject tough beans, hard rice, lumpy *upma,* and fibrous vegetables, because their texture is unlike the texture we associate with these foods. On the other hand, we enjoy crisp toast, soft velvety *halwas*, flaky pastry and sticky *jalebi*. The textural qualities of food depend on the ingredients, their proportion, the manner in which these are combined and the method of preparation.

Cereals Texture is developed with meticulous care in cereal preparations such as *chapati*, bread, and cakes. In preparation of *chapati*, we knead the dough and set it aside for a few minutes to obtain a soft velvet textured *chapati*. In preparation of bread, the dough is allowed to ferment after mixing with yeast, punched to ensure even, sponge-like structure. In making cakes, the sugar and fat are creamed, the flour is sifted to incorporate air, and mixed with the creamed sugar to obtain the desired structure, when baked.

Fruits and Vegetables The texture of fruits and vegetables is determined by the cell wall. The cell wall is composed of polysaccharides. During maturation, ripening and preparation, there are changes in the amount and kinds of polysaccharides, which result in changes in the texture of vegetables and fruits. For example, when a fruit ripens, a large part of starch is broken down to sugars, resulting in softening of texture and change in flavour of the fruit. When a bean gets mature, the bean toughens and gets lignified, its texture becomes very hard and it needs more time to cook than the immature bean. There is a change in the taste also. Thus, the texture of the food affects the time taken to cook or process it. It also affects its acceptability.

Meat As you know the texture of meat depends on the part of the animal from which the cut is taken, the age of the animal, the method and the duration of preparation. The meat cuts with low content of connective tissue, can be cooked by dry methods, such as roasting or shallow frying. But meat cuts, which have a large amount of connective tissue, are prepared by use of moist methods of preparation, such as pressure-cooking, boiling or stewing, to make these cuts tender.

The texture of meat is very easily determined by the number of times one needs to chew and how hard one has to bite to cut the piece. If it takes long to chew the meat, it is a tough product. It is possible to improve the texture of meat by treating tough meat with chemical tenderizers. These help to break down the connective tissue partially and thus improve the texture of the product.

Flavour in Food

Flavour is the sum-total of the sensory impression formed, when we eat food. It includes the aroma, the taste and even the texture, and thus involves all our senses. It is the most important aspect of food, which decides our choices of food. While an appropriate colour and texture may induce us to *sample* a food, whether we will eat *more* of it, depends on its flavour. Thus, flavour of food is as important a quality as its nutritional composition.

Food flavour is intimately related to food preparation practices. We like flavour of foods made in our home in our community and region, because these are familiar to us. Thus, food flavour acceptance is intimately related to our dietary pattern. If our exposure to food flavours has been limited, it is not easy for us to adapt to new flavours, and we may not enjoy a variety of flavours.

Odour The odour or smell of food influences our food acceptance. The aroma of ripe mango attracts us, while the smell of overripe fruit repels us. The substances, which are responsible for odour of food, are volatile, which means these evaporate and form vapours easily. The odours are carried by the air to our nose, and are transmitted by special nerves (olfactory nerves) to our brain. You can get the odour even before you eat the food; you also perceive the odour when you eat the food. The odour affects our acceptance of food, depending on whether it is liked or not. The primary odours are sweet or fragrant, sour or acid, burnt and rancid. You may have noticed that our sense of smell is far more acute than the sense of taste. Therefore, anything that affects its function, impairs our enjoyment of food. For example, if you suffer from a cold, your sense of smell is impaired and you find that the food does not taste as good as when you are well. Similarly, the function of sensory organs is impaired with age, which results in decreased enjoyment of food by the aged persons.

Touch The sense of touch contributes to our perception of food. It identifies the textural qualities of the food, such as softness and hardness. Similarly, we perceive the crisp, the crunchy or sticky texture by touching the food when the touch conforms to the textural profile of the food in our memory, it enhances the anticipation and enjoyment of food. If it does not create a favourable image, we hesitate to taste the food. For example, a slimy touch indicates spoilage, be it a carrot or a bread slice.

Taste Taste sensations are the sum-total of the sensations created by food when it is put in the mouth. The sensation of taste is perceived when the taste receptors (taste buds) are stimulated. The taste buds are located on the surface of the tongue. The food must be dissolved in liquid to enable us to perceive its taste. Hence we have to masticate dry foods such as roasted groundnuts mix these with saliva, so that we can taste these. We can perceive the taste of liquids, such as tea, *sherbet* or *lassi*, immediately, as these can stimulate the taste buds as soon as we drink these.

There are six primary taste sensations–sweet, sour, salty, bitter, astringent and pungent. The taste of the food is determined by its chemical composition. Sugars present in foods or added to foods are responsible for sweet taste, while salty taste is due to salts present in foods or added to food. Sour or acid taste is contributed mainly by organic acids found in foods (such as citric acid in limes), added to foods (such as tamarind extract added to *dal)* or developed in food (lactic acid formed when milk is made into curd).

Certain foods such as coffee beans and fenugreek have bitter taste, while breakdown of proteins produces substances, with bitter taste. The fruits such as amla, immature mangoes and apples have astringent taste; while chillies and pepper have a pungent taste. The taste of most foods is a blend of some of these primary tastes.

The primary tastes can be modified by combination of the compounds responsible for these. For example, the sourness of lime can be reduced by addition of sugar; the bitterness of fenugreek is reduced by adding coconut and jaggery. Thus, you find that a variety of steps can be taken to modify the flavour of natural foods. We can use flavouring substances, naturally present in foods or those synthesised in the factory, during food preparation and processing to improve acceptability and add variety to our diet.

Flavouring Substances

A variety of materials are used in food preparation and processing to enhance, blend and alter the natural flavours. Appropriate use of these can make a insipid dish into a highly palatable product. There is ample scope for creativity in use of flavouring substances in food preparation. A large variety of flavouring substances are used in Indian homes. These include salt, a variety of acidic substances, herbs and spices, and extracts of herbs and spices.

Salt Salt is the most widely used condiment. It is one of the few pure chemicals used in food preparation. It is obtained by evaporation of sea water. It is used to season all food preparations except sweets. It is used in food preservation to make pickles, *chutneys* and sauces. Salt has the unique property of enhancing the flavour of herbs and spices in food preparations.

Acids Lemon juice, tamarind, *cocum*, *amchur* and vinegar are the acid substances very commonly used in Indian homes. Lemon juice is used in salads and savoury preparations such as *upma*, *batatepohe*, *bhel* etc. Tamarind is soaked and the acid extract thus obtained is used in *sambar*, *rasam*, *puliyore* (tamarind rice), and many other vegetable preparations in the southern parts of India. In western India, where *ratambi* (the fruit from which *cocum* is made) is available, *cocum* is used in food preparation. Vinegar is dilute acetic acid. It is used to flavour salads, pickles, and sauces. *Amchur*, made from raw mangoes, is also used in some preparations to impart acidic taste.

Herbs and Spices India is known as the 'Home of Spices'. Spices and herbs form an indispensable part of our cultural food pattern. These impart a subtle flavour to foods. Their presence is evident by their irresistible aroma, which whets our appetite. They add zest to otherwise insipid foods. Hence, these are the most important group of flavouring materials in the Indian cuisine.

Spices and herbs come from various part of plants, such as the fruits, seeds, berries, roots, rhizomes, leaves, the bark, the floral parts, kernel, aril and exudate of bark. The flavour is due to small amounts of essential oils and organic acids present in the specific part of the plant. Each one of these has a characteristic component, which is responsible for its individual flavour. These are available as whole dried spices and as ground powders also. One problem associated with spices is adulteration. As these are expensive products, ground hulls, sawdust, and other waste materials are added to increase the bulk and thus increase profit margin. Microscopic and chemical tests can help to identify the adulterants.

Flavouring Extracts Flavouring extracts are obtained from spices by extraction with alcohol, steam distillation or by expression in a press. These are normally solutions of the essential oils in alcohol. These are best stored in a cool place in tightly stoppered containers. As these are concentrated solutions of the flavour, very minute amount is needed to be added to impart the desired flavour. Some of the flavouring extracts available include ginger, cardamom, saffron, vanilla, orange, cinnamon etc.

Many synthetic chemical compounds are now available in the market, which have a flavour similar to that of the natural extract. These are used extensively, because these are much cheaper than the natural flavouring extracts.

Use of Spices and Flavourings These are added to the food normally towards the end of preparation. There is no set proportion, which is acceptable to all, as individual variation in the tolerance to these is very great.

Spices may be used in the whole or powdered form. Whole spices are usually added to hot oil as a seasoning, before being dispersed in the food preparation. Oil acts as a solvent for the flavour components present in the spices. Ground spices may be added to the food directly, e.g., pepper, jeera powder, spice mix etc.

Herbs are normally cut and simmered is hot fat or oil to extract the characteristic flavour before being added to the preparation. As prolonged cooking will cause loss of volatile components, it is advisable to add flavouring material towards the end of preparation. As you may know, these materials are very light and very small amount is needed to impart the flavour. For example, a teaspoonful *sambar pudi* weighs only two grammes, and it is sufficient to flavour about 600 milliliters of *sambar.* Thus, it amounts to only 1 part in 300, but its contribution to improving the palatability of the product is truly remarkable. In use of flavouring materials, it is good to remember that while a small addition is good, more of it may result in decreased acceptability of the food product. So you must practice moderation in use of these materials.

Sensory Evaluation of Foods and Food Products

There has been a sea-change in our food-buying and eating practices since World War II, when a large number of women joined the work force. The demand for processed foods has been on the rise since then. It is important that the processed foods and food products meet the expectations of

the consumers to be commercially viable. Food acceptance studies thus form an important aspect of commercial food production.

Food acceptance involves all our senses organs, which record the smell, touch or feel, taste and aftertaste of foods. Hence, these are known as sensory or organoleptic attributes of food acceptance. The methods used to measure these attributes are known as sensory or organoleptic tests.

Sensory evaluation of food products are carried out

(a) To study consumer preferences.
(b) To investigate the effect of food production processes on the final product.
(c) To check the maintenance of quality of the product at a set standard during manufacture.

Consumer preference tests are conducted on large number of persons to gauge the market potential of the product. In consumer preference tests, an attempt is made to get a cross section of all potential consumers. Such tests are conducted in large super markets as also at meetings of professional and social groups.

The sensory tests carried out to check the changes in food acceptability due to processes and/or ingredients on the final product need carefully chosen persons who have ability to detect degrees of differences in flavour or quality.

Points to Remember

Colour in Food affects our acceptance of food. Natural colour is a guide to quality. Colours, synthetic and natural are added to improve acceptance of food products.

Texture A variety of textures are associated with foods–soft, crisop, elastic, sticky etc. Texture is developed with care to ensure food acceptance.

Flavour A blend of sensory impressions (odour, touch and taste) affects food acceptance. Taste of foods is a blend of six primary tastes–sweet, sour, salty, bitter, astringent and pungent.

Flavouring Substances are added or developed in foods to enhance acceptability and keeping quality. Salt, acids, herbs, spices, flavouring extracts are added, but need to be monitored.
Sensory evaluation of foods is an important aspect of food study.

Study Questions

1. Discuss the texture of food with reference to cereals, fruit and meat.
2. What are the primary tastes? Explain how these affect food acceptance.
3. List the various flavouring substances used in foods.
4. What are flavouring extracts and how are these prepared?

8

Water

Water is the most abundant substance in plant and animal matter. The water content of animals and plants varies widely.

For example, a ripe papaya contains about 90 per cent water (Fig. 8.1). A melon has about 96 per cent and a bacterial cell about 80 per cent.

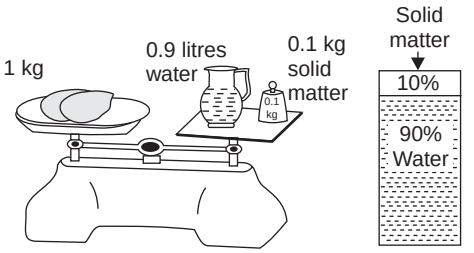


Fig. 8.1 Water Content of Papaya

Water Content in Foods

Water is as much a part of all foods as are carbohydrates, fats and proteins. Cellular material contains an abundance of water. In food, composition tables, the water content is reported under the heading 'moisture'. In green leafy vegetables there is 90 per cent or more moisture (Table 8.1). Fruits and vegetables contain plenty of moisture to the extent of 70–95 per cent. Cereals and pulses contain only about 10–12 per cent moisture, while nuts and oilseeds contain even less moisture to the extent of 4–5 per cent. Fluids like milk contain about 80–90 per cent moisture. Fats and oils except for butter and margarine contain no moisture. Butter contains about 19 per cent moisture. Moisture content in foods is important in that, it influences the texture, cooking time, and shelf-life of foods, as will be discussed later in this chapter. Water, which is present in foods, may be held as:

1. Free water or
2. Bound water

Free water is present in cells, and in circulating fluids of tissues as in cell sap. It contains dissolved and dispersed solutes in the cell. It is easily lost by drying the food. The bound water in foods is held by the proteins, polysaccharides and fats in the living cells. Bound water may also be absorbed

on the surfaces of solids in foods. The removal of bound water from tissues is very difficult. Bound water is resistant to freezing and drying.

Role in Food Preparation

The role of water in food preparation is of great importance.

As a Cooking Medium

This is perhaps the most common and important of its many uses in cookery. Water has been universally used as a medium of cooking. The ubiquitous nature of water, its free availability and its low cost of supply are some of the factors which influence the use of water as a cooking medium.

As discussed in chapter 4, foods cooked in water are boiled, simmered or steamed with or without pressure.

Dry foods absorb water and swell before they get cooked. Water acts as a medium of heat transfer from the surface area to the different parts of the food. Therefore, foods which have a lower moisture content take a longer time to cook than foods with greater moisture content.

Water has the highest specific heat of all materials. This helps it to retain and conduct heat to and away from the food very efficiently.

The neutral pH of water is very useful in that it does not react with the food constituents, thus preventing any adverse changes in the cooked food.

As a Solvent

Water is a universal solvent for many food substances. The characteristic flavours of soups, dals, tea, coffee depend upon the ability of water to dissolve or extract the flavouring agents present in the foods. Water not only dissolves flavours, but also colour pigments in fruits and vegetables like anthocyanins and falvones. Thus, the solvent action of water is responsible for the palatability of the food cooked in it.

The nutritive value of the food too is affected by cooking procedures. Certain water soluble vitamins like ascorbic acid, thiamin and simple sugars and salts are readily dissolved in water. A common method employed to increase nutrient and flavour retention is to cook the food in just enough water.

Water Absorption

Dry foods cooked in water absorb water, expand in volume and increase in weight. The weight gain in food during cooking varies from food to food and depends partly on the original moisture content of the food. Foods like cereals and pulses when cooked in water, gain weight to the extent of 2–3 times. Therefore, the nutrients supplied per unit weight are diluted to that extent.

Starches and proteins present in foods absorb water and get hydrated. Dried foods like legumes when soaked absorb water. Starch granules swell as a result of hydration. Proteins such as gluten

and gelatin are also hydrated when they are in contact with water e.g., as in *chapati* dough, jelly crystals. It is thought that the water holding capacity of meat proteins has an effect on the tenderness of the animal muscle.

Water also functions in food preparation as a dispersing medium and helps to produce a smooth texture. It helps to distribute particles of materials like starch and protein. When flour is used to thicken liquids, the particles need to be dispersed throughout the liquid phase as in a starch gel.

Moisture content in foods also has a bearing on the cooking methods employed and on the cooking time. Dry foods like cereals, millets, pulses take a longer time to cook than foods with a greater moisture content e.g., leafy vegetables. Dry foods e.g., pulses, are generally first soaked for a period of time before they are cooked. This helps to decrease the cooking time, very often rice, dals and legumes are cooked under pressure to hasten the cooking process.

TABLE 8.1 Moisture Content of Foods

Classification	Name	Moisture
Food grains	Rice, wheat, jowar	12–13
Dals, pulses	Tur & mungdal, chawali	10–13
Nuts, oilseeds	Groundnut, sesame, mustard	3–8
Sugar	Jaggery	4
	Sugar	0.4
Oils, fats	Butter	19
	Ghee, oil, vanaspati	0
Fruits, fresh	Tomato	94
	Banana	70
Fruits, dry	Apricots, raisins, dates	15–20
Vegetables, leafy	Cabbage, spinach	92
Roots, tubers	Tapioca	60
	Radish	95
Other vegetables	Cucumber, pumpkin	92–96
	Double bean	74
Animal foods	Milk, cows	88
	Eggs	74
	Fish, pomfrets	75
	Poultry, fowl	72
	Meat, mutton	72

Water as a Leavening Agent

Water acts as a leavening agent in food preparations. When batters and doughs are exposed to heat, the water present is converted to steam. The steam expands and is responsible for the leavening effect e.g., puffing of *chapaties* and *puries*; rising of cakes and *idlis*.

Keeping Quality of Foods

It is first necessary to know the foods that can be stored at room temperature and the ones that need to be stored at low temperatures. Only then we can appreciate how to store foods carefully.

The shelf-life or storage period of a food is greatly influenced by its moisture content (Table 8.1). Water is essential for the growth of microorganisms. In the presence of enough moisture, microorganisms multiply. If some of these are harmful, then they will render the food inedible.

Therefore, on the basis of their stability during storage, foods can be divided into *non-perishable*, *semiperishable* and *perishable* foods. It may be noted that cereals, dals and legumes with a moisture content below 13 per cent are nonperishable if stored in a cool, dry place in an airtight container. It is important to store dry foods like sugar, salt, coffee powder in dry airtight containers. For these foods, pick up moisture readily from the atmosphere and may deteriorate.

Semiperishable foods can be stored for a week to a month at room temperature without any undesirable change in flavour or texture e.g., biscuits, roasted chana dal, potatoes etc.

Perishable foods which have a high moisture content can be kept only for a short period e.g. milk, *paneer*, meat, fresh fruits and vegetables at room temperature. They have to be stored at refrigeration temperature; if their shelf-life is to be prolonged.

Texture and Consistency

The amount of moisture present in a food affects its texture, consistency and feel in the mouth. Softer foods and liquid foods are swallowed easily, while crisper and drier foods are more difficult to swallow. For this reason, dry foods like toast is normally buttered and *khakhras* are always served with tea. This facilitates the smooth passage of food from the mouth to the intestinal tract.

Body Needs

Water is an essential nutrient next only in importance to oxygen. Deprivation of water even for a few days can lead to death. An adult may need about 1.0–1.5 liters of water per day, in addition to the moisture contained in foods eaten. The amount of water needed by human body may increase in hot and dry climate and with strenuous exercise (Table 8.2).

TABLE 8.2 Water Needs of Human Body

Water intake		Water loss	
Water as such	1100 ml	Urine	1000 ml
Water in food	900 ml	Feces	200 ml
Metabolic water	200 ml	As vapour (skin and lungs)	1000 ml
Total	2200 ml	Total	2200 ml

Hard Water

Hard water is that which contains salts such as bicarbonates, chlorides, sulphates and silicates of iron, calcium, and magnesium in solution.

When hardness in water increases beyond a certain level, it interferes with the use of water in cooking and washing. It also imparts a peculiar taste to the water. Foods, which are cooked in hard water take a longer time to cook and may not become soft. The dissolved solutes present in hard water compete with the food for water. As a result, the food does not absorb enough water and therefore the food cooked in such water remains hard. Moreover, these dissolved salts raise the boiling point of water, thereby, increasing the cooking time. For example legumes require a longer time to cook in hard water than in soft water. Peas cooked in hard water are not as soft as those cooked in soft water. Beverages prepared from hard water are turbid.

However, hardness in water also serves a useful purpose. It is of use in canning tomatoes as it increases firmness of tomatoes and helps them retain their shape.

Hard water needs to be softened before it can be used in food preparation. Hard water, that is said to have temporary hardness, may be boiled to allow the bicarbonate salts to precipitate out. The water is filtered to remove the precipitated salts.

Hard water that is said to be permanently hard, needs more complex treatments. Permanently hard water can be softened by removing the calcium and magnesium ions. This is usually done in two ways:

1. By the use of chemicals like soda, sodium carbonate, lime or tetraborate or trisodium phosphate, and
2. by the zeolite method.

The purpose of the chemicals used, such as sodium is to precipitate the calcium and magnesium ions, which are then removed by sedimentation and filtration. This is a simple method and may be adopted in homes where water supplied is hard.

The zeolite process makes use of an ion-exchange medium through which the hard water is passed. Calcium and magnesium ions are removed and the water is softened. This process which is more expensive than the former, is normally used in institutions.

Points to Remember

Water Papaya contains about 90% water. In other foods–

Leafy vegetables	90 per cent
Fruits	70–95 per cent
Milk	80–87 per cent
Cereals and pulses	8–12 per cent
Nuts and oilseeds	4–5 per cent

Role in Food Preparation Used as an ideal, cheap cooking medium. Neutral pH prevents adverse changes in the food cooked in it. Transfers heat efficiently. High specific heat helps to retain heat. It is a universal solvent and dissolves and extracts food flavours, colours and soluble nutrients. Foods, such as cereal, absorb water and soften and swell. Helps to disperse particles. Acts as a leavening agent.

Texture and Consistency and Shelf-life Low moisture foods are hard, dry and crisp. High moisture foods are soft and smooth. Shelf-life of foods is affected by water content.

Body Needs An adult needs 1–1.5 liters of water per day. More water is needed in hot, dry weather. More water is needed with strenuous exercise.

Hard Water Contains salts of calcium, magnesium and iron. Hardness of water interferes with its use in food preparation. Temporary hardness can be removed by boiling. Precipitation is used to remove permanent hardness.

Study Questions

1. What is the importance of water in food preparation?
2. Write a short note on moisture contents in foods.
3. "Moisture content affects texture, cooking time and shelf-life of foods". Justify this statement.
4. What are the daily requirements for water?
5. (a) What is hard water?
   (b) Why is hard water undesirable for cooking?
   (c) What are the different methods to remove hardness in water?

9

Carbohydrates in Foods

Carbohydrates are one of the three main energy-providing nutrients, the other two are proteins and fats.

We get most of our energy from carbohydrate foods, which form a large proportion of the total dry weight of plant tissues. The carbohydrate foods, give the highest yields of energy per unit land cultivated, are easy to store and transport. Hence carbohydrates are the cheapest and most abundant source of energy for human beings.

All green plants synthesis carbohydrates by the process of **photosynthesis. Sunlight provides the** energy needed to transform the carbon dioxide and water into carbohydrates. Hence, photosynthesis cannot occur in the dark. Animals are unable to synthesize carbohydrates and are dependent on plants for their supply of carbohydrates.

Carbohydrates occur in plant—

- In the sap (sugar)
- In fruits (sugar)
- In storage reserve (starch) in seeds, roots and tubers, and as parts of the structural tissues (celluloses, hemicelluloses, pectins and gums)

In the animals, carbohydrates are found in milk of mammals (lactose) and as a storage reserve (glycogen) to some extent.

The literal meaning of the word 'carbohydrate' is hydrated carbon, that is carbon and water. Carbohydrates are composed of the elements carbon, hydrogen and oxygen.

Simple sugars and all substances, which on hydrolysis yield simple sugars, comprise the principal carbohydrates.

The following simple equation illustrates carbohydrate synthesis in plants.

$$6\,CO_2 + 12\,H_2O \xrightarrow[\text{Sunlight}]{} C_6H_{12}O_6 + 6\,O_2 + 6\,H_2O$$

The solar energy used in photosynthesis is stored as chemical energy in the plant. Animals, which eat plants are able to utilize the chemical energy stored in the carbohydrate molecule to meet major part of their energy needs.

Plants can synthesise a variety of carbohydrates by photosynthesis. The sugars, glucose, sucrose and the polysaccharides, starch and cellulose are important examples of carbohydrates produced by photosynthesis.

Carbohydrates have the general formula $C_x(H_2O)_y$ where *x* and *y* are whole numbers.

Naturally occurring carbohydrates are of interest in food chemistry; especially those which have six or multiples of six carbon atoms.

Familiar examples are glucose $C_6H_{12}O_6$ and sucrose $C_{12}H_{22}O_{11}$ and starch represented by $(C_6H_{10}O_5)_n$

Classification

Carbohydrates are classified on the basis of their molecular size into

Monosaccharides,

Disaccharides and

Polysaccharides

Monosaccharides as their name indicates, (mono meaning one and saccharide meaning sugar) are the simplest of carbohydrates because they consist of a single sugar unit. More complex carbohydrates are built from the units of monosaccharides.

Three monosaccharides that are of importance in food preparation are glucose (dextrose), fructose (levulose) and galactose.

Disaccharides ('di', meaning two) contain two units of sugar, which may be alike or different. Two monosaccharides unite with the loss of a molecule of water to form a disaccharide. Likewise, disaccharides can be hydrolysed by boiling with dilute acid or by enzymes, to produce the sugars from which they are made.

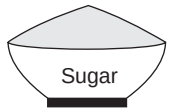
Sucrose, lactose and maltose are the most familiar examples of disaccharides.

Polysaccharides, as their name indicates, ('poly' meaning many) consist of many units of sugar. When polysaccharides are linked together to form one molecule, they may be linked together in straight long chains, or may be branched. Starch, glycogen, celluloses, hemicelluloses, gums and pectic substances are some of the polysaccharides found in plants and animals.

Monosaccharides

D-Glucose, Dextrose or Grape-sugar are all names for the sugar found in grapes and other sweet fruits. Honey contains 35 per cent glucose. During digestion, starch and other carbohydrates are hydrolyzed to glucose.

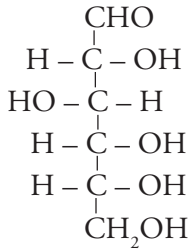
Glucose $C_6H_{12}O_6$ is a white solid. It is less sweet than sucrose and fructose. There is an aldehyde group in the glucose molecule, hence it behaves like an aldehyde. As the aldehyde gets easily oxidized to its corresponding acid, it acts as a reducing sugar, with even mild oxidizing agents. This reducing action forms the basis of many tests used for glucose and other reducing sugars.



Glucose structure as given originally with numbered carbon atoms is given below:

1. CHO
2. CHOH
3. CHOH
4. CHOH
5. CHOH
6. CH_2OH

Carbon atoms 2, 3, 4 and 5 are asymmetric, hence glucose is optically active. Ordinary glucose is dextrorotatory, which is written as *D* (+) glucose and using the projection formula it is represented thus:



D-Fructose, Levulose or Fruit Sugar is a laevoratotory sugar, found in juices of sweet fruits and honey with glucose. When sucrose is hydrolysed, fructose and glucose are formed. It is sweeter than glucose and sucrose.

Galactose is obtained by the hydrolysis of lactose, the milk sugar. It does not occur in the free state in nature. Isotope experiments have shown that galactose is synthesized from blood glucose by mammals. The galactose thus formed combines with glucose to form lactose, which is secreted by mammals in the milk to sustain their young.

Galactose, a component of lactose, has unique nutritional properties. The sugar level in the milk tends to vary directly with the weight of the adult brain. Of all the animals, man has the largest brain, in proportion to body weight, and human milk has 7.4% lactose, the highest percentage of milk sugar. In contrast, cow's milk, which is used to prepare infant milk formulas, has only 4.4% lactose.

The high percentage of lactose in human milk may be related to glycolipids of the brain, which usually contain galactose. Moreover, glucose is the only fuel normally used by the brain in its activities and it is conceivable that during brain formation (first year of life), the more stable galactose is more suitable as a building material. Hence, galactose is sometimes referred to as 'brain food'. Infants, being less able to synthesize galactose than adults, it is nature's provision that they get it in milk, their primary food.

Diasaccharides

In nature, disaccharides are formed by the combination of two monosaccharides, a molecule of water is released in the process

$$C_6H_{12}O_6 + HO(C_6H_{11}O_5) \rightarrow (C_6H_{11}O_5) - O - (C_6H_{11}O_5) + H_2O$$

Disaccharides are the most abundant and familiar of natural sugars. The sugar, we use to sweeten our cup of tea is sucrose. It is one of the few pure manufactured foods used in food preparation. It is extracted from sugarcane in the tropics and sugar beet in the temperate region. The sugar found in mammalian milk is lactose. The sugar found in malted grains is maltose. Sucrose, lactose and maltose are the most familiar examples of disaccharides.

Maltose or Malt Sugar is got from starchy materials by the action of the enzyme *diastase*. The maltose is hydrolysed to glucose by the action of the enzyme maltase or by heating with dilute acid.

Maltose contains two combined units of glucose, which are released as D-glucose by hydrolysis. Maltose is a reducing sugar, but only one of the aldehyde groups of glucose is free, the other is used up to unite the two glucose units:

Lactose or Milk Sugar is a crystalline, gritty solid. It is found in the milk of all mammals. Human milk contains 6 to 8 per cent and cow's milk contains 4 to 5 per cent of lactose. Lactose can he hydrolysed by the enzyme *lactase* or by boiling with dilute acid to yield the constituent monosaccharides D-glucose and D-galactose.

Sucrose, Cane or Beet Sugar is a white crystalline solid and is the ordinary sugar we use everyday as a sweetener in beverages and sweetmeats. It is widely distributed in the vegetable kingdom in many fruits, grasses, stems and roots. It is also present in the sap of some trees. Since it is produced economically in large quantities, it is the main sugar used in the diet. In India, its main source is cane and over 1 tons of sugarcanes are produced annually.

Sucrose, when hydrolysed with dilute acids or the enzyme *sucrase*, yields equals amounts of glucose and fructose, indicating that it is a combination of one unit of glucose with one unit of fructose. It is not a reducing sugar as the reducing groups in the two monosaccharides are involved in the link joining them. Please note from the structure of sucrose given above that the fructose unit in sucrose is a five membered ring. Sucrose is readily hydrolyzed to glucose and fructose and the solution is laevorotatory, as fructose is more strongly laevorotatory than glucose is dextrorotatory. This in known as *inversion*, as there is a change in the direction of rotation. The mixture of glucose and fructose formed is called *invert sugar*. Invert sugar is found in honey, Acidic foods tend to hydrolyze the sucrose added to these in preparation. Fruit drinks, jams and fruit *sherbets* also contain invert sugar.

Sugars

Monosaccharides and disaccharides are crystalline, water-soluble and sweet compounds. In food preparation, they are referred to as *sugars*.

Sources and Properties of Sugars

When we talk of sugars, we usually imply the monosaccharides, fructose and glucose, and the disaccharides sucrose (the sugar we use daily), lactose and maltose.

The important sugars found in foods and their natural sources are given in Table 6.1.

TABLE 9.1 Sugars—Natural Sources and their Components

Sugar	Natural sources	Components
Glucose or Dextrose	Honey, fruit and plant juices Is a part of cane and beet	–
Fructose or Fruit sugar	Honey, fruit juices Is a part of cane or beet sugar	–
Galactose	Does not occur in the free form in nature Occurs as a part of lactose	–
Sucrose	Sugar cane Sugar beet Sugar palm Sugar maple In fruit and plant juices	Glucose and Fructose
Lactose	Milk	Glucose and Galactose
Maltose	Germinated or malted grains Formed by hydrolysis of corn starch	Glucose and Glucose

Sugar occurs in solution in nature. When the solution is concentrated, the sugar crystallizes. This principle is used in the manufacture of sugar.

Sugars crystallize out of solution with ease when concentrated. This property is used in preparation of confectioneries.

When sugar is heated to a temperature above the melting point, it decomposes and forms a brown mass, which is known as *caramel*. Caramel has a bitter taste. In some products sugar is partially caramelized to enhance the colour and flavour of the product.

Manufacture of Sugar from Sugar Cane

Sugar cane is a tall giant grass and looks like a bamboo. The sugar is present in the cell sap and is extracted by crushing the cane and dissolving he sugar in the water sprayed on it. The solution is purified by boiling and adding lime to precipitate impurities. Some impurities float on the top. After removing the impurities, the sugar solution is concentrated by evaporation under reduced

pressure. Crystals formed are separated by spinning the mixture in large perforated drums. Molasses, separated in the process are used to manufacture industrial alcohol.

Sugar is refined by precipitating the impurities with lime solution and removing these. The concentrated sugar solution is passed through a bed of bone charcoal to get a clear liquor, which is concentrated by evaporating the water under reduced pressure, to get fine, clean, white, uniform sugar crystals. Pure sugar crystals are added to super saturated solution to seed it and thus hasten the process of crystallization. The process is instrumentally controlled to obtain a uniform product. The crystals are separated by centrifuging. The left over syrup is used to make brown sugar.

Sugar Consumption and Health

Increased sugar production has resulted in increase in consumption beyond desirable level. Sugar is bought and used as such and it is also consumed in a variety of manufactured foods.

High intake of sugar is undesirable for three reasons:

- It contributes to obesity.
- It increases rate of dental decay.
- It is possibly related to increased incidence of diabetes and coronary heart disease.

Use of Sugar

Sugars supply energy to our body. Each gramme of sugar supplies four calories. Sugar can be metabolized quickly to meet energy needs of our body.

It is mainly used as a sweetening agent in beverages such as tea, coffee, fruit drinks, in cereals and porridge, in puddings, pies, cakes, biscuits and frozen desserts such as ice cream.

When used in higher concentration, sugar acts as a preservative as well as a sweetening agent, e.g., jams, jellies, marmalades, squashes, sweetened condensed milk, *ladus* etc.

Confectionaries sugar is the major ingredient responsible for its shape and structure.

Brown Sugar is prepared by concentrating sugar cane juice. It is not refined and has a light to dark brown colour, due to impurities present. It contains about 96 per cent sugar, about 2 per cent moisture and traces of minerals and protein. The presence of other substances imparts a characteristic rich flavour to brown sugar. The presence of salts is noted by the slightly saltish taste.

Brown sugar is used to make *ladus* (sweet balls) with coconut, *til* or groundnut in some parts of India. It is also used in preparing toppings for cakes.

Honey is concentrated nectar of flowers, sweet exudates of leaves and plants manufactured by honeybee.

Chemically, honey is concentrated solution of fructose and glucose, in which small amounts of sucrose, dextrins, mineral matter, proteins (trace) and organic acids are present. It contains about 18 per cent water, 40 per cent fructose, 35 per cent glucose and 5 per cent sucrose. The flavour ingredients are present in minute amount, which are from the flowers. Thus, the flavour varies with the kind of flowers, from which the bees collect it.

Honey is used as spread for bread with butter. It is also used in a number of baked products, to impart a light texture and a moist feel to the product.

Glucose or Dextrose It is widely distributed in nature. It is found in fruits, honey and some vegetables. Commercially, glucose is made from corn starch by hydrolysis. Glucose is formed in sugar syrup if an acid is present.

Fructose It is mainly found in honey with glucose. It is present in fruits and molasses. It is widely distributed in nature and often is found with glucose or glucose and sucrose. It is the most soluble of all sugars and is also the sweetest of all natural sugars. Pure crystalline fructose is very expensive.

Maltose When starch is hydrolyzed with an acid, maltose is formed as an intermediate product. It is prepared commercially by enzymatic hydrolysis of starch. It is present in germinating cereals and malted products, hence the name maltose.

Lactose or Milk Sugar As the name indicates, lactose is the sugar present in milk secreted by females of mammals. Cow's and buffalo's milk contains on an average 5 per cent lactose while human milk contains about 7 per cent.

Sucrose It is common sugar available in the market. In India, it is made from sugarcane and is 99.9 per cent pure sucrose. In the temperate zone, it is obtained from sugar beet.

Properties of Sugars

Hygroscopic Nature The word hygroscopic means water attracting. Sugars absorb water on exposure and are known to be very hygroscopic by nature. Therefore, sugars should be stored in a dry place, in airtight containers. Sugar and confectionaries made from sugar tend to absorb moisture and become sticky when exposed.

Solubility Sugars are soluble carbohydrates. The sugars arranged in descending order of solubility are—fructose, sucrose, glucose, maltose and lactose. This property is important in predicting the procedure to be followed to obtain a particular product when mixture of sugars in used.

Flavour The sugars are mainly prized for their sweet flavour. Sugars vary a great deal in their sweetness. There is no objective test for measuring the degree of sweetness. All investigators agree that fructose is the most sweet and lactose the least sweet of the sugars. Glucose is rated as half to three-fourth as sweet as sucrose. Maltose is less sweet than glucose. Thus, the ranking in terms of sweetness is fructose, sucrose, glucose, maltose and lactose.

The flavour of unrefined sugars depends on the nature of the impurities present. It is sweet combined with other flavours present.

Ease of Crystallization Sugars crystallize out of solution with ease on concentration. This property is important in sugar preparations. The ease of solubility is inversely related to ease of crystallization. The least soluble sugar crystallizes even at low concentrations, but the most soluble sugar is not easily crystallized. These characteristics need emphasis and need to be understood for successful attempts in sugar cookery.

Crystallization Crystallization is a process where crystals of the solute are obtained from the solvent in which they are dissolved. Crystallization of sugar occurs when a saturated solution of sugar is cooled gradually. Crystals of sugar thus obtained are very desirable in sugar coated preparations like sugar coated nuts, *balushahi* and other such as icings and candies such as fondant etc. (Table 9.2).

TABLE 9.2 Sugar Syrup and Its Use in Various Preparations

Strength of syrup	Preparation
½ thread	Gulab Jam, Sudharas
1 thread	Rose Syrup
1½ thread	Ladus, Vadis
1½ thread	Sugar coated groundnuts
Soft ball	Sakharbhat, Candies
Hard ball	Murambba

Crystallization depends upon a number of factors. These factors include nature of the crystallizing medium, concentration of sugar in the preparation, temperature at which crystallization takes place, agitating the sugar preparation and the addition of other ingredients such as butter, ghee, lemon juice, and egg. In general, the greater the concentration of the sugar in the sugar preparation the faster is the rate of crystallization. The sugar preparation should be heated upto a temperature at which it is saturated. When this saturated sugar preparation is gradually cooled, it crystallizes at a particular temperature. Stirring vigorously or beating the sugar preparation during cooling helps to form a number of small crystals of sugar. This imparts a soft, velvety feel to the product as is seen in candies. (Table 9.2).

Presence of other ingredients such as starch, fats like butter, ghee (as in *ladus*, coconut burfi) and proteins such as egg proteins lower the rate of crystallization. The crystals of sugar adsorb these ingredients and as a result do not grow in size.

Inversion of Sugar Sugar is hydrolyzed by acids to glucose and fructose. This reaction is called 'Inversion of Sugar' and the glucose and fructose formed are referred to as 'Invert Sugar'. Invert Sugar is more soluble in water than sucrose, and therefore does not crystallize as readily as sucrose. Inversion of sugar in food preparation is observed when lemon juice is added to sugar preparations which are subsequently heated. In such cases, the rate of crystallization is slow. Therefore, acids such as lemon juice and other fruit juices, are added to sugar preparations towards the end of cooking.

Inversion of sugar can also be brought about by hydrolyzing enzymes present in foods.

Adsorption and Impurities in the Solution

The presence of foreign substances lowers the rate of crystallization. The rate of crystal growth is retarded because of adsorption of the foreign substances by the crystals.

The addition of other carbohydrates, such as glucose, fructose and starch to sucrose solution, retards the crystallization of the sucrose. The addition of acid to a sucrose solution brings down the rate of crystallization due to inversion of sucrose. Other substances strongly adsorbed by sucrose crystals are fat and proteins. Hence, butter, milk or egg white are used to retard the crystal growth, e.g., *dudhi halwa*.

Manufactured Foods Containing Sugar

Several sweets are manufactured with sugar as a major ingredient. These include boiled sweets, chocolates, toffees, pedhe, barfi, laddu and a variety of mithais. Bakery foods, such as sweet biscuits and cakes also contain sugar.

Boiled Sweets These are made by boiling sugar solutions to about 150°C with addition of cream of tartar, followed by cooling to a glass like solid. A familiar example is lemon drops. The addition of cream of tartar from 0.15 to 0.25 per cent of the weight of sugar helps to form 10 to 15 per cent invert sugar resulting in a non-sticky, non-crystalline candy. A variety of products are made by using different flavours and colours.

Toffee is made from fat, milk, sugar and glucose syrup mainly. The characteristic flavour of toffee is due to the caramelisation of milk solids during cooking. Toffee is manufactured by boiling the ingredients together. The temperature to which the ingredients are heated determines the consistency of the toffee produced. Very hard toffee contains usually 3 to 5 per cent of water whereas soft toffees such as ordinary toffees may contain 6 to 12 per cent of water. Ingredients are heated to 295–310 °F for making hard toffees whereas soft toffees are made by heating the ingredients to a temperature of 245–270°F. When the boiling is completed, the toffee is poured on to a slab, cooled, cut into the desired shape and wrapped.

Use of High Fructose Corn Syrup (HFCS) in Place of Sugar

The use of sweeteners based on glucose is increasing and it partially or completely replaces sucrose in food products. Maize starch is hydrolyzed by heating under pressure with dilute hydrochloric acid to produce a colourless syrup. The glucose content of the syrup varies according to the degree of hydrolysis. It is expressed as *dextrose equivalent* (*DE*). It is a mixture of dextrose, maltose and dextrin.

More recently, the glucose syrups are treated with the enzyme *glucose isomerase* to convert about half of the glucose to fructose to produce *high fructose corn syrup* (*HFCS*). The HFCS formed is at least as sweet as sucrose or more sweet, depending on the fructose content. It enhances fruit flavours. It is used in soft drinks, bakery products, jams, preserves, and many other convenience foods.

In USA and UK most of the new convenience foods are made using HFCS in place of sugar, as it is cheaper than sugar. These foods include soft drinks, biscuits and other bakery products, candy and a number of other convenience foods. The intake of these HFCS containing foods has resulted in extreme increase in obesity in these populations. Latest research studies conducted to study this

problem, have revealed the deleterious effects of extensive fructose intakes on the health of the consumers. These include increased lipogenesis (fat formation), VLDL formation (very low density lipoproteins), leading to triglyceridemia (too high concentration of triglycerides in blood), too much insulin in blood and low glucose tolerance. Thus, there is high incidence of heart ailments and diabetes in these populations.

Fortunately in India, HFCS is not used in soft drinks and other food products due to its high cost. Sucrose is used in soft drinks and other food products. But, consumers and authorities have to be vigilant and avoid overuse of fructose in food products in place of sucrose.

Starch

As mentioned earlier, starch is a polysaccharide which upon complete hydrolysis releases glucose. Most of the starches and starchy foods used in food preparation are obtained from cereals (rice, wheat, maida, sago, maize, barley), roots (cassava, tapioca, arrowroot) and tubers (potatoes, sweet potatoes). Starch is present in small particles known as *granules*. These granules are of various shapes and sizes. Starch granules present in the corn grain is of a different shape and size from that of a potato tuber (Fig. 9.1).

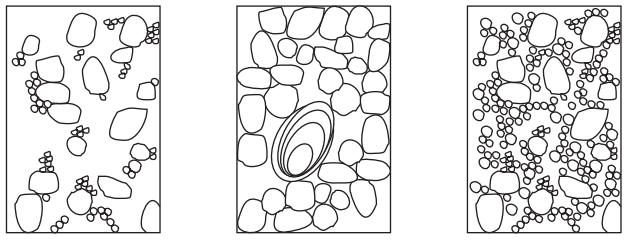


Fig. 9.1 Structure of Wheat, Potato and Corn Starch Granules

Starch is made up of two fractions *Amylose and Amylopectin*. The amylose fraction of starch is composed of straight-chain structure, while the amylopectin fraction has a branched chain configuration. The two possess different properties. Amylose contributes gelling characteristics to cooked and cooled starch mixtures. Amylopectin provides cohesive or thickening property but does not usually contribute to gel formation.

Uses In food preparation, starch is used either in the pure form (arrowroot starch, corn starch) or as cereal flour in which starch is mixed with other components (wheat flour, rice flour, corn flour, bajra flour). Cereal flours contain not only starch but protein, fat and fiber also. Starch accounts for 60–70 per cent of the flour. Starch may be used as:

1. Thickening agents as in soups, white sauces, dals.
2. Binding agents, e.g., Bengal gram flour is used to coat cutlets, bhajias etc.
3. To form moulded gels, e.g., corn starch puddings and custards.

Properties of Starch

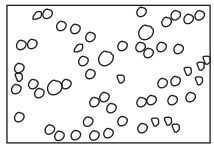
The starch granule is completely insoluble in cold water. However, when a mixture of starch and water is cooked, a starch paste is formed. The starch granules absorb water, swell in size and as the temperature is increased, they burst. (Fig. 9.2). Some pastes are opaque, some are clear, semiclear or cloudy in appearance. In general, pastes made with cereal starches such as corn, or wheat, are cloudy in appearance, whereas those made from root starches such as potato, tapioca are clear.

When some starch pastes are cooled, they become rigid and form a gel on standing, e.g., corn starch. However, some starch pastes do not form a gel.

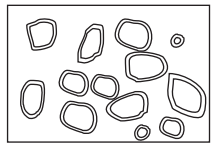
Preparation of Foods Containing Starch

Effect of Dry Heat When dry heat is applied to starchy foods, the starch become more soluble in comparison to untreated starch and has reduced thickening power when made into a paste. This is desirable in some preparations like *upma*. Some of the starch molecules are broken down to dextrins when exposed to dry heat. This process in known as *Dextrinization*. Dextrinization is accompanied by colour and flavour changes also. A characteristic brown, toasted colour and flavour develops. This change is observed when bread is toasted, and when rava or rice flakes are roasted.

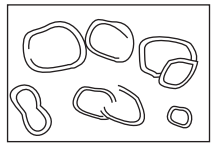
Effect of Moist Heat When starch is heated with water, the granules swell and the dispersion increases in viscosity until a peak thickness is reached. The dispersion also increases its translucency. These changes are described as *Gelatinisation*. Gelatinisation is gradual over a range of temperature and occurs at a different temperature range for different starches. Gelatinisation is usually complete at a temperature of 88°C–90°C (Fig. 9.2).



Uncooked starch



Starch cooked to 72 °C, granules are Swollen



Starch cooked to 90 °C, granules are Ruptured

Fig. 9.2 Gelatinization of Starch Granules on Cooking

Gelatinization may be partial or complete. When the starch granules are dextrinized prior to being cooked in water, they undergo only partial gelatinisation. This is observed in the preparation of *upma, sheera, pulav,* where the cereal grains are first roasted with or without fat and then cooked in water. In such a case, because of partial gelatinisation, the cereal grains remain separate and do not stick together.

Gel Formation As a starch-thickened mixture cools after gelatinisation is complete, bonds form between the molecules of starch in the mixture. This bonding produces a three-dimentional network that increases the rigidity of the starch mixture and results in formation of a gel. Water is trapped in the network of starch. This rigid shape of the gel forms only gradually after the starch mixture has been allowed to cool. It has been found that starches containing relatively large amounts of amylose form firmer gels than starches with lower concentration of amylose. Hence, cornstarch gels are more rigid than gels formed from tapioca or potato which contain less amylose. This is because, the bond which form between the straight chains of amylose molecules are stronger and more readily formed than the bond which form between the branched chains of amylopectin molecules.

Syneresis As starch gels are allowed to stand for some time or age after gel formation is complete, additional bonds are formed between the straight chain amylose molecules. Some of these molecules get associated and aggregate in a particular area in an organized crystalline manner. As these molecules tend to pull together, the gel network shrinks, pushing out the entrapped water from the gel. This process of weeping from a gel is called *Syneresis* (Fig. 9.3).

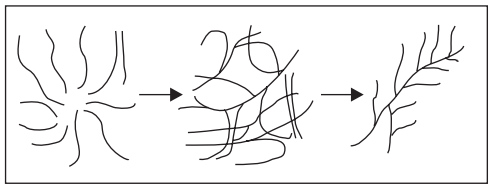


Fig. 9.3 Gel Formation and Syneresis of a Starch Dispersion

Cereals

Cereals are seeds of the grass family. The most commonly used cereals are: rice, wheat, maize (corn), and millets such as jowar, bajra, and ragi. Cereals are inexpensive and rich sources of carbohydrates. They contain approximately 65–75 per cent carbohydrates. Rice and vermicelli contain about 78 per cent carbohydrates. Cereal grains are the major staple food in many countries in the world.

Composition and Structure As shown in Fig. 9.4, whole cereal grains are composed of an outer bran coat, a germ, and a starchy endosperm.

The outer chaffy coat that covers the kernel during growth is eliminated when the grains are harvested. The outer layers of the kernel, which are called *Bran*, constitute 5 per cent of the kernel. During milling, the bran is discarded. The bran has a high content of fibre and minerals. It is also a good source of thiamin and riboflavin (vitamins of the B-complex group).

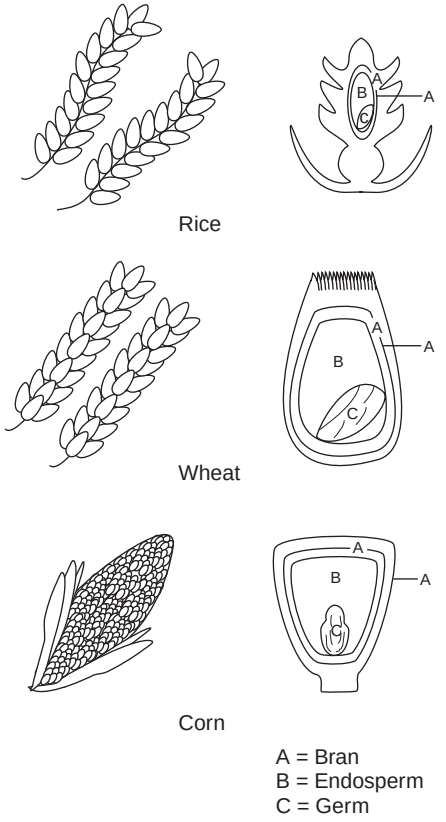


Fig. 9.4 Structural Parts of Rice, Wheat and Corn Grains

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

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

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

Nutritive Value Cereals are an important and economic source of energy. The chief nutrient which supplies energy, is starch. Cereals are also a significant source of protein in the diets of people whose staple food is cereals. But, cereal protein is incomplete in that it lacks in an essential amino acid, lysine. This lack is made up, when cereals are eaten along with other protein foods such as dals, pulses and milk.

The nutritive value of cereals varies with the part of the grain used. All whole cereals chiefly furnish starch, proteins, minerals, *B* vitamins and fibre, but refined cereals lose part of the protein, minerals and *B* complex vitamins in milling. They contain a little more starch than whole cereals. Whole grains contain more vitamins, minerals and fibre than refined grains and are valuable dietary sources of iron, phosphorus, thiamin and fibre.

Wheat Wheat is widely cultivated in the world. The average production of wheat in the year 1980–1981 was 1.65 tonnes per hectare. In India, Punjab is the leading state, which grows wheat. There are two crops in a year; the summer and winter crop. There are several thousand different varieties of wheat.

Wheat is commonly milled into flour or ground to obtain whole wheat flour. Refined flour or *maida* is commonly used in bread and other baked products while whole wheat flour or *atta* is used in the preparation of *chapaties*, *puries*, *parathas*, *khakras* etc. As mentioned earlier, whole wheat flour contains more protein, iron and thiamin than refined wheat flour. Wheat's used for flour is often classified into "hard wheat" or "soft wheat". Hard wheat is higher in protein than soft wheat and is better suited for making breads.

Products of wheat, commonly used are: broken wheat, semolina (*suji*), and extrusion products like vermicelli, noodles and macaroni.

Wheat Preparations

Whole wheat flour is used to prepare typical Indian unleavened breads such as *chapati*, *paratha, roti, khakra, puri* and variations of these. The ingredients of the dough are whole wheat flour, water and a little oil and salt. Of these, *chapati, khakra* and *roti* are roasted after rolling, *parathas* are shallow fat fried and *puris* deep fat fried.

Leavened products of wheat flour include *nans*, *bhatura* and bread. *Nans* and *bhaturas* are leavened by the addition of curd to the flour while making the dough. Yeast is used to leaven bread. *Nan* is roasted after rolling and *bhatura* deep fat fried. Bread is baked in an oven.

Rice Rice is the major food of many people living in Asia, and is the most widely used of all cereals next to wheat. The average production of rice in the year 1980–1981 was 1.34 tonnes per hectare.

Rice is available as milled, unpolished, polished, parboiled, flaked and puffed rice. Milling removes the bran, aleurone layer and some of the germ. Polishing further removes more than half the mineral matter and most of the vitamins. By a special process, grains of rice may be parboiled before milling. Parboiled rice contains more vitamins and minerals, because the steeping in hot water causes migration of these nutrients from the outer coats to the interior of the kernel and are

not lost during milling. Parboiling also gelatinizes the starch and changes the cooking characteristics of the rice. Rice flakes are made after soaking the rice paddy in hot water and then pounding it. It is an important source of iron and thiamin in the Indian dietary and contains more minerals and fibre than the milled rice.

Millets

Millet is a common name applied to edible seeds of members of the grass family. These include bajra, jowar, maize, ragi and vari, which are the common millets consumed in India. Millets are hardy crops and require less care than do cereals. They grow under conditions of poor rainfall and soil.

The average calorie content of millets is 350 kcal per cent and is comparable to that of cereals. On an average, these contain 10–11 per cent of protein. Millet proteins lack in the essential amino acid lysine. The protein quality of millets may be improved if they are eaten along with dals or milk products. Millets are a good source of iron. Ragi is known for its high calcium content which is 344 mg per cent. Ragi is cheaper source of calcium than milk or nuts and oilseeds. Millets also contribute *B*-complex vitamins-thiamin, riboflavin and niacin to our diets. They are high in fibre content.

Millets are ground and the flour made into unleavened product like *bhakris, rotlas* etc. The ingredients of the dough are the flour, water and salt. These products are roasted on a hot skillet.

Ragi flour is roasted and used in preparations such as porridges. Water or milk may be used in the porridge. Addition of milk increases the nutritive value of the porridge. Ragi is often malted and used to make a beverage, which is a common weaning food given to infants. Preparations made of ragi or its flour are rich sources of calcium in an infant's diet.

Cereal Cookery Cereal cookery is fundamentally starch cookery, because starch is the predominant component of cereals. Fibre, which is chiefly exterior bran layers, until softened or disintegrated, will hinder the passage of water to the interior of the kernel and thus may retard swelling of starch in contact with water. If the fibre is finely ground, its affinity for water is greatly increased. Thus, whole grains take a longer time to cook than refined grains.

In the cooking of cereals, attention must be paid to the technique of combining finely ground cereals with water. Cereals in finely powdered form e.g., wheat flour, corn flour, should be first mixed with cold water with continuous stirring to prevent lumping and to obtain a paste of uniform consistency. This paste may then be added gradually to boiling water. Uniform consistency ensures equal exposure of all particles of the cereal to water and heat. If lumps form, dry material remains inside a gelatinous external coating. Alternatively, if the cereal is not in a very finely ground form, it may be gradually poured into boiling water with continuous stirring.

The principal factors that affect the cooking time of cereals are:

(a) The size of the particle: Cereal grains take longer to cook than flours made from these as the surface area of whole grains is much less, as compared to the flour.

(b) Soaking treatments swell the cereal grains partially. This enhances the speed of cooking. The cereal grains should be cooked in the water used for soaking, add more water if necessary.
(c) The presence or absence of the bran layer: As mentioned earlier, the bran layer interferes with the passage of water into the kernel and may thus delay the cooking time. But if the cereal grains are finely ground, then this effect may be minimized.
(d) The temperature: Boiling temperatures are normally used. Once the cereal mixture has been brought to a boil, the heat is reduced and it may be simmered until done. However, temperatures above boiling (100°C), as in pressure cooking, decreases the cooking time to a great extent.

Cooking of Rice Rice grains are normally cooked with twice its own volume of water. It is cooked till the grains are tender, and increases in weight to about three times the weight of dry grains. However, old rice that has been stored for a long time, requires more water for cooking than new rice.

Retention of identity of the rice grains is desirable, as in pulav. In such preparations, the rice grains are lightly roasted with hot fat/oil before being added to boiling water. This treatment causes partial dextrinisation of the rice grains, and helps to keep the rice grains separate after cooking.

Cooking of Wheat Wheat is mainly used as whole wheat flour in Indian cookery. Whole wheat flour is used to make *chapaties*, *puries, parathas* etc. Wheat flour contains specific proteins known as *Gluten*, which when hydrated develops into strong elastic fibres in the dough. Gluten is a protein made up of two fractions *Glutenin* and *Gliadin*. When water is added to wheat flour to form a dough, and the dough manipulated, glutenin and gliadin form gluten. When the dough is stretched and manipulated, gluten is developed. It forms a strong and elastic network in the dough. Gluten formation and development is desired in products such as *chapaties* and bread. It is minimized in muffins, cakes and *puries*.

Factors that Affect Gluten Formation and Development are:

1. *Variety of the wheat*: As mentioned earlier, hard wheat is better suited for making bread as it has more gluten than soft wheat. Thus, your choice of variety will depend on the characteristics desired in the final prepared product.
2. The amount of water added to make the dough/batter. Generally, gluten should be well hydrated to develop completely. If the liquid content is insufficient, a hard dough is formed and the gluten development may be poor. However, addition of excess water may produce a runny batter, which may be difficult to manipulate.
3. *Kneading time and keeping time*: Generally, greater the kneading or manipulation of the dough or batter, greater is the gluten development. However, over manipulation may break the gluten network. In cake and muffin batters, and in the preparation of biscuits, manipulation is minimal, as gluten development is undesirable, whereas *chapati* and bread dough is manipulated well. Keeping time ensures complete hydration of the gluten in the

dough. If keeping time of the dough is extended beyond a certain optimal value, it does not have any effect on the texture of the final product. Thus, *chapati* and bread dough is allowed to rest after being kneaded.

4. *Presence of fat/oil*: Fat or oil added to the dough in large quantities hinders the development of gluten. A small amount of oil is added to the puri dough. Refined oil, butter or vanaspati is used in cakes and biscuits.
5. *Fineness of Milling*: Wheat flour that has been milled finely, has a greater gluten development capacity than coarsely milled flour. Coarsely milled grains have less surface area than finely milled flour, and thus are hydrated to a lesser extent.

Buying and Storage of Cereals

Cereals Cereals, millets and their products are the staple foods in the Indian dietary. It is important that these be selected carefully as they supply a major part of our energy, protein, iron and thiamin needs.

Grain quality has two aspects. The first is physical quality, which refers to cleanliness, soundness of grain and freedom from foreign matter. The second is processing quality, which means suitability for use. For example, thin long grain rice, which does not clump after cooking, is considered suitable for making *pulao*, a particular type of wheat is required to prepare *puran poli* etc. Let us consider the specific criteria for selection of these foods.

Wheat is selected on the basis of the quality aspects mentioned above. Whole wheat is ground for individual use by the families. Whole wheat flour is mainly used to prepare unleavened bread (*chapati, roti, parantha* etc.) in India. In these preparations, very little nutrient loss occurs. Normally consumers buy the variety that suits their needs in terms of performance. Not much information is available about the performance of various varieties in indigenous wheat preparations. Therefore, selection is based on the consumer's personal knowledge and experience.

Rice is available as milled, hand-pounded and parboiled varieties. The degree of milling and polishing affects the nutrient content. The parboiled rice and hand pounded rice contain significant amount of thiamin; highly polished milled rice has very little thiamin.

A number of grain types such as long, medium and short are available. The selection is made depending on the intended use. For example, thin long varieties are preferred for table use, medium and short varieties are used for preparations of rice made after grinding.

Indians prefer the individual rice grains to retain their identity after cooking. Ageing appears to help develop this characteristic in the rice grain. Yet no visual criteria have been established, which could guide the consumer to judge the extent to which rice has aged.

Other grains include bajra, jowar, ragi, maize or any other millet, which is used as a staple.

Millets The criteria for selection are the same as for all grains—soundness of grain, cleanliness, freedom from admixture with other grains and trash. Most of these are ground and used to prepare unleavened bread (roti). As whole grain flours are used in most preparations, not much loss of nutrients occurs. It may be noted that ragi is an exceptionally good source of calcium and iron.

Processed Cereals Products

A number of processed products are made from cereals and pulses. These include wheat products such as cracked wheat, semolina (*rawa*), atta, maida, rice flakes, puffed rice etc. These are made by grinding to varying degrees of fineness (various particle sizes) or by roasting and pounding, or any other method. These processes increase the surface area of the product exposed to atmosphere, decrease the preparation time and also reduce the shelf-life of these products. While the whole grains have a shelf-life of a year or more, the shelf-life of these processed products may vary from two weeks to a few months.

Broken Wheat or Dalia is whole wheat coarsely ground into large particles. As the losses during milling are very little, it is a very nutritious food. Good quality is indicated by sweet taste and an absence of sour, mouldy odour and flavour. It spoils very quickly in storage, due to insect infestation. It can be cooked as such, made into *upma, shira* or porridge.

Semolina, Suji or Rawa is available in varied sizes. The fine grain varieties are used for the preparation of halwas, while the large grain varieties are suitable for preparation of *upma, shira* etc. These are selected on the basis of uniformity of size, freedom from insect infestation, freedom from oxidised or mouldy odour, grit and bran.

Maida is white finely extracted wheat flour. It is free from bran and has a lower content of protein, iron and *B*-vitamins. It has a lower shelf-life than semolina, as the large surface area permits faster rate of spoilage. Good quality maida is free from insect infestation, bad odours, and lump formation.

Processed Rice Products include rice flake and rice puffs. Rice flakes are made after soaking the paddy in hot water, parching it by roasting and then flattening it by force while it is hot to form flakes. It retains a large part of the iron and *B*-vitamin of the aleurone layer. The roasting helps to toast the grain, resulting in partial cooking of the grain. It needs very little the to prepare and is used as a snack. It should be free from bran, broken particles, fragments of the seed coat, insects, stones, trash and bad odour.

Rice Puff's are another ready-to-eat rice product. It is selected for crispness, freedom from stones, seed coats, sand and dirt.

Points to Remember

Carbohydrates Starch, the storage reserve in seeds, roots and tubers, is the main source of energy for human beings.

Carbohydrates are classified on the basis of number of sugars in the molecule into mono-, di- and polysaccharides.

Sugars are derived from fruits and cell sap of certain plants. Sugar, used in cookery is sucrose, extracted from sugarcane.

Uses of Sugar Used as a sweetening agent as such or a concentrated syrups, used to prepare crystalline candies. Decomposed at high temperature to form caramels.

Sugars are hygroscopic by nature, water soluble, sweet to taste, crystallize easily, hydrolyzed by acids to form invert sugar.

Starch Major source of starch are cereals, roots and tubers. Used as thickening agents, binding agents and to form moulded preparations.

Properties of Starch Insoluble in water. Absorbs water, swells and forms gel when heated.

In Preparation Starch dextrinises when roasted, with change in colour, flavour and texture. In the presence of water, absorbs water, swells, thickens and gelatinizes. Starch gels on ageing, weep with discharge of trapped water.

Cereals Rice, wheat and their products. Millets include bajra, jowar, ragi, maize and vari—are ground into flour and made into unleavened products such as chapaties, roties, paranthas etc., and leavened products such as bread, bhaturas etc.

Study Questions

1. What are carbohydrates? How do they occur in nature?
2. How are carbohydrates classified?
3. What different sugars are found in foods?
4. What are the uses of sugar in food preparation?
5. What is Honey?
6. List the different properties of sugar.
7. What is inversion of sugar?
8. What are starches? How do they occur in nature?
9. List the different uses of starch in food preparation.
10. Explain briefly the following:
    (a) Crystallization of sugar
    (b) Dextrinization
    (c) Gel formation
    (d) Syneresis
11. What are the different preparations in which cereals and millets are used?
12. List the different products of rice and wheat.
13. List the factors that affect gluten development in wheat.
14. What are the criteria of selection and purchase of cereals?

10

Protein Foods of Plant and Animal Origin

Proteins are the second group of the three major nutrients. Plants are the primary source of proteins as they synthesises protein by combining nitrogen and water from soil with the carbon dioxide from air. Animals eat plant proteins to meet their protein requirement.

Protein is found in every cell of our body. All the tissues in our body, such as those of muscles, blood, bone, skin and hair are made up of protein. Protein is essential to life. Mulder, a Dutch chemist, discovered this fact in 1838. He reported that all living plants and animals contain certain substances without which life is impossible. He called this substance *protein*, meaning "to take the first place". Later research has amply justified this name. There are hundreds of different kinds of proteins. For this reason the word protein implies not one, but a group of substances.

In the human dietary, both plant and animal foods provide proteins. Plant sources of protein include dals, pulses, nuts and oilseeds. Cereals and their products are supplementary sources of protein in India, as they are consumed in large quantities. Animal sources of protein include milk, egg, fish, poultry and meat. It may be observed that in India, protein in our diets is supplied mainly by plant foods. Dals and pulses are cheaper, easily purchased, have a longer storage life in contrast to the animal protein foods.

Animal protein foods entail a great expense at all stages of its purchase, preparation and storage. They are expensive foods and cannot be afforded by all. They have a much shorter storage life than dals or pulses and need refrigerated storage before and after preparation. Therefore, it is only natural that plant protein foods are consumed in greater amounts than any of the animal protein foods.

The recommended intakes of protein foods suggested by the Indian Council of Medical Research (I.C.M.R) for an adult are that the average consumption of dals and pulses be 50 g per day and that of milk 200 g per day.

Dals and Pulses

In most text-books, the word *pulses* has been used to mean dals. This is an incorrect usage of the word. In fact pulses are edible seeds of leguminous plants. Therefore, pulses and legumes refer to the same foods. The word *dal* has been used in this book to indicate decorticated, split products obtained from pulses.

The word legume is derived from the Latin word *legumen*, which meant any leguminous plant. Pulse is an alternate term for legume. The word pulse denotes edible seeds of leguminous plants. It is reported that legumes have been a part of human dietary for 8000 years or so.

Legumes belong to *Leguminosae* family, which is the largest family of seed plants. It has about 600 genera with 13000 species. Of these, only twenty species are widely cultivated in various parts of the world and form a part of human diet in appreciable amounts.

A list of twenty important pulses grown in tropics is given in Table 10.1. Thus, a choice can be made from a variety of peas and beans which are available.

Most of the pulses are used in three forms—the immature beans as vegetable, the whole dry bean or as split dal preparation.

TABLE 10.1 Important Tropical Pulses[1]

S. No.	Common name	English name	Hindi name	Botanical name	Yield (kg/ha)
1.	Tur	Pigeon pea	Arhar	Cajanus cajan	800–1500
2.	Masur	Lentil	Masur	Lens esculenta	600–1200
3.	Chana	Chick pea	Chana	Cicer arietinum	800–1200
4.	Mung	Green gram	Mung	Phaseolus aureus	300–600
5.	Urad	Black gram	Urd	Phaseolus mungo	200–700
6.	Chavli	Cowpea	Lobia	Vigna catjung	300–1000
7.	Matki	Hyacinth bean	Moth	Phas. Aconitifolius	500–1500
8.	Vatana	Pea	Matar	Pisum sativum	500–1500
9.	Rajma	Kidney bean	Rajmah	Phaseolus vulgaris	400–2500
10.	Kuleeth	Horse bean	Kulthi	Dolichos biflorus	500–2300
11.	Val	Field pea		Pisum arvense	400–1200
12.	Pavata	Field bean	Sem	Dolichos lablab	400–1200
13.	Lakh	Lathyrus pea	Kesaridal	Lathyrus sativus	
14.	Soyabean	Soybean	Bhatmas	Glycine max	1000–2000
15.	Limabean	Lima bean		Phaseolus lunatus	400–1500
16.	Locustbean	Locust bean		Parkia africana	
17.	Seeng Dana	Ground nut	Moongphali	Arachis hypogaea	1500–2000
18.	Methi	Fenugreek	Methi	Trigonella foenum Graecum	
19.	Til	Gingelly seeds	Til	Sesamum indicum	
20.	Kala til	Niger seeds	Kala til	Guizotia abyssinica	

1. Aykroyd W R & Joyce Doughty, *Legumes in Human Nutrition*, p 15, FAO, Rome, 1964

Nutritive Value

Pulses are dry seeds and contain only 8 to 11 per cent moisture.

The pulses are normally used after removal of the seed coat. The decorticated pulse is known as *dal*, in Hindi as well as Marathi and Gujarati. The most commonly used dal is *Tur* or *arhar dal*. The other dals used in Indian dietary are *mung, masur, chana dal* and *Urad dal*. The dals and pulses provide 18 to 24 per cent *proteins*. Please refer to the composition of *dals* and pulses in Table 10.2.

Thus, each ten grammes of *dal* supplies a little more than two grammes of protein, while the calorie content of dals in same as cereals, which is about 35 per 10 grammes. The high protein content and the ease with which these can be purchased and stored, make these an important source of protein in our diet. The value of a protein in the diet depends upon its essential amino acid content, as mentioned earlier in chapter three. In our dietary, cereals are eaten with a pulse preparation *e.g., rice–dal, rice–sambar, chapati–usal* etc. Some one-dish meals and snacks are made by combining cereals and dals *e.g., khichadi*, *bisibeliehulianna*, *pongal* etc.

Other Nutrients Dals and pulses are a rich source of iron. The iron content varies from 5 to 12 mg per cent. Groundnuts have a low iron content of only 2 mg per cent.

Dals and pulses have between 55 to 200 mg of calcium per cent. Sesame has an unusually high content of calcium of 1450 mg per cent.

Dals and pulses are a rich source of vitamins of the B-complex group. Thiamin content is fairly high, from 0.5 to 1.0 mg per cent, while riboflavin is low and varies from 0.1 to 0.3 mg per cent; niacin content is in the region of 2.0 mg per cent.

When pulses are germinated, there is an increase in the concentration of *B* group of vitamins. In addition, vitamin *C* is also produced in the process of germination of pulses.

Buying and Care

There are many varieties of pulses and legumes available in the market.

Dal, which we use daily include:

English	Marathi
1. Red gram dal	Tur dal
2. Green gram dal	Mung dal
3. Black gram dal	Udid dal
4. Bengal gram dal	Chana dal
5. Lentil dal	Masur dal

Commonly used pulses are:

English	Marathi
1. Green gram	Mung, Moog
2. Cow pea	Chawli
3. Moth bean	Matki
4. Bengal gram	Chane, harbhara
5. Peas	Vatana
6. Lentil	Masur
7. Horse gram	Kulith/hulge
8. Chick peas	Kabuli chane
9. Rajmah	Rajma
10. Field bean	Val

Dals and pulses are selected on the basis of their appearance, colour and variety. The grains are inspected for uniform size, cleanliness, soundness of grain, absence of broken pieces, freedom from insect infestation, absence of admixture with foreign seeds and trash, dirt, mud, stones and sand.

TABLE 10.2 Composition of Dals and Pulses (per 100 g E.P.[1])

Dal/Pulse	Moisture (g)	Energy (Kcal)	Proteins (g)	Fat (g)	Calcium (mg)	Iron (mg)	Thiamin (mg)	Riboflavin (mg)	Niacin (mg)
Dal									
1. Red Gram dal	13	340	22	2	73	6	0.5	0.2	3
2. Green Gram dal	10	350	25	1	75	9	0.7	0.2	2
3. Black Gram dal	11	350	24	1	154	9	0.4	0.4	2
4. Bengal Gram dal	10	370	21	6	56	9	0.5	0.2.	2
5. Lentil dal	12	340	25	1	69	5	0.5	0.2	3
6. Kesari dal	10	350	28	1	90	6	0.4	0.2	3
Pulses									
1. Green Gram	10	330	24	1	124	7	0.5	0.4	2
2. Cow pea	13	320	24	1	77	6	0.5	0.2	1
3. Moth bean	11	330	24	1	202	10	0.5	0.1	2
4. Bengal gram	10	360	17	5	202	10	0.3	0.2	3
5. Pea	16	320	20	1	75	5	0.5	0.2	3
6. Horse Gram	12	320	22	0.5	287	8	0.4	0.2	2
7. Rajma	12	350	23	1	260	6	—	—	—
8. Field bean	10	350	25	1	60	3	0.5	0.2	2

1. E.P.: Edible portion.

The grain can be chewed to detect the texture and flavour. Hollow, soft texture indicates deterioration in quality. Sour or rancid flavour and odour indicate spoilage during storage. Nuts and oilseeds must be free from any absorbed or rancid odour and flavour.

The dals, which contain broken grains cost less. These can be used in preparations, in which dals are used after grinding (wet or dry) such as *vadas, idli, dhokla, pakodas* etc.

Dals and pulses are cleaned after purchase to remove stones, sand and any other foreign matter and washed to remove any dust and dirt present. Then these are dried in the sun. After drying, these are allowed to cool before being put in clean, dry containers for storage.

Preparation of Dals and Pulses

Most of the dals and pulses may undergo some treatment before preparation. These treatments help to reduce cooking time and improve digestibility. Soaking, germinating (sprouting), decortication, grinding to paste or a powder, roasting are some of the treatments used in pulse processing.

Methods of Preparation

Dals and pulses are cooked by boiling in water or by steaming with or without pressure. The proportion of water added 2 to dal is 2:1. Soaking before cooking reduces the cooking time. Dals need only half an hour, while pulses need one hour or more depending on the size of the grain. It takes about 25 minutes to half an hour to cook dals and pulses in a simple cooker. In pressure cooker, it takes four to five minutes cooking time after the pressure is attained.

Roasting whole beans prior to cooking reduces the time needed to cook these to doneness. The texture of pressure cooked beans is soft and tender.

It is not advisable to add soda to pulses while cooking, as its alkaline pH accelerates the destruction of thiamin, a B-complex vitamin.

The cooked dal or pulse is seasoned with salt, oil and spices.

A number of preparations of dals and pulses are made by frying. The products prepared by frying include *dal-muth, bhajias, vadas* etc.

Addition of salt, and acid substances such as tomatoes, tamarind or *cocum* extract prior to cooking hardens the grain. Therefore, these ingredients must be added after the dal or pulse is cooked.

Dals tend to foam while cooking. Addition of a few drops of oil (helps to reduce the surface tension) prevents formation of foam and the dal does not boil over.

Soaking—Water is used to soak dals and pulses. In winter, warm water is used to facilitate soaking. The pulses absorb water and increase in size during soaking. As the mucilagenous layer between seed coat and the grain is dissolved in water, the seed coat can be easily removed after soaking. The soaked decorticated beans need shorter time for cooking or processing than the dry beans.

Germination of Pulses

This is a process used prior to cooking, in which the whole beans are soaked for about 6–8 hours. When the beans have absorbed water (and almost doubled in size), the excess water is drained and beans are wrapped in a wet muslin cloth or placed in basket and covered and allowed to germinate for 12 hours or more as desired. In dry weather, it is necessary to keep the beans moist by sprinkling water periodically. When the beans have sprouted sufficiently these are cooked and seasoned as desired. The most popular preparation made from germinated beans is *usal* or *shundal*. As mentioned earlier, vitamin C is produced in the process of germination of pulses. Therefore, these should be cooked to doneness in minimum amount of water to retain the vitamin C. Germination of pulses has to be controlled to prevent excessive sprouting.

If beans are germinated for a prolonged period, it leads to the development of undesirable taste and flavour, further, such beans take longer time to cook than those sprouted to the right degree.

Decortication The removal of the fibrous seed coat is known as decortication. It can be done at home. But most of the dals, which are decorticated pulses, are available commercially. The germ of the bean is removed in this process. Therefore, the nutrients (such as thiamin), which are present in the germ are lost in the process of decortication. However, this process reduces the cooking time. The digestibility is also enhanced by this process.

Grinding Dals are ground to a dry flour or wet ground to a paste prior to use. The flour is used as a coating in preparation of fried savoury preparation such as *bhajia*, *batavatada* etc. It is used as a thickener in soups (*kadhi, amti*). In leafy vegetables, it is used to bind the water released during cooking. The ground paste is fried as *vadas* (*medu vada, dahi vada*), after addition of salt and spices.

The size of particles is reduced in grinding and hence the cooking time is reduced considerably. For example, *zunka* or *pithale,* a favourite preparation of Maharashtrians (made from *chana dal* flour) takes only five minutes to cook, whereas dals take half an hour to cook.

Fermentation Occurs in certain doughs due to the presence of yeasts in the flour, which act on the starch to produce first glucose, then alcohol, lactic acid and carbon dioxide. This is by far the most common type of anaerobic respiration occurring in food products. It is known as **fermentation**.

Partial fermentation of starch occurs in doughs which after grinding or mixing with water are left overnight to ferment. This includes wet-ground rice and dal mixtures left overnight and used to prepare *idli, dosai, uttappa* etc. The carbon dioxide released in the fermentation leavens the dough and produces a fluffy texture when steamed (*idli*) or fried (*dosai*).

The same basic principle is used to prepare bread. The yeast added brings about a partial fermentation. When the dough is baked, the carbon dioxide released on fermentation produces the desired spongy and velvety structure.

In milk, the lactics added in the form of curd or pure cultures act on the lactose and produce lactic acid and carbon dioxide. A partial fermentation of lactose in milk occurs in preparation of curd and production of cheese. In all the milk products, the proteins get coagulated by the action of

lactics, bind the water and thus we get solid curds from liquid milk. In cheese making, the coagulated mass is squeezed and the water is drained off as whey.

Roasting It is a common practice to roast dry beans prior to cooking these. Roasting imparts a special flavour to the product and also reduces the cooking time. Thus, moderate application of heat prior to cooking is beneficial. Green gram, *chawli*, *wal* and lentils are some of the pulses, which are roasted before cooking.

Roasted pulses such as *chana* and *seeng dana*, are a favourite snack in India. The process used to prepare these varies with the pulse used. For example, groundnuts and others which have high fat content are roasted directly, as the presence of fat helps to produce desirable texture in the process of roasting.

The pulses such as chana are soaked and partially dried prior to roasting. The step helps to produce the fluffy open texture, which we associate with roasted pulses.

Toxic substances in Dals and Pulses

Some toxic substances are naturally present in some pulses. These include trypsin inhibitors and haemagglutinins. Trypsin inhibitor, as the name indicates, interferes with digestion of proteins by inhibiting the action of the enzyme trypsin. Haemagglutinins combine with haeme and thus destroy haemoglobin.

Fortunately, for us both of these toxic substances are destroyed by heat, which is used in normal cooking process.

Broad beans contain some toxic substance. When these beans are consumed raw a disease called *favism* occurs. This disease is characterized by haemolytic anemia. Since human beings do not consume broad beans raw, they are not likely to suffer from favism.

Kesari dal contains a toxic substance. This dal is usually grown in Madhya Pradesh (M.P). It was observed that during draught conditions, only this bean was grown, when other crops failed. Therefore, kesari dal is used as a staple food during the drought period. When this dal is consumed over a long time, paralysis of lower limbs occurs in males. This is known as *lathyrism*.

It is reported that when the intake of keasari dal is restricted to 30 per cent of the total calorie intake, no adverse effects are observed. Therefore, it is important to ensure that the intake of this dal must be restricted to a maximum of 30 per cent of total calorie intake.

Nuts and Oil Seeds

Nuts and oil seeds are one of the important sources of plant proteins in our diets. Some of the commonly used nuts and oil seeds in India are groundnuts, coconuts, dry and fresh cashew-nuts, gingelly seeds, mustard seeds, almonds, walnuts, pistachios etc.

Nuts are used as whole roasted nuts or as crushed roasted nuts. Nuts (groundnuts, coconut) and oilseeds (gingelly) are used to prepare *chikki*, which contains jaggery, sucrose or glucose as

sweetener. Nuts and oilseeds are used in bakery products, in *halvas*, *mithai* and desserts (*shreekhand, basundi, payasam* etc.). Powdered mustard seeds are used in pickles.

Nuts and oilseeds are used as garnishes in many food preparations. Groundnuts and coconut are added as a salad dressings. Some oilseeds are added as a salad dressing. Some oilseeds e.g., gingelly, are powdered, while others are crushed lightly; and used in various preparations like curries. They impart a delectable flavour to the product. Crushed oilseeds may also thicken the product. Oilseeds and nuts (groundnuts, gingelly and coconuts) are mainly used for the extraction of oil.

Groundnuts These are also known as peanuts. They are grown underground and this may account for the name groundnuts. Groundnuts belong to the legume family. The pods contain 2 to 4 nuts each. There are two varieties, white and red. Groundnuts contain 26 per cent protein, 41 per cent fat, 0.9 mg per cent thiamin. Groundnuts are an exceptionally good source of niacin. The niacin content varies from 14 to 25 mg per cent. It is a common practice to roast and crush to powder these nuts for use in various preparations. Groundnuts are sold as roasted nuts in the pod, roasted after soaking in salt water and nuts fried after dipping in spiced chana dal flour mix.

Groundnuts are used for the extraction of oil. Groundnut oil is used as a cooking medium, as a seasoning and for many other preparations. The residue (from which oil has been extracted) can be useful, as it is a high protein powder (groundnut cake). This cake is fortified with cetain nutrients and addition of Bengal gram flour. This is called Multi Purpose Food (MPF).

It is important to buy nuts and oilseeds which are free from dirt and rancid flavour. After purchase, it is necessary to store these in dry, airtight containers.

In 1960–61, groundnut meals containing the mould *Aspergillus flavus*, was found to have the toxin **aflatoxin** in it. If groundnuts are stored with a high moisture content, that is above 15 per cent, the black mould (*Aspergillus flavus*) present in the nuts produces the toxin, aflatoxin. Therefore, it is important to dry the groundnuts promptly after harvest to a moisture content of 10 per cent or less and ensure that the nuts do not absorb moisture during storage.

Groundnut as such can be used in cooking in many ways. Tender ones can be consumed as they are. Immature groundnuts can be used in salads or vegetable preparations. Mature groundnuts are used for making various savoury and sweet preparations like—*chikki*, groundnut *ladus*, savoury groundnut, curries, *usal*, groundnut cookies etc.

Coconut Both dry and fresh forms of coconuts are available.

Fresh Coconut Tender coconuts have plenty of sweet water which makes a nourishing drink. The flesh in tender coconut is very tasty and is eaten as it is. Mature coconuts are used in various preparations. The mature nut is cut in the centre to give two halves. The coconut is scraped and used in curries, vegetables, chutneys etc. Coconut milk is extracted from scraped coconut and is used in a number of sweet and savoury preparations. Coconut milk is sensitive to high temperatures. Therefore, low temperatures should be used to prepare delicacies using coconut milk. Alternatively, coconut milk could be added at the end of the cooking period. The milk gets separated when refrigerated. Therefore, it should be consumed directly or soon after preparation.

Dry Coconut The hard coconut shell is removed and the mature coconut is sun dried. The dry coconut can then be stored and used throughout the year. The coconuts are grated and used in various preparations. The keeping quality of dry coconuts is greater than that of the fresh coconuts, as a nut and as a part of the prepared product. However, dry coconuts lack the characteristic delicate flavour of fresh coconuts. The dry coconut is usually roasted lightly and used in preparations such as chutney powders as an ingredient in dry masalas, and in sweets (chikki, biscuits etc.).

Gingelly Seeds Two varieties are available—black and white. The white seeds are widely used. Use of the black seeds is restricted. Very few food preparations require black gingelly seeds.

Oil seeds and the oil extracted from them are used in food preparation. Gingelly seeds are used in curries and gravies as thickening agents: Chutneys and powders are made out of gingelly seeds. This serves as a base for some masalas.

Gingelly seeds give us 18 per cent proteins, 43 per cent fat. It is a very rich source of calcium. Gingelly seeds are a fair source of iron, thiamin and niacin.

Pumpkin Seeds, Cashew nut, Walnuts, Almonds, Pistachios

These nuts are usually used as garnishes. These nuts are quite expensive and hence they are used occasionally for their rich flavour and colour. The nuts are roasted, and used whole, as chopped nuts or used after grinding.

Gardencress Seeds These seeds contain 25 per cent protein, and are a rich source of iron and calcium. These seeds are used to prepare very nourishing preparations such as *ladus* and porridge for nursing mothers, as it is a galactogogue.

Poppy Seeds (***Khaskhas***) are small white, seeds. Their most common use is in gravies as thickening agents. These seeds contain 21 per cent protein and are a very rich source of calcium. Their use is restricted to certain preparations for nursing mothers such as poppy seed *ladus*, *porridge*, *vadis* etc.

Buying and Care of Nuts and Oil Seeds

Clean nuts and oilseeds should be selected, so that these are free from dirt, foreign matter and stones. Choose nuts, which are evenly coloured as unnatural spots on nuts is a sign of deterioration.

Nuts and oilseeds have a high oil content and can turn rancid if stored over long periods.

Nuts and oilseeds should be destoned and made free from foreign matter. Nuts and oil seeds should be consumed within reasonable time as they turn rancid easily. All the nuts and oil seeds, if sun dried before storage, keep well.

Milk and Milk Products

Milk has a very special place in the Indian dietary. It is an essential part of our morning's cup of tea or coffee. Curd and butter milk are made from milk. Milk is also used to make popular sweets such as *pedhas*, *barfi* and a variety of *halwas*. A number of desserts from milk made for special feasts

include *kheer*, *shreekhand*, *rasgullas*, *gulab jamuns* etc. In fact we in India, may boast of having the largest number of preparations made out of milk. Therefore, its important for us to understand the composition and nutritive value of milk.

Composition of Milk

Milk from different animals is used as food, but in India, buffalo and cow are the two species which are most important for the commercial production of milk and milk products.

Milk is a complex food, which contains more than 100 components. Most of these components are suspended in water and thus milk is a colloidal solution and is opaque. The composition of milk and milk products is given in Table 10.3 in which besides water, only eight nutrients are included.

The major components of milk are water, protein, fat, the sugar lactose and minerals. The composition of milk varies with species. It may be observed from Table 10.3 that buffalo's milk contain twice as much fat as cow's milk.

TABLE 10.3 Composition of Milk and Milk Products (per 100 g)

	Moisture (g)	Calorie	Protein (g)	Fat (g)	Lactose (g)	Ca[1] (mg)	Fe[2] (mg)	Vit. A (mcg)	Thiamin (mg)	Riboflavin (mg)
Cow's milk	88	67	3.2	4	5.0	120	0.2	57	0.05	0.19
Buffalo's milk	81	117	4.3	9	5.0	210	0.2	53	0.04	0.10
Human milk	88	65	1.1	3	7.4	28	—	137	0.02	0.02
Curd	89	60	3.1	4	3	150	0.2	34	0.05	0.16
Butter milk	98	30	0.8	1	4	30	0.8	0	—	—
Butter	19	730	—	81	—	—	—	317	—	—
Ghee, Buffalo's	0	900	—	100	—	—	—	89	—	—
Ghee, Cow's	0	900	—	100	—	—	—	198	—	—
Channa, paneer	54	265	18.3	21	—	208	—	121	0.07	0.02
Cheese	40	348	24.1	25	6.3	790	2.1	—	—	—
Khoa	31	421	14.6	31	—	650	5.8	—	—	—
SMP (Skimmed milk powder)	4	357	38	0.1	—	1370	1.4	0	0.45	1.64
WMP (Whole milk powder)	4	496	26	27	—	950	0.6	462	0.31	1.36

1. Ca – Calcium
2. Fe – Iron

The main proteins in milk are *casein* and *lactalbumin*. Casein, which accounts for 87 per cent of the total proteins present is a *phosphoprotein*. The reactions of these proteins are important in milk preparations.

Milk fat contains some volatile fatty acids (e.g., caproic and butyric acid). These are released when butter turns rancid. Their presence is noticeable in rancid butter due to their bad smell.

Lactose is the sugar present in milk. It is present in the milk serum. Milk is an excellent source of the minerals calcium and phosphorus. The minerals in milk are present partly in solution, partly in suspension and some as components of proteins and fats. For example, most of the phosphorus is suspended in the form of calcium phosphate, but a little is combined with casein and another trace is found in combination with the fat.

Milk contains all the vitamins known to be beneficial to human nutrition.

Nutritive Value

The composition of milk from various species of mammals differs markedly (Table 10.3). The milk of each species is designed to fulfill the needs of the young of that species.

It may be noted that human milk has the highest lactose content and lower protein, fat and mineral contents than those in cow's and buffalo's milk. The high fat content of buffalo milk is reflected in the higher calorific value. These differences need to be taken into account when milk formulae are prepared for human babies using milk from other species.

In India, buffalo's and cow's milk accounts for 96 per cent of the total production of milk. Therefore, the discussion will be restricted to these only.

Milk contains proteins of high biological value, which can support life through the first critical six months. Milk proteins contain certain essential amino acids, which supplements those of proteins from cereals. Milk proteins are easily digested to the extent of 97–98 per cent.

Milk fat is in an emulsified form and hence is readily utilised in the body. It is liquid at body temperature, therefore, it is digested quickly.

Lactose, the only sugar in milk contains galactose, which is essential for brain development Lactose is the least fermentable sugar. Lactic acid is formed on fermentation of lactose. Lactic acid formed, provides acidity in the intestinal tract, which facilitates absorption of calcium and phosphorus. It provides a substrate for lactic acid bacteria, and tends to supress putrefactive bacteria in the intestine.

Milk is an excellent source of calcium and phosphorus. Thus, in presence of vitamin D in the milk, these minerals can be readily used for bone development.

Milk contains very little iron. Therefore, infants need supplements of iron rich foods by the fifth month, when the prenatal store of iron is used up.

All vitamins known to be essential for human nutrition are present in milk. Milk is an excellent source of riboflavin, a vitamin of the B-complex group. It is low in niacin, but a good source of tryptophan, an amino acid, which acts as a precursor of niacin.

Milk contains only about 2 mg ascorbic acid per 100 g. As milk is used only after boiling in India, part of the vitamin C is destroyed. Therefore, milk-fed babies need supplements of foods containing ascorbic acid.

Milk is a fair source of vitamin A, as it contains both the vitamin and its precursor, beta carotene. The vitamin content varies with the feed of the animal. All processed milk products from which fat is removed, contain very little vitamin A e.g., skimmed milk powder.

Processing of Milk Milk may be given various treatments like heating, concentrating, drying or altering its pH to obtain a number of different products. The objective of such treatments is to preserve milk and add variety to our meals. This is done by:

(i) exposing milk to high temperatures at which microorganisms are killed,
(ii) binding or reducing the water present in milk and thus making moisture unavailable to micro-organisms,
(iii) by increasing the acidity of milk to a level that does not permit growth of spoilage microorganisms, and yet imparts a desirable sour flavour to the product.

Some of the processing methods employed and the common milk products available are discussed below.

Pasteurization of milk is a process which consists of heating milk to a certain temperature, for a definite time to ensure destruction of pathogenic bacteria, which are likely to be present.

There are three methods used to pasteurize milk.

Holding Method Milk is heated to 62.7°C and held at that temperature for 30 minutes.

Higher Temperature Short Time Method (HTST)—Milk is heated to 71.6°C at least for 15 seconds.

Ultra High Temperature Process Milk is heated to a temperature of 89–90°C or more for 1 second or less.

In all three processes, milk is immediately cooled to 10°C or lower and held at that temperature. Since cold storage facilities are not commonly available in most homes, milk is routinely boiled prior to use in India, which results in improving the shelf-life of milk. Therefore, pasteurization does not have the same significance here from the health point of view as in the western countries.

The purpose of pasteurization in India is to increase the keeping quality so that the additional time required to deliver it from the plant to the various parts of large cities does not result in its spoilage. Even then, the consumer boils the milk when received to ensure its keeping quality for a day.

The constituents of milk are not altered to any great extent, during pasteurization, since the temperatures used are not very high. If pasteurization is well controlled, the cream layer is not much affected.

Concentrated Milks These include *khoa*, evaporated milk, sweetened condensed milk and dried milk made from both whole and skimmed milk. Varying amounts of water are removed to make the concentrated milk products. These products have a longer shelf-life and some can be reconstituted to their original form.

When milk is heated to concentrate it by evaporating part of the moisture, colour of the milk changes to light brown. There is a change in aroma and flavour also. Milk is concentrated for preparing *basundi*, *rasamalai* etc.

Evaporated Milk is made by evaporating more than half the water from milk under vacuum. It is necessary to fore-warm milk 10 minutes to prevent coagulation of casein during sterilization after it is canned. Colour and flavour are best preserved if sterilization is carried out at high temperature for a short time.

Condensed Milk is concentrated to about 1/3 of its original volume and has about 15 per cent sugar added to the milk. Since the finished product contains at least 40 per cent of sugar, which acts as a preservative, it is not necessary to sterilize it before canning. Indian standards require 31 per cent total milk solids and 9 per cent fat in sweetened condensed milk.

Homogenization Homogenization is carried out by forcing milk through small openings under high pressure. Homogenization reduces the size of fat globules in milk and thus prevents their separation. This treatment increases the stability of the emulsion, as the cream does not separate on standing.

Dehydrated Milk Products include whole milk powder, skimmed milk powder, infant milk foods and malted milk.

Dried milk products are manufactured by two methods.

(i) Roller or drum drying in which the milk is sprayed on the surface of the heated metal cylinders in vacuum.
(ii) and spray drying in which the partially evaporated milk is sprayed into a chamber of heated air.

Indian Standards require that the moisture content of the dried milk be less than 4 per cent. Therefore, dehydrated milk is a concentrated source of protein, calcium and riboflavin and other nutrients.

Skimmed Milk Powder In production of skimmed milk powder, the milk fat is removed or skimmed from the milk, before the milk is dehydrated to a moisture content less than 4 per cent. It has therefore lower energy value, higher protein, calcium and riboflavin content as compared to dried whole milk and is devoid of vitamin A. The Indian Standards require that dried skimmed milk must contain less than 0.5 per cent fat and 96.5 per cent total solids.

Uses of Milk Powder When fresh milk or curd is unavailable, milk or curds can be prepared from milk powder. It is also used in various biscuit, chocolates, halwas, gulab jamuns. Milk powder is very handy and can be used in the place of milk during emergency.

Infant Milk Foods are fortified[1] with varying amount of certain nutrients, such as iron, vitamin C and vitamin D.

1. Fortification consists of addition of certain nutrients to the food to improve its nutritional value.

Malted Milk is made by combining the liquor of a mash, made up of ground barley and wheat flour with whole milk and drying the moisture; some of the malted milks are flavoured with chocolate. These are used to prepare beverages.

Khoa is made from milk by concentrating it in a broad, open pan till the desired consistency is reached. About 2/3 to 3/4 of the water is removed. It has a shelf-life of about *two to four days*; depending upon the atmospheric temperature. It can be preserved for a longer period if sugar is added, or if it is stored at low temperature. It is not produced on a commercial scale. It is mainly prepared to utilize unsold milk in the shops vending milk. These shops make milk candies, such as *pedhas*, *barfis* and *gulab jamun* from *khoa*. All the nutrients in milk are present in *khoa* in a concentrated form. Only a fraction of the thiamin which is heat labile may be lost due to the heating process.

Care of Milk in the Home

Fresh clean milk has a delicious rich taste. It is important to ensure that the taste of milk is retained during production and storage. It is very necessary to receive and store milk in a clean container in the home. Raw milk sours on storage due to the action of lactic acid producing bacteria, especially in summer months, when the atmospheric temperature is high. Milk should therefore be boiled as soon as it is received in the home to prevent spoilage. Further, it should be covered and stored in a cool place. If there is a refrigerator in the house, milk should be stored in the refrigerator after boiling and cooling. Never mix stale milk with a fresh lot of milk, as it hastens spoilage. In the refrigerator, milk must be stored covered and kept away from strong smelling foods, such as cut onion or other foods, as it absorbs their strong flavour.

Effect of Heat on Milk

In India, milk is boiled prior to use. A number of changes occur in the milk due to heat, the extent of changes depend on the temperature and period of heating. The changes affect the colour, flavour and viscosity of milk.

Colour changes occur when milk is heated. A light brown tinge develops when milk is concentrated by heat. The brown colour is due to the reaction of milk protein with reducing sugars such as lactose, glucose and fructose. A change of aroma and flavour accompanies the colour change. This change is very much liked by Indians.

The dispersion of calcium phosphate in milk decreases, when milk is heated and a part of it is precipitated at the bottom along with the coagulated lactalbumin. Volatile elements such as iodine, tend to be lost when milk is heated.

Scum Formation

Scum forms when milk is heated. As the temperature of heating increases, a scum forms at the top, which can be removed. But as soon as it is removed, another layer of scum forms. The milk boils over due to the scum formed. The scum is a tough, leathery, insoluble layer. The scum is forced

upwards due to the pressure built up under it and the milk flows out of the pan under this pressure. The tendency to boil over is increased when the pan is covered during heating of milk. Scum consists of a mesh of coagulated albumin, mineral salts such as calcium phosphate and fat globules.

It is necessary to prevent scum formation in preparation of milk recipes. This is achieved by agitating or stirring with a rotary motion during heating of milk. Use of a milk cooker to boil milk, prevents loss of milk due to boiling over.

When milk is heated, it scorches due to the film of coagulated albumin, which collects at the bottom of the pan. This is prevented by heating milk in a double boiler or a milk cooker.

The film of protein, which surrounds the fat globules, breaks on heating and the fat rises to the top. This is cream or *malai*, which can be removed if we wish to reduce the calorie content of milk.

Coagulation of Milk It was mentioned in chapter 2 that coagulation of proteins occurs between 65–90°C. Lactalbumin, a milk protein, begins to coagulate at about 66°C. This is evident from the coagulum that coats the utensil, when milk is heated. The coagulum is flocculent and hence results in the thickening of milk, which is heated for long time. Thus, there is an increase in viscosity of milk. Casein, the major protein of milk is not coagulated by heat *alone*. When the concentration of casein increases due to evaporation of water, the time required to precipitate it decreases. It takes a combination of factors such as heat and acidity to coagulate casein.

Influence of Acids and Salts Milk, which appears normal, and is not acid enough to taste at room temperature may curdle when heated. It is known that increase in acidity hastens the coagulation of milk protein by heat. A very good example of this phenomenon is the preparation of *paneer*, where acid and heat are used to coagulate milk. As you are aware *paneer* is prepared by adding lemon juice to boiling milk.

Addition of acid foods, like tomatoes to milk in cooking, may curdle it. The coagulation of milk proteins by heat is affected by the kind and amount of salts present.

In certain preparations, such as cream soups, it is necessary to prevent the curdling of milk, to get an acceptable product.

Curds (Yoghurt) Curds is a very popular milk product in India. It ranks second to milk in the extent of consumption.

Milk is boiled and cooled to about 50°C and a teaspoon of curd from an earlier batch of curd is added and mixed thoroughly. The lactic acid bacteria present in this sample of curd curdle the milk. They utilize the lactose in milk and break it down to lactic acid. The formation of lactic acid increases the acidity of milk. When the pH reaches 4.6, the milk protein, casein, coagulates as curd. Since the process is gradual, the milk serum is bound in the mass of coagulated proteins.

The optimum temperature for the formation of curd is 35–40°C. The time needed for curd formation varies from 8–12 hours depending on atmospheric temperature. Once made, curd keeps well at refrigerator temperature of 2–3 days. It is used as dressing on salads made from fresh vegetables. It combines well with plain cooked rice (Fig. 10.1).

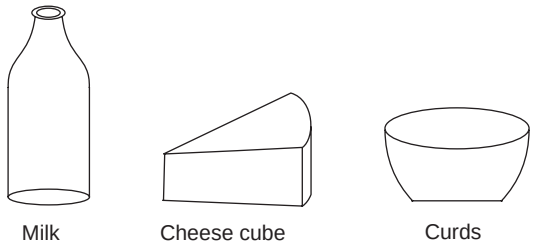


Fig. 10.1 Milk and Milk Products

Preparation of curd is one method of prolonging the shelf-life of milk by several days. Soured milk does not readily undergo proteolysis and other undesirable changes. Curds can be held at refrigerator temperature for several days without loss of acceptability. It is reported that the riboflavin and thiamin content increases during curd formation. It is also reported that fermented milk inhibits the growth of *Bacillus typhosus, Bacillus dysenteriae*, and *Vibrio cholerae* to a certain extent.

Paneer is prepared by addition of lemon juice or citric acid to hot milk and precipitating the casein. The liquid released in this process is known as *whey*, which contains most of the soluble nutrients from milk. Paneer contains about 18 per cent protein and is a good source of it.

Cheese The milk is subjected to several process steps to produce cheese. The milk it held at about 27°C in vats and a lactic acid culture is added. When the milk gets acidic, rennet is added to it and the milk is allowed to coagulate. The curd formed is cut into strips and heated to about 37°C with stirring to separate the whey. The whey is drained. Salt is mixed with the curd and it is pressed to remove further amounts of whey. The cheese formed is coated with paraffin to prevent loss of moisture and allowed to ripen at low temperature.

Cheese contain about 24 per cent protein and is thus a concentrated source of protein.

Buttermilk Buttermilk is made by adding water to curd and churning to remove fat in the form of butter. The energy value is thus reduced due to fat removal. The concentration of the other nutrients is reduced in proportion to the dilution.

It is known to re-establish intestinal flora after an attack of diarrhoea.

Chakka Curd is tied up in a muslin cloth. All the water is allowed to drain out by hanging it from a hook for about 4–6 hours. The solid mass that remains in the muslin cloth is known as *chakka*. It is used for making *shreekhand*.

Eggs

Eggs are a good and an important source of protein in the human diet. Eggs of all birds may be eaten, but in India, eggs of hen and duck are mainly utilised for human consumption.

Structure

The egg is composed of the shell, the white, and the yellow or *yolk*. The egg shell is covered with a protective coating, which helps in maintaining the freshness of the egg, as it covers the innumerable minute holes in the shell. If this layer is removed, the egg spoils, due to entry of micro-organisms, which hasten the deterioration of quality.

Inside the shell, there are two membranes—the outer and the inner membrane. The egg white is made up of three layers, two are thin and hold the thick layer between them. The yolk is encased in the vitelline membrane and held in the centre of egg white by means of two cord-like structures, which are called the *chalazae*. The yolk is made up of alternate layers of white and yellow (Fig. 10.2).

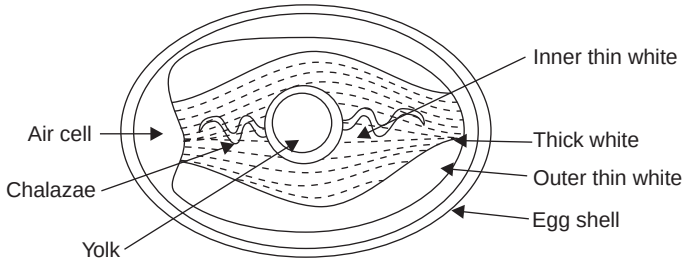


Fig. 10.2 Structure of an Egg

Composition

In a day old egg, shell accounts for 11 per cent, the egg white for 58 per cent and the yolk for 31 per cent of the total weight of the egg.

TABLE 10.4 Average Composition of an Egg[1]

Egg	Moisture (g)	Protein (g)	Fat (g)	Minerals (g)	Calories
		(per 100 g …)			
Hen	73.4	13.3	13.3	1.0	173
Duck	71.0	13.5	13.7	1.0	181

As can be observed from Table 10.4, the edible portion of egg contains about 71–73 per cent water, about 13 per cent protein, about 13 to 14 per cent fat and 1 per cent mineral matter.

1. I.C.M.R: *Nutritive Value of Indian Foods*, 1991.

The egg white contains a large percentage (88 per cent) of water, protein (10 per cent) and some mineral matter (1 per cent). In contrast, the percentage of water is much reduced (49.0 per cent) in the yolk and it contains a large percentage of fat (32.0 per cent) and protein (16.7 per cent), and some mineral matter (2.0 per cent).

Nutritive Value

Eggs are a good source of protein of high biological value. One egg contains about 5 to 6 grams of protein, 1 mg of iron, about 1000 I.U. of vitamin A and appreciable amounts of thiamin, riboflavin, and certain other vitamins of the B-complex group.

Grading

Eggs can be graded on the basis of size and quality factors. The size is easily determined by means of weighing. The eggs produced in modern farms or poultry development units of various states, are sorted according to size. The various sizes are designated by letters to indicate variations in size. But the codes used vary from one production unit to another. The sizes on the basis of weight are as follows:

Extra large	60 gms or more
Large	55 to 60 gms
Medium	45 to 54 gms
Small	35 to 44 gm

Some farms only indicate by a stamp that the eggs are graded but use no mark to indicate size.

Buying and Care

It is important to buy fresh eggs of high quality.

The quality can be judged by considering

(i) shell condition,
(ii) size or aircell,
(iii) position of yolk,
(iv) condition of white,
(v) defects, if any, such as blood spots etc.

A clean egg with unbroken shell is considered to be of good quality. The protective mucin layer called 'bloom' must be intact, so that entry of microorganisms, which may cause undesirable changes is avoided.

A fresh egg has a small air cell (less than 0.3 cm), which can be observed by holding it against light or a candle. The yolk is in the centre.

Eggs are sorted according to size. Large eggs are bought for table use. When eggs are bought for use in preparation, size is not important and selection is made in terms of price in relation to size. It is advisable to purchase fresh, clean and unbroken eggs.

Storage

The egg starts deteriorating soon after it is laid. Therefore eggs should be refrigerated promptly after they are collected. While purchasing, it is advisable to buy eggs from stores, which have refrigerated storage. Flavour and quality changes occur rapidly if eggs are held at room temperature, but very slowly at refrigeration temperature. Normally refrigerators have a built-in rack on the inside of the door to store eggs.

The air cell in a good quality egg is less than 0.3 cm deep. The yolk is in the center. When the egg is broken, the condition of yolk and white can be observed. The yolk is firm and stands up in the centre of white, which is viscous. The egg white forms a definite ring around the yolk and the thick white holds its shape. No blood spots are present and there is no bad odour. The quality of eggs is very important from the culinary and acceptability points of view.

The deterioration of egg starts as soon as it is laid. Factors, which affect quality of eggs include age, the atmosphere and the temperature of storage, relative humidity and any pre-treatment given prior to storage.

Two undesirable changes occur in stored egg—increase of alkalinity in egg white and bacterial growth.

Coating of Shells Coating of shells is one way to decrease the speed of deterioration. Coating prevents entry of microorganisms and prevents spoilage. Mineral oil is widely used for coating the egg shells. The oil-bath is maintained at 110°F, the eggs are dipped for a few seconds, drained, packed and refrigerated.

Low Temperature Storage Low temperature storage is quite effective in increasing the shelf-life (storage time) of eggs. Humidity and air currents need to be controlled during cold storage. The lower the temperature of storage, the longer the shelf-life of eggs. The loss of carbon dioxide from eggs can be prevented by maintaining a definite concentration of carbon dioxide in the storage room. Optimum temperature for long-term storage is between 29 and 31°F. It is possible to store eggs upto six months, when storage conditions are optimal.

Changes in Eggs During Storage A number of changes occur in shell eggs during storage (Fig. 10.3a, b). These include:

(i) The air cell increases in size due to loss of moisture.
(ii) Carbon dioxide is lost resulting in increase in pH.
(iii) Water passes from white to yolk, thus the size and fluid content of yolk increase. Due to pressure of the enlarged yolk, the vitelline membrane weakens and eventually breaks.
(iv) The thick egg white becomes less viscous and it changes to a watery white fluid which runs easily.

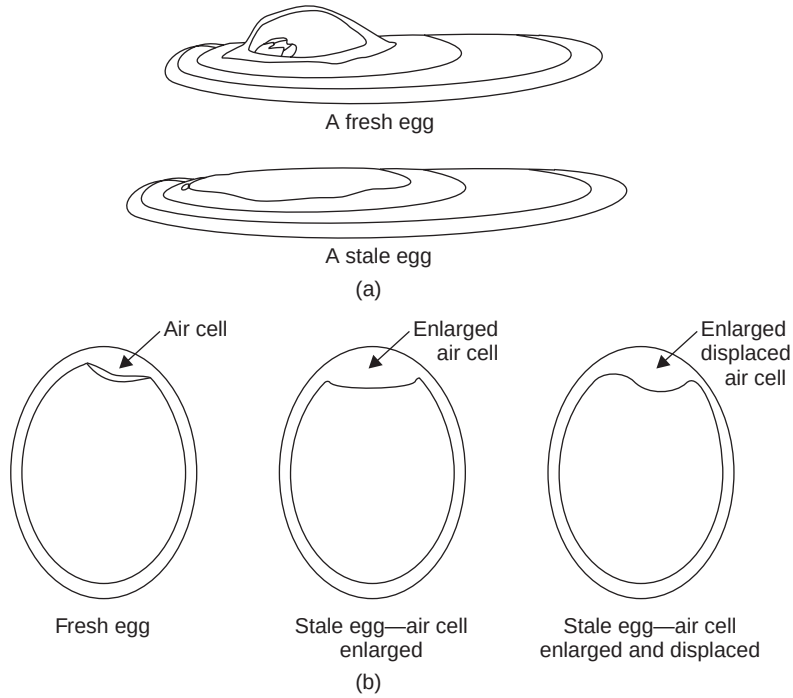


Fig. 10.3 (a) Egg Quality (b) Air Cell

Method of Judging Quality and Freshness of Eggs

Candling is a method used to determine quality of shell eggs. The egg is held in front of the light to observe the size of the air cell and the position of egg yolk. If the egg is of poor quality the air cell is large, the yolk is not in the centre and yolk moves readily when the egg is given a quick twist.

Effects of Cooking

Since egg contains less than one per cent of carbohydrates, the reactions of proteins in food preparation can be observed and demonstrated very clearly in egg cookery.

Certain changes occur in eggs due to cooking. The proteins are first *denatured*, which results in change in structure and solubility of proteins. With further heating, the proteins *coagulate*. Coagulation refers to the change from a liquid to a solid state. When eggs are hard-boiled, the egg white and yolk are completely coagulated. Egg white begins to coagulate at 52°C and the coagulation is complete by 65°C. Egg yolk coagulates between 65 and 70°C. If other ingredients are added, the time needed and temperature of coagulation is affected.

Functions of Egg in Cookery

The egg proteins coagulate on heating. The coagulation of proteins is accompanied by binding of moisture and increase in viscosity. Therefore, eggs can be used as *thickening agents* in food preparation. Egg custard is a good example of this property of eggs.

The egg proteins coagulate between 65 and 70°C and help to hold the shape of the product in which these are used. Eggs are therefore useful as *binding agents* in cutlets, chops, fried fish.

Eggs, when beaten, form elastic films, which can trap air. This air expands during baking, and gives fluffy, spongy product. Thus, eggs are used extensively as *leavening agents* in baked products such as cakes and muffins.

Besides proteins, eggs contain phospholipids such as lecithin, which are known for their *emulsifying quality*. Hence, the egg used is an excellent emulsifying agent in products such as mayonnaise.

Fish

Fish and shellfish are two large groups of sea-foods used in coastal regions. These are very good sources of animal proteins, minerals and vitamins. Salt water fish and fresh water fish each have distinct individual flavours.

Fresh fish include many varieties. Fresh fish do not have any odour, and have a mild pleasant flavour, a firm elastic flesh and bright, clear eyes.

Fresh fish are stored on ice blocks as soon as they are caught. Some fishing boats have their own arrangements for refrigerating fish.

Fish is sold in many forms (Fig. 10.4).

Dressed Fish The head, tail and fins are removed and the fish scaled and eviscerated.

Steaks Dressed fish is cut into slices from head to tail.

Chunks Dressed fish is cut into big pieces of chunks down its whole length.

Fillets Dressed fish is sliced lengthwise from the backbone. Butterfly fillets can be made by keeping the outer skin intact which holds both pieces together. However, some varieties of fish have high fat content. These are mainly used for the extraction of fish liver oil, e.g., Cod-liver oil, shark liver oil. Fish liver oils are rich in vitamins A and D. Fish contains polyunsaturated fatty acids. Those fish, which contain 6 to 20 per cent fat are called *fatty fish*. As fish are an aquatic food, they provide us iodine. Canned fish are also available e.g., canned sardines. Some fish are dried, salted or pickled for further use. Ready-to-eat fish are also available. These require warming before being served.

Nutritive Value Fish are an excellent source of protein. Most fish have a low fat content.

Cooking Fish is more tender than other animal food. The amount of connective tissues is very low. Fish cooks quickly as it consists of proteins, which coagulate between 65–80°C. Therefore, if one is not careful there is a danger of overcooking the fish. Longer cooking processes render fish tough.

Dry heat as well as moist heat methods such as frying, baking, broiling, poaching and steaming are used to prepare fish.

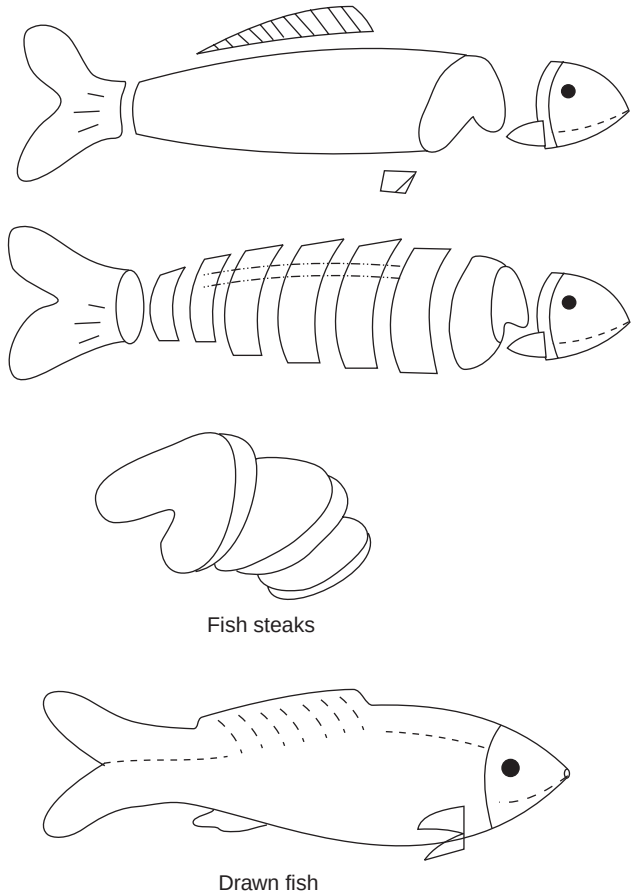


Fig. 10.4 Fish and Fish Cuts

Poultry

Various types of birds like the chicken, turkey, goose, duck etc. are included in this group. *Poultry* is one of the sources of animal proteins in our diet. Poultry is sold in various forms—whole live birds, or dressed as whole (Fig. 10.5). Various cuts of poultry fresh or frozen are also available. Younger birds are more tender than mature ones. The young bird has a soft skin, which can be separated easily from the flesh. The breast bone and other bones of young birds are tender and can be removed easily.

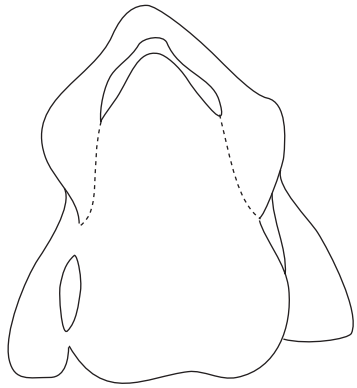


Fig. 10.5 *Poultry*—Chickens

Nutritive Value

Poultry is considered to be a delicacy. It is served in various forms. Its nutritive value is comparable to that of meat. The fat content is lower than that of meat. Poultry provides less calories than meat. The total calories in the prepared product may increase if high calorie foods like fat, butter, oil, are liberally used in preparation.

Buying and Storage

While buying a whole bird, the weight of bones, feathers and other parts to be discarded must be considered. Therefore, it is wise to buy twice as much weight of poultry as needed.

The quantity of poultry purchased should be decided after due consideration to the other items in lunch or dinner menu.

Family size and storage facilities available are other factors to be borne in mind when buying poultry. The whole bird, or halves or cuts are available to suit your family's needs.

Sex differences are not significant in young birds but are significant in mature birds. Older female birds are more juicy and less tough. On the other hand, the older male birds are more tough and stringy (Table 10.5).

Poultry should be refrigerated soon after purchase. The chance of spoilage in poultry that is stored at room temperature is very high. It is a very good medium for rapid bacterial growth. Most of the poultry is marketed in frozen form. Frozen poultry should be kept under refrigeration until required.

Frozen poultry should be allowed to thaw in the refrigerator before being used for cooking.

Great care should be taken in the storage of stuffed poultry. The stuffing and the bird should be stored separately. If the stuffed bird is stored, it may spoil quickly. After cooking, poultry may be stored in the refrigerator again until required. Left overs of prepared poultry can also be refrigerated.

Cooking

Roasting and boiling are some of the common methods used in the preparation of poultry. Another method, which is extensively used, is frying. Less tender cuts may be steamed or cooked in juices till slightly tender and fried. Mature poultry is usually cooked by moist heat methods. Braising and stewing, using a covered pan are some of the moist heat methods used. Cooked pieces of the bird may be added to curries, soups etc.

TABLE 10.5 Classification of Poultry

	Name	Age	Weight
1.	Chicken		
	Broiler Fryer	9 to 12 weeks	2 to 2½ lbs
	Roaster	3 to 5 months	3 to 5 lbs
	Capon	Less than 8 months	
	Hen	5 to 7 weeks	2 lbs
	Stewing hen	mature female	
	Cock	Mature male	
2.	Turkey		
	Fryer Roaster	Less than 16 wks	4 to 8 lbs
	Young hen	5 to 7 months (female)	8 to 14 lbs
	Young tom	5 to 7 months (male)	12 lbs
	Old turkey	15 months (mature)	
3.	Ducks	Small ducklings	3 to 7 lbs
4.	Geese	Young bird	6 to 12 lbs

Meat

Meat is one of the animal protein foods used in diet. Meat protein has high biological value. The high cost of meat, shortage of animals, customs and religious beliefs are some of the reasons why meat is not consumed by some people in India.

Meat is a good source of proteins and fat. The proportion of nutrients in meat depend upon the kind of animal, the species and the type of cut. The protein content of meat decreases with an increase in fat content. The average protein content of meat ranges from 16 to 23 per cent and the average fat content ranges from 10 to 40 per cent. Meat is a good source of phosphorus, iron and some trace elements. Unless the cooking water is discarded, minerals and water soluble vitamins are not lost to a great extent. Meat provides us vitamin B-complex and some vitamin A, depending on the cut.

The meat of sheep, which is under 12 months of age, is sold as *lamb*. After the age of 12 months, it is called *mutton*.

Pork is the meat of swine slaughtered between the age of 5 and 12 months.

Veal is the meat from cattle that is slaughtered 3 to 14 weeks after birth. If slaughtered between 14 and 52 weeks, the meat is called *calf*. Meat obtained from cattle that is slaughtered one year after birth is called *beef*.

Variety of Meats Available

Various organs of the animal are used in food preparation. They may be liver, kidney, tongue, brain etc. These organ meats are less costly than muscle meat (Fig. 10.6).

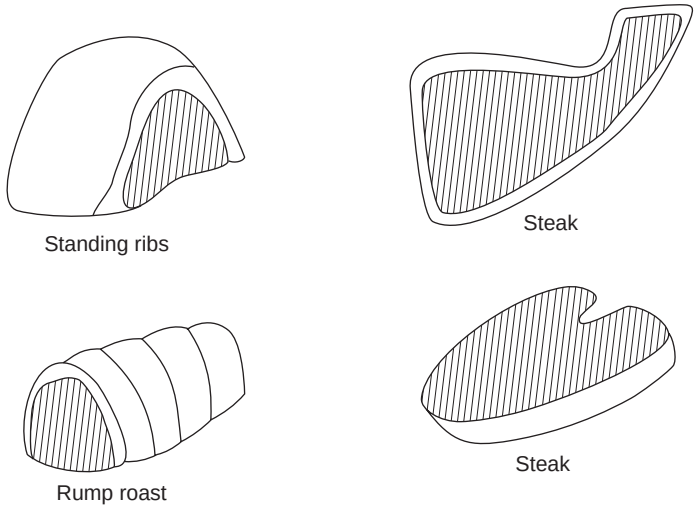


Fig. 10.6 Meat cuts

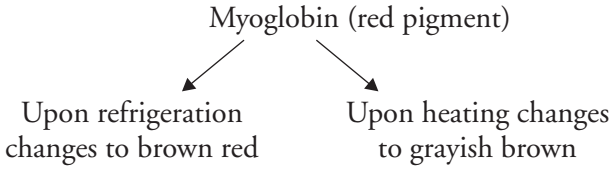
Sausages Ground meat from pork and beef is made into sausages. Chicken and turkeys are also now being used for this purpose. Some sausages are ready to eat where as others require cooking. Sausages are usually used in sandwiches.

Structure of the Muscle

1. *Muscle Tissue* Muscle is a complex structure. The smallest unit of a muscle is a *muscle fibre*. Many fibres are joined by connective tissue into bundles. These bundles are called *fasciculi*. The fasciculi together with fat deposits are covered with a thick membrane and attached to the bone.
2. *Connective Tissue* These are the tissues, which bind meat fibres together. Meat muscle is connected to the bone by means of a connective tissue. Collagen and elastin are two types of connective tissues. During cooking, collagen is softened and converted to gelatin. Elastin does not become soft during cooking. Some parts of the animal have greater amount of connective tissues, where as others have a lower amount of the tissue. The part of the

animal which is exercised more contains greater amount of the connective tissues e.g., the leg. The greater the amount of connective tissue the less tender is the cut of meat.

3. *Fatty tissues* These are made up of connective tissues with embedded fat cells. Fat is deposited under the skin, around the glands, organs and between and within the muscle fibres. Fat distribution in lean part of meat is called *marbling*. A meat which is well marbled is desired by consumers.
4. *Bones* The appearance of the bone is an indicator of the part of the animal from which the cut of meat is taken. Bones are either long or short. Long bones are hollow and contain yellow marrow. Other bones, which contain red marrow, are spongy inside.
5. *Pigments* Myoglobin is the pigment in meat that gives the characteristic red colour to meat. The greater the amount of myoglobin, the darker the colour of meat. As the animal ages the amount of myoglobin increases. Raw meat when allowed to stand in the refrigerator, changes its colour from red to brownish red. If myoglobin is heated the colour changes from red to brown.



Postmortem Changes

When the animal is slaughtered, certain changes take place. The meat starts to stiffen. This change is called *rigor mortis*. Along with this change, other metabolic changes also take place. More lactic acid is formed, which lowers the pH. The muscle fibre swells with fluid and become hard.

As soon as the animal is slaughtered, the circulatory system stops functioning but the enzymes continue to remain active. Oxidation of glycogen brings about production of lactic acid. The amount of glycogen stored in a particular animal decides the amount of lactic acid produced after slaughter. A lower glycogen storage produces sticky and gummy meat which is undesirable.

Stiff muscles of the animal start softening after holding for some time. This is called *aging*. Tenderness in the meat increases with holding time. Holding conditions should be carefully controlled. Uncontrolled conditions may allow putrefactive bacteria to grow. Controlled conditions of holding are:

(i) Temperature of holding should have a range of (34–36°F)
(ii) Carbon dioxide in the atmosphere
(iii) 70 per cent humidity

This helps keep the meat in a good condition for 3 to 6 weeks. After this aging process, the meat is ready for sale. This process of aging is also called ripening of meat.

Ways of Preserving Meat

Curing Many methods are used. Meat is treated with salt, sugar, sodium nitrate and spices to give different flavours. Smoke is used some times to give a desirable flavour and to improve the keeping quality of meat.

Freezing This is a common method of preserving meat. Nutrient loss is least during freezing. The one undesirable effect, freezing has on meat is that, the meat when cooked, is less juicy. This method is commonly used for storing cooked meat.

Canning Meat can also be preserved by this method. Higher temperatures which are used during canning bring about some undesirable changes in flavour and texture.

Radiation and Sterilization This is a new method of preservation of meats. The meat is sterilized and bacteria present killed. According to some people, this meat is not palatable.

Cooking Meat

The method of cooking depends on the type of meat. Dry heat methods like roasting, broiling, pan frying are used for tender cuts or young animals. Moist heat methods like pressure cooking, closed pan cooking, steaming are used for less tender cuts.

Most common cooking methods appear to be roasting, broiling and pan-frying.

Effect of Heat on Meat

Thiamin in meat is partially lost during cooking. If the food is heated for a long time, the loss is extensive. If water or juices, in which the meat is cooked, are discarded, then the loss of the vitamin increases. Low temperatures are preferred for meat cookery.

Points to Remember

Protein found in every living cell. Primary source plants, animal proteins made from plant proteins.

Plant Sources Dals, pulses, nuts and oilseeds.

Animal Sources Milk, eggs, fish, poultry and meat.

Dals Decorticated, split products from pulses.

Pulses Edible seeds of leguminous plants.

Dals and pulses are easily bought, stored and prepared for the table.

Are an important source of protein in the Indian dietary. Are a good source of iron and B-complex vitamins also. Germinated pulses contain vitamin C.

Dals and Pulses are selected for appearance, colour, variety, uniform size, sound grain, absence of foreign matter and dirt.

Cooked by boiling, roasting (whole beans), frying, grinding and frying or steaming.

Cooking time reduced by decortication, soaking, germination or roasting before cooking.

Toxic substances in dals and pulses include trypsin inhibitors, haemaglutinins, and others (from field bean and kesari dal). All are inactivated by heat.

Nuts and Oilseeds are high fat edible legume seeds. They are rich in protein, fat and B-complex vitamins, and also used to extract oil.

Roasted nuts are used in salads, soups and other products.

Gingelly seeds are an excellent source of calcium.

Milk and Milk Products form an essential part of our dietary.

Milk is a colloidal solution.

Nutrients Contains proteins of high biological value. It is an excellent source of calcium and phosphorus, lactose, which helps absorption of calcium and phosphorus, and is an excellent source of riboflavin also, a vitamin of the B-complex group.

Care in the Home Receive and store in clean container, after boiling, keep away from strong smelling foods.

Effect of Heat Heating leads to change in colour, flavour and viscosity. Scum forms, cream separates at the top and coagulated matter at the bottom.

Addition of acids, salts, to heated milk, hastens coagulation of proteins.

Processing helps to increase storage life. Processes used include pasteurization, concentration and dehydration.

Eggs are an important source of protein of high biological value, vitamin A value and vitamins of the B-complex group.

Structure Shell, the white and yolk.

Buying and Care Buy fresh clean eggs, and store in refrigerator to delay staling.

Staling Deterioration indicated by increase in air cell, thinning of yolk and white. Candling helps to observe size of air cell and position of yolk.

Effect of Cooking Proteins denature and coagulate and bind moisture.

Functions Used as, thickening agent, binding agent, leavening agent, emulsifying agent.

Fish, Poultry, Meat are all excellent sources of high quality protein, fair amount of iron and vitamins of B-complex group. Liver is an excellent source of vitamin A. Marine fish supply iodine also.

Structure consists of muscle fibre, connective tissues, fat, bones and pigment.

Effect of Heat The main component is protein, which denatures and coagulates, binds water and softens. Excessive heat may lead to loss of moisture, shrinking and the texture may become tough and leathery.

Postmortem Changes stiffening of muscles (rigor mortis) occurs, the period of rigor varies from one species to another.

Ageing under controlled conditions (temperature, humidity and atmosphere) helps to tenderise meat.

Preservation methods used include curing, canning, freezing and radiation sterilization.

Cooking Methods include roasting, broiling, boiling and pressure cooking.

Study Questions

1. What are proteins? What are their functions?
2. List the different sources of protein in our dietary.
3. What are the different methods used for preparing dals and pulses?
4. How would you increase the biological values of dal and pulse protein?
5. What nutrients are contributed by nuts and oilseeds?
6. Write a short note on each of the following:
   (a) Nutritive value of milk
   (b) Care of milk in the home
   (c) Homogenization of milk
   (d) Pasteurization of milk
7. What are the effects of heat on milk?
8. List the different milk products used in our diets.
9. What changes take place when an egg deteriorates?
10. List the different uses of egg in food preparation.
11. What are the criteria for selecting good quality fish?
12. What are the post-mortem changes that take place in meat?
13. How are flesh foods preserved?

11

Oils and Fats

In both animal and plant foods, three groups of naturally occurring organic compounds are very important oils and fats, carbohydrates and proteins. These are essential nutrients which sustain life.

Fats and oils have a simple molecular structure. Oils and fats belong to a naturally occurring substances called **lipids**. The common characteristics of lipids are:

- They are soluble in organic solvents (ether, acetone etc.)
- They are insoluble in water
- Most of them are derivatives of fatty acids

Some important examples of lipids which are derivatives of fatty acids are oils, fats, phospholipids and waxes. **Steroids** which are also lipids, are an exception in that these are not derivatives of fatty acids. Cholesterol, a steroid is an important constituent of body tissues and is present in animal foods. Vitamin D and bile acids are other important steroids, which are related to cholesterol.

In this chapter, we will be dealing with oils and fats. One of the phospholipids, lecithin, which is an important natural emulsifier, will also be discussed.

In every day use, the group oils and fats has a definite meaning. It includes such familiar substances as:

Vegetable oils Groundnut, sesame (gingelly), mustard, coconut, safflower, coconut, corn, cotton seed, soyabean and palm oil.

Animal fats Butter, ghee and cream from milk, lard from hogs and tallow from cattle.

Manufactured fats *Vanaspati* and margarine.

Some plants store fat in the seeds, for example, oil seeds and nuts. Animals secrete fat in the milk, which is extracted as cream and butter and later clarified to yield ghee. Animals store fat in adipose tissues from which it can be extracted, e.g., lard from hogs and tallow from cattle.

Most cereals, vegetable and fruits contain very little fat. The only exceptions are the grain corn, and the fruit palm, which contain sufficient fat to permit commercial production.

Both oils and fats are extracted from vegetable and animal foods by various processes. Thus, these are processed foods, and their quality is affected by the process used to extract these. Fats have been used for a much longer time in man's dietary, than oils, which gained commercial importance only at the end of the nineteenth century.

In Chapter 3, it was mentioned that oils and fats are the most concentrated sources of energy in our diet. A gramme of oil or fat supplies nine calories in contrast to starchy foods, which provide only four calories per gramme. They are prized for the flavour and richness they impart to foods. Oils and fats provide 10 to 30 per cent of our daily energy intake.

Oils and fats are similar in composition, but physically, fats are solid at normal temperatures (18–25°C), whereas oils are liquids.

Fats and oils are widely distributed in nature and are found in almost every natural food. Oilseeds and nuts are rich sources of oils (Table 11.1) and are used in the commercial manufacturing of oils. Corn, olives and fruit palm are also used as sources for oil extraction. Whole grain cereals and legumes contain 1 to 6 per cent of fat. Even fruits and vegetables contain between 0.1 and 1 per cent of total fat (Fig. 11.1).

Animal foods, milk and its products, eggs, fowl, fish and meat are natural sources of fat in our diets.

Oils and fats are added in food preparation as spreads, shortening, as flavour enhancers and as seasonings. They are also used as a medium of cooking in shallow and deep fat frying of foods.

Even when no oil or fat is added to the diet, the natural fat in the foods provides 10 to 12 per cent of the total energy intake (Fig. 11.1)

TABLE 11.1 Fat Content of Foods[1]

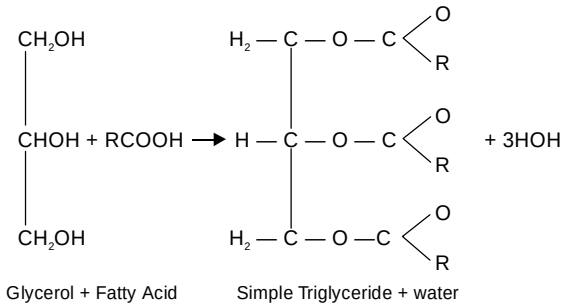
S. no.	Food	Total fat (%)
1.	Ghee	99
2.	Butter	81
3.	Coconut	62
4.	Sunflower	52
5.	Gingelly	43
6.	Groundnut, Mustard	40
7.	Safflower	26
8.	Soyabean	20
9.	Fatty fish	5 to 21
10.	Egg	13
11.	Meat, Poultry	1 to 13
12.	Milk	1.5 to 7
13.	Cereals and Pulses	0.5 to 6
14.	Corn	4
15.	Vegetables	0.1 to 1

1. *Nutritive Value of Indian Foods*, NIN, p 47–58, 2000.

Composition and Classification

Oils and fats are composed of the elements carbon, hydrogen and oxygen. Fats are built up by linking together a number of individual fatty acids with glycerol.

Glycerides are formed by the combination of glycerol and fatty acid with elimination of water as shown below:



The kind of glyceride formed is indicated by the prefix attached to the word glyceride. Thus, the union of one molecule of glycerol and one molecule of fatty acid forms a *Monoglyceride* (mono-one); in the process one molecule of water is freed. If two fatty acids are attached to glycerol, it is called a *Diglyceride* (di-two), and if three fatty acids are attached to glycerol, it is a *Triglyceride* (tri-three).

In a mixed glyceride, more than one kind of fatty acid is present. When three fatty acids in a triglyceride are of the same kind, the fat is a *Simple Triglyceride*. If the fatty acids are different, the fat is a *Mixed Glyceride*.

Edible fats are complex mixtures of mixed triglycerides and small amount of other associated substances occurring naturally in plants and animals. This may account for the wide variation in the flavour and consistency of food fats.

Fats may be classified into solid and liquid fats according to saturation of the fatty acids they contain.

Solid fats are so called because they are solid at room temperature. This is partly because they contain a high proportion of saturated fatty acids. Some examples of solid fats are butter, vanaspati and margarine. Vanaspati and margarine are hydrogenated fats and hence are solid at room temperature.

Liquid fats better known as *oils*, are liquid at room temperature. They contain a high proportion of unsaturated fatty acids. Oils such as corn, soyabean, cottonseed and safflower contain a fairly large proportion of polyunsaturated fatty acids. The fatty acid composition of some fats is presented in Table 11.2.

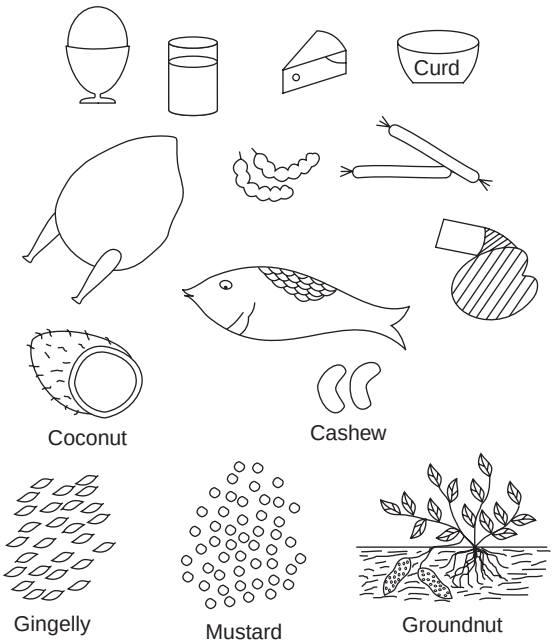


Fig. 11.1 Sources of Hidden Oils and Fats

TABLE 11.2 Fatty Acids in Food Fats[1]

No. of carbons	Fatty acid		Coconut oil (%)	Groundnut oil (%)	Corn (%)	Cotton seed (%)	Lard (%)	Mutton tallow (%)	Butter (%)
	Saturated	Unsaturated							
4	Butyric		–	–	–	–	–	–	3
6	Caproic		0.5	–	–	–	–	–	2
14	Myristic		18	–	–	1	1	2	10
16	Palmitic		9	6	6	21	28	34	30
18	Stearic		2	5	2	2	8	19	11
18		Oleic	7	61	37	25	56	43	30
18		Linoleic[2]	2	22	54	50	5	2	3
	Other acids		61.5	6	1	1	2	–	11
	Total		100	100	100	100	100	100	100

1. Meyer Lilian, *Food Chemistry*, AVI Pub., 1978.
2. This is an essential fatty acid.

Fatty acids are composed entirely of carbon, hydrogen and oxygen atoms. They are found in all simple and compound lipids. Some common fatty acids are palmitic, stearic, oleic and linoleic acid. Fatty acids differ from one another in their chain length (the number of carbon atoms in each molecule) and the degree of saturation. There are short chain fatty acids (with a chain length of 10 or fewer carbon atoms), examples of which include acetic acid found in vinegar and butyric and caproic acid in butter. Long chain fatty acids have a chain length of 12 to 18 carbon atoms and include palmitic and stearic acid found in lard and beef tallow respectively. Oleic acid and linoleic acid (18 carbon atoms) are also long chain fatty acids. They are found in olive and corn oils respectively.

Fatty acids may be saturated or unsaturated. Certain fatty acids contain as many hydrogen atoms as the carbon chain can hold. They are called *saturated fatty acids*; of which stearic acid is an example. Other fatty acids have only one double bond linkage (two hydrogen atoms missing) in the carbon chain. They are referred to as monounsaturated fatty acid, e.g., oleic acid.

A third group the polyunsaturated fatty acids, may have two, three, four or more double bond linkages in their carbon chain. An example of this group is linoleic acid. As mentioned in Chapter 3, vegetable oils contain several polyunsaturated fatty acids, of which linoleic is essential for human beings.

Naturally occurring unsaturated fatty acids have a low melting point and are liquid at normal temperatures.

Oils have a large amount of olein (a triglyceride of oleic acid—18 carbon unsaturated fatty acid) and hence are liquid at ordinary temperature.

Selection and Buying of Oils and Fats

A number of household fats and oils are available in India. The choice depends on the food preparation in which the fat is to be used, the family needs, the food budget and regional preference.

Ghee is preferred for its delicate flavour, in preparation of sweets and to serve with rice or snacks. Butter is used as a spread and in some baked products for the same reason.

Oil is normally used for seasoning vegetables, *dals* and as a frying medium. The choice of oil varies from one region to another e.g., mustard oil is used in Bengal, coconut oil in Kerala, groundnut oil in Gujarat and gingelly (til) oil in Tamil Nadu.

A large amount of oil is marketed as unrefined or crude oil. Criteria for selection of oil are presence of the natural characteristic aroma, natural colour, clarity, freedom from admixture with other kinds of oils, freedom from solid particles and flat or rancid odour.

All the oils and fats supply energy irrespective of their source. Most of the vegetable oils supply unsaturated fatty acids. The animal fats, ghee and butter, supply some vitamin A also. Refined oils have a longer shelf-life than unrefined oils of the same kind. As impurities are removed in refining, the smoke-point of refined oils during frying is higher than that of unrefined oils. Refined oils are used in bakery products (bread, biscuits etc.) by large bakeries.

Hydrogenated fats (vanaspati) are also available for use in food preparation. Hydrogenated fat is more stable than the vegetable oil from which it is made. The hydrogenation process is designed to produce characteristics most desired in terms of use and consumer acceptance. In India, it is made as a substitute for ghee, and therefore its physical appearance and texture resembles ghee. It is also fortified with vitamin A to the same level as ghee (or 2,500 I.U. per 100 g) to protect the consumer. Hydrogenated fats have a higher smoke point than refined oils, and are used for frying bland foods. These are also used in pastries as a shortening agent.

Nutritive Value and Digestibility

Fats and oils are concentrated sources of energy. Each gramme of pure fat or oil supplies nine kilocalories. Fats and oils have other functions in the body besides supplying energy. They carry fat soluble vitamins A, D, E and K into the body and assist in the absorption of these vitamins. Some vegetable oils contain an essential fatty acid, which is necessary for normal body functions. Essential fatty acid is not synthesized in the body.

Fats impart special flavour and texture to our foods, thus increasing the palatability. Fats are also valuable for the satiety value that they give to meals. They are slow in leaving the stomach and hence may delay the recurrence of hunger pangs. Fats that are ordinarily consumed as constituents of common foods do not differ greatly in digestibility being utilized to the extent of 95–98 per cent.

Digestion is the process which prepares food for assimilation by the body. The digestion of fat starts in the small intestine. When the food enters the first part of the small intestine called the duodenum, the gall bladder is stimulated to release some *bile* and the pancreas a fat splitting enzyme called *lipase*. These fluids enter the duodenum through a common duct. Bile neutralizes the acidity of the food mass and provides the alkaline pH necessary for the action of the pancreatic enzymes. It emulsifies the fat and increases their surface area which helps the lipase hydrolyze part of the fat to glycerol and fatty acids and the rest to mono-and di-glycerides. The bile salts disperse the fatty acids and glycerol into small units called *micelles* in the small intestine so that they are easily absorbed through the intestinal walls. The remaining partly hydrolyzed products viz., mono-and di-glycerides are broken down completely to fatty acids and glycerol by the intestinal lipase and are also absorbed, after being converted to micelles.

When fat is oxidized in the body, it releases more energy than carbohydrate but utilises more oxygen.

Physical and Chemical Properties

A study of the properties of fats is important in that, they influence the role of fats in cookery. The following are some of the physical properties of fat which play an important role in food preparation:

Melting Point All food fats are mixtures of triglycerides, and therefore, do not have a sharp melting point, but melt over a range of temperatures.

Creaming of Fats Solid fats like butter and margarine can be creamed or made soft and fluffy by the incorporation of air. Fat and sugar are usually creamed together in the preparation of cakes.

Plasticity of Fats Fats are mouldable and can be creamed to exhibit plasticity. Such fats do not have the ability to flow at room temperature and are thus solid fats. The spreading quality of butter is the result of its plastic nature. Plastic fats are composed of a mixture of triglycerides and not of one kind of a molecule. They, therefore, do not have a sharp melting point and are plastic over a fairly wide range of temperature.

Emulsification The specific gravity of oils and fats is about 0.9, which indicates that they are lighter than water. Though insoluble in water, they can form an emulsion with water when beaten up with it to form tiny globules in the presence of suitable emulsifying agent. Butter is an emulsion, so also is cream. The presence of minute amounts of milk protein helps to stabilise these emulsions. Lecithin, a phospholipid from egg yolk helps to stabilise mayonnaise, a salad dressing made from vegetable oil. Emulsification of fats is a necessary step in a number of products such as cakes, ice cream and other frozen desserts.

Smoke Point The smoke point is the temperature at which a fat or oil gives off a thin bluish smoke. Foods that are fried are added to the hot oil just before it reaches its smoke point. Fats and oils with low molecular weight fatty acids (those with a short chain length) have low smoke point. Normally, oils that are selected for deep fat frying are those, which have a high smoke point. If oils with low smoke points are used for deep fat frying, then the foodstuff is fried at a lower temperature and thus will take a longer time to acquire the stage of doneness. In this case, the exposure of the foodstuff to the oil is increased thereby increasing its oil absorption.

Repeated use of the same sample of oil for frying results in a decrease in its smoke point and ultimately in its decomposition. The effect of prolonged heating on the nutritive value of oils and fats is dealt with later in this chapter.

Chemical properties of fats (such as iodine value, acid number and saponification number) are useful in that they have been widely used in the identification of different kinds of fats and oils, and in the detection of adulteration of refined oils with other oils that are cheaper and of poorer quality.

Iodine Number measures the degree of unsaturation in the oil and thus gives an estimate of the total amount of unsaturated fatty acids present.

$$CH = CH + I_2 \rightarrow CHI - CHI$$

One molecule of iodine is needed to saturate each double bond. Iodine value is expressed as the number of grams of iodine required to saturate 100 grams of oil.

Reichert- Meissel Number (RM Number) : The Reichert-Meissel number is a measure of the volatile water soluble fatty acids present in the fat. It is an important parameter to detect adulteration of butter, especially with coconut oil. The RM number is defined as the number of mls of 0.lN alkali (e.g., KOH) needed to neutralize the volatile fatty acids in a 5 g sample of fat. The volatile acids will be those from butyric to myristic acid. (C4 to C14). The RM test measures the amount

of butyric, caproic, caprylic and capric acids present. The RM value of butter is between 24 and 34 (variation is due to season, nutrition and stage of lactation), which is higher than other edible oils.

Saponification Number: is defined as the number of mg of potassium hydroxide needed to sponify 1 g of fat or oil. The fat containing lower molecular weight fatty acids will have a high saponification number. Butter which contains high percentage of butyric acid has the highest saponification number, i.e., 17.

Refining of Crude Oils

About 80 years back, oils used to be extracted from oilseeds and nuts in small pressure extraction units. The extracted oil was used in the human diet and the oilseed concentrate was used as cattle feed. Now most of the oils used in human diet are refined.

In the refining process the impurities in oils are removed. The impurities in the oils include moisture, free fatty acids, colouring pigments, resins, gums and sometimes vitamins. The colour, flavour, odour and clarity as also the shelf-life of the oil are affected by impurities. Hence, the impurities are removed by refining to increase the shelf-life and acceptability of oils. The refining process consists of the following five steps:

1. *Degumming* Some impurities in the crude oil form gums in the presence of water. Such impurities are removed by adding water to the warm oil and centrifuging it to remove the denser gum particles. Thus, a clarified oil is obtained as an upper layer, which is siphoned off.
2. *Neutralising* All crude oils contain some free fatty acids formed due to spoilage. The oil is neutralized with caustic soda solution and the insoluble soaps formed from the free fatty acids, which settle at the bottom are removed.
3. *Washing and Drying* The last traces of soap from the oil are removed by washing. The lower aqueous soap layer is run off and the oil layer is dried under vacuum. The oil thus obtained has a yellowish colour and a distinct odour. To remove these, the oil is bleached and deodourised.
4. *Bleaching* To absorb the colouring matter from the oil, adsorbing substances such as activated carbon and fuller's earth are added to the warmed oil. The mixture is stirred with maintenance of partial vacuum. After, all the coloured matter is adsorbed, the mixture is put through filter presses to get a clear colourless oil.
5. *Deodourising* Finally the oil is deodourised by injecting steam with agitation to remove all odourous material as vapour. The deodourised oil is packed as such or blended with other oils and packed. The refined oil has to be stored under an inert gas such as nitrogen or vacuum packed to prevent oxidation.

Role in Cookery

The role of different types of fats and oils in cookery is largely based on their composition and properties. Thus, liquid fats or oils with a high smoke point are used for deep-fat frying purposes and likewise, solid fats like butter and margarine are used as shortening and tenderizing agents in foods.

Fats are used in food preparation

(i) as a medium of cooking.
(ii) as a shortening as in *chakali, puri, shankarpala,* biscuits, pastry and cakes.
(iii) to add richness and flavour as in *shira, halwa,* seasoning of vegetables and salads.

As a Medium of Cooking

Fat and oils have a high boiling point as compared to water. Therefore, foods get cooked in fat in shorter time than when cooked in water. Fried foods, such as *Wafers* and *Chivda,* have a crisp texture and a delectable flavour. The high temperature used in frying destroys harmful bacteria, thus making the food safe for consumption. Some fat is absorbed by the food and the calorific value of the food is increased when it is cooked in fat or oil.

As a Shortening

In many preparations, such as cakes, biscuits *chakali* and *chirote*, fats or oils are added to improve the texture. The fat covers the surface of the flour particles and prevents the sticking of particles together. Many factors such as the nature of the fat or oil, the amount added, the temperature, presence of other ingredients, manipulation and the extent of mixing, affect the shortening power.

As a Seasoning

Fats and oils are used to season most food preparations. In sweet preparations, fats, such as butter, ghee, vanaspati are used, as they have mild flavour, which blends with the sweet preparation.

In most parts of India, oils are used to season savoury preparations. The choice of oil varies with the region. In Kerala, it is coconut oil, in Madras, Mysore, Gujarat, Andhra Pradesh and Maharashtra, groundnut oil and sesame oil are used and mustard oil is preferred in Bengal. Each of these oils impart a characteristic flavour to the food.

In a typical method of seasoning vegetables and salads, the fat or oil is heated, a few whole grains of mustard or cumin seeds are popped, and a number of other spices such as chillie pieces, turmeric, asafoetida etc., are added as desired. Since most of the flavour components of spices are fat soluble, this addition in fat is an excellent way of extracting and dispersing these in the food preparation.

Changes in Fat Used for Cooking

When fat is used to fry foods, due to the interaction with food, several changes occur in its physical and chemical properties. Part of the fat is absorbed by the food.

Some of the changes noted in fat used for frying are:

(i) The free fatty acid value increases, indicating partial decomposition of fats
(ii) The temperature at which the fat smokes is lowered
(iii) The fat polymerises
(iv) The fat darkens in colour

The increase in free fatty acids can be measured in the laboratory. When fried foods are prepared at home it is noted that the fat smokes a lot towards the end even though the rate of heating is not changed, indicating that polymerization has occurred. Darkening of fat used for frying is noted whenever a large batch of fried preparation is made. In fact, light coloured foods fried in such medium absorb the brown colour.

Factors Affecting Absorption of Fat During Cooking

A number of factors affect the amount of fat absorbed during frying. Fat absorption is proportional to the surface area of the product, when all other factors are kept constant.

The time of cooking affects the fat absorption. The absorption, in general, increases with longer cooking period. There may be some exceptions to this statement. Foods, which harden at the frying temperature may not absorb more fat with a longer cooking period.

Temperature of cooking affects fat absorption indirectly. If a food is added to frying medium, before it reaches the desired temperature, it needs to be fried for a longer time to reach the stage of doneness and hence may absorb more fat.

The composition and nature of food affects the amount of fat absorbed. For example, hard wheat flours show less fat absorption as compared to soft wheat flour. When sugar and/or water in the recipe is increased, more fat is absorbed.

Effect of Prolonged Heating on Nutritive Value of Fats and Oils

A lot of emphasis was laid on the effect of heat on the deterioration of fats and oils in the earlier research studies. In the recent research work attention has been focussed on the nutritional aspects of use of overheated fats in the diets.

It must be emphasized that continuous heating of fats and oils for over eight hours results in thermal oxidation. In the normal use of fats and oils in the home, such damage is not likely to occur unless fats and oils left over from earlier frying are routinely added back to the stock. But in eating houses or large scale preparation of fried snacks, heat damage may occur. A number of factors may speed up the thermal deterioration. These include use of large amounts of soda in the recipe,

addition of water to the fryer during preparation to reduce the temperature and addition of fats and oils leftover from the day's frying to the next day's lot and so on. In this manner, though the hours of frying in one day may not be sufficient to cause thermal damage, there is a build up of hours, as fresh fat or oil is added to that leftover from the previous day.

The effects of using thermally oxidized fats and oils have been studied in the last forty years. It is found that the requirements for nearly all vitamins is increased. Adaption to reduced caloric intake is poor. Certain organs, such as liver are enlarged. Functions of certain enzymes are altered, resulting in increased susceptibility to certain diseases.

In India, many fried snacks are used in everyday life. The tendency to buy these ready-made is on the increase. Therefore, the effect of intake of thermally damaged fats and oils is an important aspect from the point of view of the consumer.

Changes in Fats During Storage

Fats and oils undergo certain undesirable changes during storage, which result in spoilage. The major kind of spoilage is known as *rancidity*. Rancidity implies development of undesirable odour and flavour in fats and oils. It occurs in a number of foods and is not restricted to pure fats and oils or foods with high fat content. In fact, the spoilage of foods containing very small percentage of fat such as cereals, flours, infant foods is brought about by change in the fat fraction.

Flavour Reversion The fats undergo a peculiar change before the onset of rancidity. The characteristic flavour is lost and the fat or oil has a flat taste and a greasy feel on the tongue. This is known as flavour reversion and precedes rancidity changes.

Rancidity Spoilage of fats results in off flavour and renders the fat inedible. These changes are known as rancidity of fats. Fats and oils can get rancid by the action of

(a) air (oxidation),
(b) water (hydrolysis) and
(c) enzymes (enzymatic breakdown).

Let us look at these in detail:

1. Hydrolysis is the decomposition of fats (triglyceride molecules) to glycerol and free fatty acids. Presence of moisture, microorganisms and the enzyme lipase hastens the hydrolytic breakdown. This kind of spoilage is known as **hydrolytic rancidity**.
   The unpleasant odour and flavour of rancid fats is due to the release of free fatty acids of low molecular weight. For example, the butyric acid produced in the hydrolysis of butter is responsible for the rancid odour of spoiled butter. Even when a small amount of butyric acid is released, the butter has a disagreeable flavour and odour which indicates the onset of rancidity.

Oils containing combined fatty acids with more than 14 carbon atoms do not develop hydrolytic rancidity as the free acids are flavourless and odourless. Oils should be stored in completely dry, airtight containers to prevent hydrolytic rancidity.

2. Oxidation of unsaturated fats leads to oxidative rancidity. Thus, oils or fats containing more double bonds (unsaturation) are more likely to develop oxidative rancidity than those with few double bonds. This oxidation is a chain reaction initiated by the production of free radicals.

   Addition of small quantities of antioxidants suppresses the production of these free radicals and improves the shelf-life of fats and oils. Some of the antioxidants used in fats and oils are vitamin E (tocopherol), butylated hydroxy toluene (BHT) and permitted gallates.
3. Enzymatic breakdown normally accompanies hydrolysis as indicated above.

Prevention of Fat Spoilage

Storage of fats and oils so as to minimise possibility of spoilage is a very important aspect.

The following points must be noted to prevent spoilage of fats:

Keep fats and oils in dry, tightly covered containers to ensure exclusion of air and moisture. Keep the container sealed until needed. Keep fat in a container having a narrow opening to prevent undue exposure. Store in a cool, dry place away from cooking area, where the temperature and humidity fluctuations are not great.

Addition of antioxidants, such as tocopherols, and other phenolic compounds such as BHA[1], BHT[2], or propyl gallate, are used to retard rancidity in commercial fatty products.

Hydrogenation

Plant oils contain a large percentage of unsaturated fatty acids and hence have a tendency to become rancid.

These unsaturated glycerides in the oil can be converted to more saturated glycerides by addition of hydrogen. This process is known as **hydrogenation**. Hydrogenated fat is manufactured from vegetable oils by the addition of molecular hydrogen to the double bonds in the unsaturated fatty acids in the presence of a catalyst (finely divided nickel). The product formed is a solid fat with higher melting point than that of the oil used as a starting material. Hydrogenation is of great economic importance, because it allows oils to be converted into fats, which have better keeping quality. The various brands of Vanaspati we find in the market are prepared by this process.

1. BHA—Butylated hydroxy anisole.
2. BHT—Butylated hydroxy toluene.

Points to Remember

Oils and fats include vegetable oils, animal fats and manufactured fats used in human dietary.

Oils and Fats Are composed of carbon, hydrogen and oxygen. These are built by linking fatty acids and glycerol.

Oils are liquid at 20°C, while fats are solid at this temperature. Fatty acids may be saturated or unsaturated. Linoleic acid is essential for nutrition.

Selection Choice of oils and fats depend on the use, family needs, budget and regional preference. Selected for colour, clarity, characteristic aroma, and absence of bad odour.

Nutritive Value Concentrated sources of energy, carry and help absorption of fat-soluble vitamins. Supply essential fatty acid, impart flavour, texture, palatability and satiety to foods, digestibility 95–98 per cent. Bile and pancreatic lipase aid digestion of oils and fats.

Properties Creaming, plasticity, smoke point are considered to decide use of oils and fats.

Role in Cookery Used as a cooking medium, a shortening and to season foods.

Changes in cooking Partially hydrolyse to release free fatty acids, smoking point is lowered, polymerises and darkens.

Absorption of Fat in Frying Varies with surface area, period of frying, temperature of frying, composition and nature of food.

Prolonged Heating Leads to thermal damage, which is accelerated by the addition of soda and water. Consumption of thermally damaged fat is harmful.

Spoilage Leads to flavour reversion, and rancidity.

Hydrogenation Conversion of unsaturated fats to saturated one by the addition of hydrogen, in order to alter its properties and extend storage life.

Study Questions

1. What are the different kinds of oils and fats used in our dietary?
2. (a) What elements are fats made up of?
   (b) What are monoglycerides, diglycerides and triglycerides?
3. What are saturated and unsaturated fatty acids? Give example of each.
4. Write a short note on smoke point of oils and fats.
5. What are the roles of oils and fats in food preparation?
6. What nutrients are contributed by oils and fats?

7. What is rancidity? What are the different kinds of rancidity?
8. What precautions should be taken when storing oils and fats?
9. List the changes that oils and fats undergo when used in food preparation.
10. List the factors that increase the absorption of fat during frying foods.
11. What are the effects of continuous heating on the nutritive value of oils and fats?
12. What does the choice of oils and fats depend on?
13. List the desirable characteristics of fat used for deep fat frying.

12

Vegetables

Vegetables and fruits are important in improving the acceptability of a meal, because of the innumerable shades of colour, flavour and texture they contribute. A meal without vegetables and fruits would be very dull indeed.

Vegetables and fruits have many similarities in composition, methods of cultivation, harvesting and storage.

The term vegetable as used in practice includes those plant parts that are served raw or cooked as a part of a meal.

The parts of plants normally used as vegetables include leaves, roots, tubers, bulbs, fruits, seeds (beans and peas), flowers, stems and shoots. Some parts of plants can be grouped under more than one heading. The normal classification of the parts of plants used as vegetables in the tropics is given in Table12.1.

TABLE12.1 Plant Parts Used as Vegetables in Tropics

Leaves	Roots and Tubers	Bulbs	Fruits	Flowers	Stems and Shoots
Amaranth	Beet	Garlic	Cucumber	Agasti	Amaranth
Cabbage	Carrot	Leek	Brinjal	Broccoli	Colocasia stem
Colocasia	Potato	Onion	Drumstick	Cauliflower	Celery
Fenugreek	Potato (sweet)		Capsicum	Drumstick	Lotus stems
Lettuce	Radish		Ladies finger	Plantain	Onion stalks
Mustard	Tapioca		Kovai	Waterlily	Khol khol
Radish leaves	Turnip		Papaya		Plantain stem
Spinach	Yam		Tomato		Spinach stalk
			All Beans		
			All Gourds		

TABLE 12.2 Composition of Leafy Vegetables (per 100 g E.P.[1])

Name	Water (g)	CHO[2] (g)	Protein (g)	Fat (g)	Calories	Vit. A value I.U.	Vit. C (mg)	Riboflavin (mg)	Iron[3] (mg)	Ca[4] (mg)
Dark green			2.4	0.3	22	3,560–14,000	70	0.19	3	166
Light green			1.5	0.1	18	126–3,000	5–61	0.08	1	55
Cabbage	92	4.6	1.8	0.1	27	1,200	124	0.09	1	39
Lettuce	93	2.5	2.1	0.3	21	990	10	0.13	2	50
Radish leaves	91	2.4	3.8	0.4	28	5,300	81	0.47	4	265
Spinach (Palak)	92	2.9	2.0	0.7	26	5,580	28	0.26	11	73
Coriander leaves	86	6.3	3.3	0.6	44	6,920	135	0.06	18	184
Amaranth	86	6.1	4.0	0.5	45	5,520	99	0.30	25	397
Ambatchuka	95	1.4	1.6	0.3	15	3,660	12	0.06	9	63
Bathua leaves	90	2.9	3.7	0.4	30	1,740	35	0.14	4	150
Methi leaves	86	6.0	4.4	0.9	49	2,340	52	0.31	16	395
Colocasia leaves	83	6.8	3.9	1.5	56	10,270	12	0.26	10	227
Drumstick leaves	76	12.5	6.7	1.7	92	6,780	220	0.05	7	440

1. E.P. Edible portion.
2. CHO–Carbohydrate
3. Iron content–rounded off to the nearest whole number.
4. Ca–Calcium

Classification

The vegetables are normally classified into three broad groups–leafy vegetables, roots and tubers and all the remaining vegetables as one group under the title other vegetables.

The three groups of vegetables are depicted in Fig. 12.1.

Leafy Vegetables: In the tropics, a lot of variety in the leafy vegetables is available. The nutritive value of 70 leafy vegetables is reported in the food value tables. The leafy vegetables—commonly called greens or *sags* have distinct flavours. Some are acidic, some sticky and others bitter. Special techniques are used in preparation and other ingredients are added to bring about a happy blend of flavours.

The leafy vegetables grown in most countries in the tropics include amaranth (also known as Chinese spinach in some countries) cabbage, cowpea leaves, fenugreek leaves, radish leaves and spinach. Colocasia, lettuce, mustard leaves may be available and used in certain parts, and drumstick leaves and leaves of gourds in other parts.

As may be noted from Table 12.2, leafy vegetables have a high water content (85–95 per cent) and a low (about 0.5 per cent) fat content. They contain 2 to 5 per cent protein, 5 to 12 per cent carbohydrate and 0.5–4 per cent fibre. Leafy vegetables have a very low calorie content. They are rich sources of vitamins A and C, and minerals calcium and iron.

Leaves contain complex carbohydrates such as celluloses, hemicelluloses which absorb water, increase the surface area of the food mass and thus help digestion and absorption of nutrients. It also helps to ensure the smooth movement of food through the digestive tract.

The green colour of leafy vegetables is due to chlorophyll. It is a green coloured fat-soluble plant pigment. Chlorophyll turns olive green, in acidic medium. It is sensitive to heat and changes to olive-green on prolonged heating.

The leaves contain two pigments in association—chlorophyll (green) and carotene (yellow). The carotene is masked by the chlorophyll, and we can see only the green colour of chlorophyll, when both are present.

The intensity of the green colour is an indirect indicator of the vitamin A value of the leaves. The dark green leafy vegetables are a rich source of beta-carotene, which is a precursor of vitamin A. The light coloured bleached inner leaves of plants that form compact heads e.g., cabbage, contain little vitamin A value.

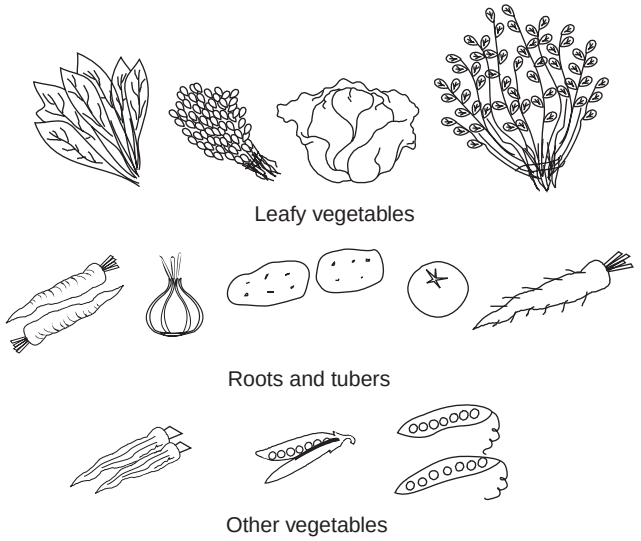


Fig. 12.1 Leafy, Roots and Tubers and Other Vegetables

Some leafy vegetables contain a high amount of oxalic acid, which if released in the digestive tract could be harmful. But the calcium present in these leafy vegetables forms an insoluble calcium oxalate and thus gets rid of the oxalic acid from the body. This is one of nature's ways of providing protection to us from harmful effect of oxalic acid. It must be noted that the calcium thus bound is excreted and is not available to our body.

Leafy vegetables can be used in salads or cooked and served after seasoning (with oil, salt, pepper) as desired. Leafy vegetables combine well with other foods such as *dals*, beans, groundnuts, sesame seeds or dry fish in making soups and sauces or stews.

The retention of vitamin C in leafy vegetables is aided by

(i) cutting these just before cooking,
(ii) introducing the leafy vegetable in boiling water, while cooking,
(iii) cooking until just done and
(iv) serving soon after preparation.

Roots and Tubers The roots and tubers and bulbs are characterized by lower water content than leaves and other vegetables (about 70 per cent). Most of the utilizable carbohydrate is in the form of starch, with a small amount of it in the form of sugar.

The roots and tubers and bulbs provide 1.2 to 3 per cent protein. The only exception are radish and tapioca, which supply only 0.7 per cent. These vegetables supply a small amount of minerals and vitamins. The only exception is carrot, which is a fair source of beta-carotene, the precursor of vitamin A.

Other Vegetables The fruits, flowers, beans, stem and shoots are included in this group. Fruits include not only cucumber, brinjal, tomatoes, ladies finger, but also all gourds-ash gourd, bitter gourd, snake gourd, ridge gourd, pumpkin, etc. Flowers include cauliflower, plantain flower and many others. All beans such as french beans, cluster beans, all tender beans and peas belong to this group. Over 75 of these vegetables have been analysed.

These vegetables supply variable amounts of minerals and vitamins. The immature beans and peas contain more protein (3–6 per cent) than the rest of the group. The fat content of all these vegetables is negligible, and therefore, the calorie content per100 grams varies from 40 to 80, depending on the carbohydrate content. These vegetables, supply fibre, which is necessary to add bulk to the diet and maintain muscle tone in the digestive tract and help in the elimination of food waste.

Some of these vegetables are used in salads, e.g., cucumber, tomato, capsicum (giant chillies). Some are cooked and served with the main course (peas, beans), others are baked or boiled and served with dressing (e.g., squash, brinjal) and many of these are used in soups. All these vegetables should be cooked in the shortest possible time to ensure retention of flavour, texture, appearance and nutrients, and served soon after preparation.

Colour Pigments

Colour of foods has much to do with its acceptance and enjoyment. Vegetables and fruits contribute a variety of colours to the dietary. The main pigments in vegetables and fruits can be classified on the basis of colour as carotenoids (yellow-orange) chlorophylls (green) and flavonoids, which consist of anthocyanins (red-blue-purple) and anthoxanthins (cream yellow). The following pigments are present in plant foods singly or in combination:

Chlorophyll The green coloured fat soluble pigment is present in many vegetables. The dark green colour of leafy vegetables is due to the presence of chlorophyll.

Carotenoids Carotenoids are fat-soluble pigments. The yellow-orange coloured pigments are present in many vegetables and fruits such as carrots, pumpkin, mango, orange. It was first isolated from carrots and therefore was named carotene. Its concentration is indicated by the intensity of the colour of the vegetables.

Carotenoids are present in most green leafy vegetables also. But the carotene colour is masked by the green chlorophyll and we can see only the green colour of chlorophyll, when both are present. The fresh yellow-green colour of spring leaves is due to carotenoids. A small amount of chlorophyll is present in these leaves.

Flavonoids are very widely distributed in the plant kingdom. These are water-soluble pigments. These consist of the anthocyanins, which are the red-blue-purple pigments of plants, the anthoxanthins and flavones, which are yellow-white in colour, and tannins, which are colourless and are derivatives of flavones.

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

Anthocyanins The red-blue pigments of this group are present in beetroot, red cabbage, blue grapes, etc.

Tannins These are colourless, but turn brown, when vegetables which contain these are cut and exposed to air e.g., the vegetables brinjals, bottle gourd, and fruits such as apples. The plant pigments can be classified on the basis of solubility into two groups:

(i) Fat-soluble pigments—chlorophyll and carotenoids are soluble in fat
(ii) Water-soluble pigments—flavonoids

The colour pigments may be affected by the method of preparation. The water soluble pigments may leach in the cooking water and changes may occur due to the pH (acids or alkalies present) and the effect of heat during cooking. The effects of these factors are summarised in Table 9.3. Knowledge of these factors may help us to modify the preparation in such a manner as to retain the attractive colour of vegetables.

Flavour

Vegetables contribute a variety of flavours and add to our enjoyment of foods.

Plant acids and their salts, sugars, tannins and sulphur compounds are the substances responsible for flavour of vegetables. Each vegetable has its unique individual flavour as these substances are present in vegetables in varying combinations and amounts.

Malic and citric acid are the most common acids present in vegetables and fruits. Oxalic acid occurs in some leaves and traces of tartaric acid are present in a few vegetables. The amounts of the acid present vary with variety, maturity of vegetables and the season. In addition to these acids, a few volatile acids are also present in vegetables and fruits. The flavour and colour of prepared vegetables would vary depending on whether the volatile acids are retained during cooking or not.

The presence of a variety of sulphur compounds imparts a distinct flavour to the vegetables, which contain these. The sulphur compounds may be present either as volatile compounds or as complex compounds from which volatile organic sulphur compounds are released when the vegetable is cut or cooked.

The characterististic penetrating flavour of garlic, onion and related species is due to sulphur compounds. The peppery flavour of radishes, mustard and the vegetables is also contributed by organic sulphur compounds. Cabbage, turnip, cauliflower and white mustard owe their flavour to yet another sulphur compound. Incidentally, the strong flavour of mustard oil is also due to occurence of organic sulphur compounds in it.

Most acceptable vegetable products are made by cooking vegetables only to the just done stage. Prolonged cooking produces undesirable flavours due to formation of hydrogen sulphide and organic sulphur compounds.

The change in flavour during preparation depends on the kind of sulphur compounds present. Vegetable such as onions, which have strong flavour when raw, become mild with cooking. Cabbage and such others, which are mild when raw, become strong flavoured, with increased cooking time, indicating release of volatile sulphur compounds from other complex compounds during cooking.

TABLE 12.3 Factors Affecting Plant Pigments

S. No.	Food source	Name of the pigment	Colour	Soluble in	Effect of prolonged heat	In presence of	
						Acid	Alkali
1.	Leafy green vegetables	Chlorophyll	Green	Fat	Olive green	Olive green	Intense green
2.	Carrot, Mango Tomato	Carotene	Yellow	Fat	May darken	No change	No change
3.	Beet root	Anthocyanin	Red	Water	Little	Bright red	Bluish purple
4.	Cauliflower Potato	Flavones and Flavanols	White or yellowish	Water	May darken	White	Yellow

Effect of Heat on Vegetables

Vegetables undergo profound changes in appearance, texture, flavour and colour, during cooking.

All vegetables soften when cooked, due to change in their cellular structure. The cell proteins are denatured and precipitated, leading to the oozing out of solutes and water. The rigidity of cell wall and structural tissues is lost. The starch granules swell, become gelatinized, hydrolyse to dextrins and moisture, cooked potato is an excellent example of this phenomenon.

The colour changes which occur, depend on the pigments present (Table 12.3).

Carotenoids are fat soluble pigments, which are not affected by acids or alkaline medium and normal cooking temperature. If cooked for prolonged period, the colour may darken.

Chlorophyll The colour becomes intense when exposed to heat, due to loss of air from intercellular space. It turns olive-green, when heated for prolonged period or when heated in the presence of acid. When green vegetables such as spinach or beans are cooked with lid on, the volatile plant acid released dissolve in the steam and are condensed into the pot where they react with chlorophyll to form pheophytin. Pheophytin is an olive-green coloured compound. If the cooking water is alkaline, the green colour of chlorophyll becomes intense.

Anthocyanins are soluble in water, and the colour may be leached if the vegetable is cut and cooked. Therefore, vegetables such as beet root is cooked whole to avoid loss of colour. The red colour is intensified by adding acids such as lemon juice or vinegar, as a dressing . In the presence of alkalies, the anthocyanins turn blue-green.

Flavones or Anthoxanthins Are also soluble in water. Their colour darkens on prolonged cooking. In the presence of acid, these turn white and in alkaline medium they turn yellow.

Flavour Changes occur when vegetables are cooked. The changes are brought about due to the sum total of changes in the components present. The starch granules hydrolyse partially during cooking to dextrins and maltose, which results in an agreeable sweet flavour. The solutes such as acids, salts, sugar are released and contribute to the flavour. The flavour is further modified by the release of volatile compounds present. Thus, the flavour changes during cooking of vegetables are a sum total of all the changes that occur in components simultaneously.

The extent of these changes depends on the length of cooking period, the pH of the cooking medium, the manner in which the vegetable is cut and whether it is cooked with or without a cover.

The taste of the cooked vegetables is dependent on all the changes that occur in the components and the method of preparation used. It is further modified by addition of ingredients such as salt, pepper, jaggery, spices, herbs to blend the flavour and to obtain a tasty product.

How to Minimize Nutritional Losses

Vegetables provide some vitamins A and C, proteins, minerals and fibre in our dietary. They provide a variety of textures and colours, which improves the acceptability and intake of the staple foods.

The losses in vegetable preparation may be quantitative as well as qualitative. Quantitative losses occur when edible parts of vegetables are discarded. For example, when leafy vegetables such

as colocasia are used, the stems which are delicious, may be discarded, due to ignorance of their possible use. Similarly soft stems of fenugreek (*methi*), amaranth and other leafy vegetable may be discarded. Thus, the vegetable eaten may be only half of the quantity purchased. Qualitative losses include losses of soluble nutrients. As we know, ascorbic acid or vitamin C and thiamin are two water-soluble vitamins, which may be affected by cooking. If vegetables are cut and then washed, some loss of these vitamins and other soluble components may occur from the cut surfaces of vegetables. When the vegetables are cooked in water and the water is discarded the dissolved nutrients may be lost. Such loss may amount to about five to ten per cent. About twenty per cent thiamin is destroyed in normal cooking. If the food is reheated, it leads to additional loss of thiamin.

As mentioned in Chapter 3, vitamin C is the most labile vitamin. The average cooking losses range from 25 to 35 per cent. Therefore, preparation procedures that minimise losses of vitamin C result in conserving all other nutrients.

Please follow the following guidelines to minimise losses of nutrients and flavour during preparation:

1. *Wash* vegetables before cutting.
2. *Use* some raw vegetables to add colour, texture and to retain nutrients.
3. Vegetables and salads should be prepared *just before* serving.
4. *Use of acid foods* such as lime juice, tomatoes, vinegar or curd (as dressings in salads) *prevents* loss of vitamin C, because it is stable in acid medium.
5. Cut vegetables *just before* cooking and introduce into the heated oil used for seasoning and cook until just done.
6. Use a vegetable *peeler* to remove skin as it helps to remove a very thin layer of skin.
7. Cut vegetable *just before* cooking and introduce into boiling water, if it is to be cooked in water.
8. Use *just enough* water for cooking, if the vegetables or other foods are to be served as such.
9. Cook foods until *just done* and serve immediately.
10. Cook roots and tubers, whole with skin, to retain flavour, and nutrients. For example, potatoes, sweet potato, beet root, colocasia.
11. After the *first couple of minutes* of cooking to permit volatile plant acids to escape, cook vegetables *covered* on a low flame to reduce losses of nutrients.
12. *Avoid the use of soda* in vegetables, as it increases the loss of vitamin C and B-complex vitamins–thiamin, and riboflavin.
13. When preparing soups, the slowest cooking ingredient should be cooked first, followed by the addition of other ingredients, which cook in a shorter time. For example, meat needs longer time and hence can be cooked half–way before adding vegetables, which need much less time. This procedure helps to avoid overcooking of the vegetables.
14. Spices and other flavour ingredients should be added in the oil used for seasoning, as the flavour compounds which are soluble in fat, are thus easily dispersed in the preparation with the oil or fat.

Buying, Care and Storage

Most fresh vegetables and fruits retain their freshness for a short time under ideal conditions of storage. Standards for selection of vegetables vary with the specific commodity. In general, freshness, uniformity of size, colour, degree of ripeness and freedom from defects are the qualities most frequently sought. When purchasing, select fresh vegetables and fruits, which are firm, crisp, bright in colour, with no visible bruises or signs of decay and wilting.

At the peak of season, each vegetable and fruit has the *highest nutrient* content, *flavour* and is available at a reasonable price. It is, therefore, advisable to buy vegetables and fruits *which are in season*, as the quality is high and the price low.

Leafy vegetables include all *sags* or *keerai* such as amaranth, bathua, coriander, fenugreek (*methi*), spinach (*palak)* colocasia leaves, mint and mustard. Dark green, leafy vegetables are good sources of minerals, iron and calcium, and vitamins A, C and some of the B-complex vitamins.

Select clean leafy vegetables, which are tender, crisp, brightly coloured and free from flowers, insects, mud and spots or holes in the leaves. In head vegetables, such as cabbage, the hard, heavy and compact heads, free from bruises and worm injury, are a good buy.

Other vegetables include stems, fruit vegetables such as brinjals, cucumber, all gourds, pumpkin, ladies finger, giant pepper, tomatoes, cauliflower, pods such as cluster beans, french beans, immature seeds-corn, *wal*, *chawali* and peas, and all other vegetables, which are not included in the groups leafy or roots and tubers.

Generally, tender, firm, crisp, bright coloured vegetables free from worm injury, are selected and over mature, dry, wilted, shrunken, shrivelled discoloured vegetables are rejected. Small or medium sized vegetables are likely to be more tender and less fibrous in texture than large and very mature ones. Each vegetable is selected according to the preparation in which it is to be used. For example, tomatoes used for salads need to be large and fleshy; small and medium sized ones can be used in mixed vegetables or stews.

Root vegetables include potatoes, sweet potatoes, onions, tapioca (cassava), colocasia (aravi), yams, and many lesser known varieties of roots and tubers. In general, the roots and tubers should be firm, heavy, free from sprouts, heavy in relation to size, with shallow eyes and without green discolouration. The varieties, which hold their form in cooking are preferred in most preparations.

Onions-select hard, well-shaped globes, with dry skins, free from spots and bruises.

We must remember that vegetables and fruits continue to respire after they are harvested. Harvesting disturbs the normal life processes, and vegetables start losing their vitality, turgidity and food value. The harvested vegetables continue to respire during transport and storage. This involves the using of oxygen, the metabolism of cell food materials, and the release of carbon dioxide, water and energy. Most of the energy is released in the form of heat. The process of respiration must be slowed during storage, by control of temperature and relative humidity, in order to minimise these processes.

Vegetable tissues change during storage. These changes include loss of water, modification of the fibres, and change in the pectins. The loss of water is reduced by storing vegetables in an atmosphere of high relative humidity. Removing the tops of radishes, carrots onions, reduces loss of moisture, due to decrease in surface area. Peas in pods keep better than when shelled. Peas and corn become less palatable during storage due to sugar being converted to starch. It is better to buy these vegetables only in the quantity needed for immediate use. Succulent vegetables should be kept cold in a dampened cloth or in a covered ventilated container. Roots and tubers may be stored in a cool, ventilated place, the storage temperature being maintained between 3 and 10°C (38–50°F) to keep sprouting to a minimum. Only sound vegetables should be selected and stored; even a few bruised tubers may contaminate the entire lot.

Leafy and other vegetables and fruits start ageing soon after harvest. The crispness and flavour of green leafy vegetables deteriorates as water evaporates from it. These changes, related to ageing, are retarded by low temperature storage.

Leafy and other vegetables tend to shrivel and become unpalatable when stored uncovered in the refrigerator. Most refrigerators provide at least one covered container called *a crisper* for storage of vegetables and fruits. Use of plastic bags for storage of clean dry vegetables and fruits, retards the evaporation of moisture.

Salads

Salads bring a variety of colours, textures, flavours and taste to the menu. Their cultural importance is evident from the fact that no menu for a feast or a guest meal, is considered complete without it. In fact, a number of salads are included in the menu for special occasions.

Vegetables used to prepare salads contribute some protein, vitamins and minerals to the dietary. Vegetable salads are an important means of providing part of the need for fibre.

Each vegetable has its characteristic texture and colour. Further vegetables can be grated, diced, cubed, or cut into a variety of shapes to prepare salads.

The orange colour of carrots, the pale green of cabbage, the red colour of tomatoes, the green peppers and the white colour of cucumber, all indicate the variety of colours available to make attractive salads.

Some of the favourite combinations in traditional Indian salads are given in Table 12.4.

TABLE 12.4 Indian Salads and Dressing Used

Vegetables	Dressing used
Tomato and Cucumber	Curd
Carrots	lemon juice and seasoning with oil, mustard, green chillies and crushed, roasted groundnuts

(Contd)

Vegetables	Dressing used
Cabbage	lemon juice and seasoning with oil, mustard, green chillies and crushed, roasted groundnuts.
Cucumber	curd and seasoning with oil, mustard and green chillies.
Radish	curd and seasoning with oil, mustard and green chillies, addition of ground mustard.
Beet root (cooked, grated)	lemon juice, seasoning with oil, cumin seeds and green chillies, addition of crushed groundnuts.
Cabbage and chana *dal*	Soaked coarsely ground chana *dal*, lemon juice, seasoned with oil, mustard and green chillies.
Sprouted Mung	grated coconut, lemon juice, seasoned with oil, chillies, mustard and asafoetida.

It is important to select fresh, crisp, tender vegetables for salads. Thorough cleaning is an important step, as most of the salads are made from raw vegetables. These should be washed in a large basin of cold water. This step is especially important in case of coriander leaves, mint leaves, lettuce, used in salads. Washed leaves should be drained in a collander, wrapped in a clean damp muslin cloth and placed in the refrigerator or a cold place, until use. If the greens are wilted, place them in ice cold water for an hour or so. Add a table spoon of lemon juice to water to freshen the vegetable quickly.

Salads should be mixed just before serving. The cold, moist ingredients must be placed in the salad bowl. Add the dressing and mix lightly, without breaking or mashing the pieces.

Vegetable cutters, which cut vegetable into attractive pieces are available. These may be used to make decorative salads.

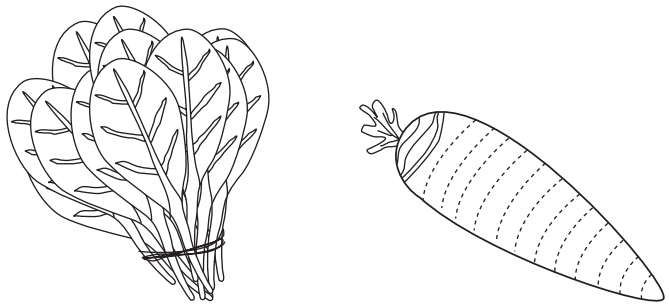


Fig. 12.2 Carotene-rich Foods

In the Indian menu, variety of salads are made from the same vegetable by modifying the dressing. The emphasis is more towards an agreeable blend of flavours rather than attractive presentation of a bland salad some vegetables used to make Salads are shown in Fig. 12.2.

Fruits in Salads

Pineapple, orange or grape fruit segments, apple cubes, papaya cubes, grapes, bananas, sapotas, mangoes, pomegranates are some of the fruits which can be used in a salad. Some of the fruits darken when cut. Addition of lemon juice, light syrup or thin custard, helps to prevent darkening.

Points to Remember

Vegetables are the plant's parts other than fruits, served raw or cooked as a part of meal.

Vegetables are classified on the basis of part of the plant used. For example, leaves roots and tubers and other vegetables, which include fruits, flowers, stems and shoots as also immature beans and peas.

Leafy vegetables are an excellent source of beta-carotene (a precursor of vitamin A), vitamin C, iron and calcium.

Roots and tubers supply energy from starch. Carrots supply beta carotene also.

Other Vegetables provide few calories, some minerals and vitamins. Immature beans and peas provide some protein (3–6%) and B-complex vitamins.

Colour Pigments Chlorophyll (green) and carotenoids, which are fat soluble are found together in leaves. Water solube flavonoids are found widely distributed, the red-blue anthocyanins are present in few vegetables, but cream white ones are found everywhere. Pigments are affected by pH and heat.

Vegetables provide a variety of colours, textures and flavours. To minimise nutritional losses, all edible parts of vegetables must be used, after cooking in minimal time and water and eaten promptly.

Select fresh, tender, crisp vegetables, store in cool, covered humid atmosphere to minimise losses in weight, turdigity and quality.

Salads must be made from crisp, fresh tender vegetables, after thorough washing and seasoned to blend flavours.

Study Questions

1. What are vegetables? How are these classified?
2. Why are leafy vegetables included in protective vegetables group?
3. What are other vegetables? Give examples to support your answer.

4. What are the plant pigments found in vegetables? How are they modified in preparation?
5. What can one do to minimise colour, texture and nutrient losses in vegetable preparation?
6. List the points to be considered in the selection and storage of vegetables.
7. Why should salads be included in our menu?
8. List some of the common Indian salad dressings. Where is each one used and what is its function?

13

Fruits and Fruit Preparations

Fruits are the mature ovaries of plants, which contain the seeds. Fruits are produced from a flower or flowers. The edible portion of most of the fruits is the fleshy part of the pericarp, surrounding the seeds. Many fruit vegetables are fruits of those plants. The word fruit, as used in this book in the context of food science, is restricted to those fruits, which on ripening soften with distinct desirable changes in colour and flavour. Fruits are pulpy, often juicy, with an exquisite blend of sweet and sour taste, fragrant aroma and flavour. Ripe fruit is nature's inimitable poem of aroma, colour and flavour.

Fruits may be classified according to the number of ovaries and flowers from which it develops. Thus, some of the classes may be; *simple* fleshy fruits; citrus fruits–oranges, lemons, limes, grapefruit.

Multiple fruit pineapple, developed from a cluster of several flowers.

Drupes which have a stone or pit to hold the seed, e.g., mangoes, amla, apricots, cherries, peaches, plums.

Pomes which have a sac, which holds the seeds, apples and pears.

Aggregate fruits which are developed from several ovaries in one flower, such as strawberries, black-berries, raspberries.

Composition

Fresh fruits have a high water content (70–96%), varying amount of carbohydrate (3–27%) and fibre (0.2 to 3.1%), and a low content of protein, fat and minerals (Table 13.1). Most fruits contain an edible part combined with some inedible refuse.

There are some fruits which are wholly edible such as berries, guava, grapes and tomato, while apples, pears, peaches, cherries and sapota have 85–90% edible portion. Other fruits, such as bananas, sweet lime, orange, and pineapples contain a third or more inedible refuse.

The carbohydrate in the fruit is made up of fructose, glucose, sucrose and starch as well as some fibre. The carbohydrate content of fruits varies from 3 in watermelon to 27 per cent in banana. Most of the energy of fruits (80 to 96%) is provided by the sugars present. Therefore, fruits or fruit juices are given when a quick source of energy is needed, e.g., as appetizers and as refreshing drink for athletes.

Fruits contain some free organic acids. Malic and citric acids are present in most of the fruits, while tartaric acid is a prominent constituent of grapes.

TABLE 13.1 Composition of Fruits[1, 2] (per 100 g E.P.[3])

Fruits	Moisture	Calories	Carbohydrate	Fibre	Protein	Minerals
Very High Moisture Fruits Watermelon, musk melon, tomato	95	16–20	3	0.2–0.8	0.2–0.9	< 0.5
High Moisture Fruits Orange, sweet lime, grapefruit, pummelo, papaya, pineapple, strawberry.	90	32–48	9	0.3–1.0	0.4–0.8	< 0.5
Medium Moisture Fruits Amla, cashew fruit, guava, apple, peach, pear, plum, blue grapes	85	50–59	12	0.4–5.2	0.2–1.2	< 0.9
Low Moisture Fruits Mango, grapes, bor	80	71–74	6	0.7–2.9	0.6–0.8	< 0.6
Very Low Moisture Fruits Banana, sapota, seetaphal, jackfruit	73	88–116	24	0.4–3.1	0.7–1.9	< 0.9

1. ICMR, Nutritive Value of Indian Foods, 1971.
2. The fat content of all fruits listed is < 0.5%, exception Sapota 1.1%.
3. E.P.—Edible portion.

Fruits are generally acidic and sweet. There are a number of other flavour components, which give distinctive taste and flavour to each variety of fruit.

There are many varieties of fruits in the tropical region. These include bananas, papayas, pineapples, mangoes, guavas, melons, lemons, limes, grapefruits, pomoloes, oranges, tangerines, dates, figs, berries, etc. A cross-section of some of the fruits is given in Fig. 13.1.

Fruits are the important sources of provitamin A and vitamin C.

Many tropical fruits, such as *amla*, cashew apples, *bor*, guava contain three to ten times the vit. C found in citrus fruits.

Some dry fruits are rich source of minerals, calcium and iron.

Fruits have a protective tissue, which may take many forms such as peel, skin or rind. Surface of these protective structures is waxy, which helps in retaining the moisture, which is necessary to retain the freshness of a fruit.

The presence of a waxy outer cover helps citrus fruits to retain vitamin C even on exposure to high atmospheric temperature.

A variety of fruits are grown in tropics. These are depicted in Fig. 13.2.

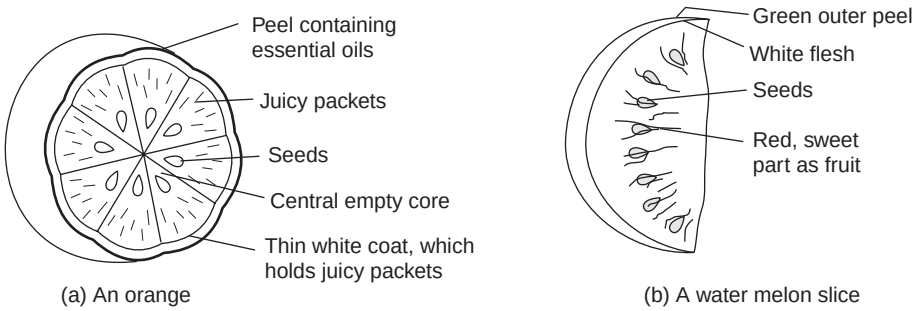


Fig. 13.1 (a) and (b), A Cross Section of some Fruits

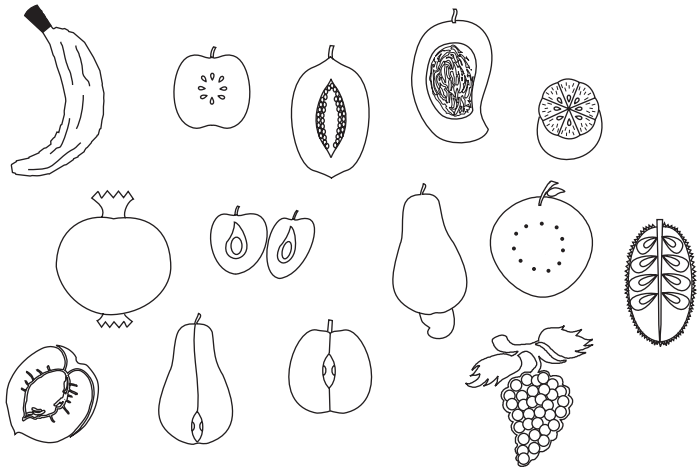


Fig. 13.2 Variety of Tropical Fruits

Fruits contain pigments, which are responsible for their colour. The orange-yellow fruits contain beta carotene, which is converted to vitamin A, when absorbed from the digestive tract.

Serving of Fruits

Usually fruits are eaten uncooked. Fruits can be served whole, sliced, in the form of juice, or fruit salad.

Fruits are an important source of vitamin C. As exposure of cut fruit to the air results in loss of part of the vitamin C, fruit should be eaten soon after it is pared or sliced. The knife used for cutting or paring should be of stainless steel, with a sharp blade. Vitamin C is quite stable in acid foods, it is advisable to squeeze a slice of lime on fruit salad to prevent loss of vitamin C. The contact of cut surfaces, with air, can be reduced by adding a light syrup, or adding cream, which would help in reducing loss of vitamin C. Storage at refrigerator temperature also reduces loss of vitamin C.

Some fruits, such as banana and apples, darken when cut surface is exposed to air. The darkening of such fruits can be prevented by covering these with a light syrup, cream or lime juice and sugar.

The protein content of most fruits (with the exception of banana, seetaphal and jackfruit) is less than one per cent. The fat content is less than 0.5 per cent, with the exception of sapota (1.1 per cent) and avacado pear (22.8 per cent).

Nutritional Contribution

Fruits are valued for their contribution as quick sources of available energy. The soft texture of most fruits, permits their use in infant diets, diets for the aged, and the sick. The fruits with lower carbohydrate content find place in energy restricted dietaries also.

In India, there are fruits, such as *amla*, guava, cashew fruit, which are extremely good sources of vitamin C, providing 180 to 600 mg of vitamin C per 100 g edible portion. The choice of fruits, as sources of vitamin C, is large in tropical countries, as can be observed from table 13.2. The quantity of fruit eaten may have to be increased, if a source containing medium or low amount of vitamin C is used. Fruits such at papaya, orange and mango, which contain orange-yellow pigment carotene, provide this precursor of vitamin A.

TABLE 13.2 Nutritional Contribution of Fresh and Dry Fruits[1] (per 100 g E.P.[2])

Fruit	Vitamin C (mg)	Carotene C (mcg)	Calcium (mg)	Iron (mg)
Fresh Fruits				
Very High Vitamin C Fruits Amla, cashew fruit, guava	180–600	0–23	10–50	0.2–1.4
High Vitamin C Fruits Cape gooseberry, Sweet lime, papaya (ripe), Strawberry, bor, orange juice	49–76	666–1428	4–40	0.3–2.0
Medium Vitamin C Fruits Grapefruit, safed jamb, lemon, lichi, orange, persimmon, pineapple, seetaphal, tomato ripe	27–39	0–1104	17–70	0.1–2.3
Low Vitamin C Fruits Banana, Cherries, blackberry, jack-fruit, jambufruit, ripe mango, muskmelon, passion fruit, pomogranate, pummelo	7–26	0–2743	10–54	0.3–2.0
Apple	1	0	10	1.0
Dry Fruits Raisins, apricots, dates, black currants	1–3	2–58	87–130	4.6–8.5

1. I.C.M.R. *Nutritive Value of Indian Foods*, 1971.
2. E.P.—Edible portion.

Fruits are not very good sources of calcium. Berries such as strawberry, raspberry, mulberry, bor, sapota, peaches etc. are a fair source of iron. Dry fruits, if available, can contribute appreciable amounts of iron to the diet.

The cell walls, the fruit skin, and all structural part of fruits are made up of celluloses and hemicelluloses, which are polysaccharides. The pectic substances, which cement the cells together, are found in the cell walls. These polysaccharides are not digested in the human body. However, these substances do have an ability to imbibe large quantities of water and get swollen. The food residue is thus softened and passes smoothly through the intestine.

Flavour Constituents

Many compounds contribute to the characteristic flavour of each variety of fruit. These include sugars, organic acids, organic esters, tannins and mineral salts. Organic esters and organic acids impart their individual odour and flavour to fruits. Many acids occur either in free form or as salts. Malic and citric are the most commonly occurring acids in fruits.

Besides these, sugars and mineral salts present also contribute to the flavour of the fruits. Tannins are another group of compounds, which contribute astrigency to the fruit flavour. Some fruits contain essential oils e.g. lemons and oranges have these in the peel.

In each fruit, one finds a unique blend of the flavour components. For example, a ripe mango can be identified by its aroma and flavour. In fact, each variety of mango has its own combination of flavour components, for example the flavour of Alfanso mango is distinct from that of *Payari* and *Totapuri* mangoes. Fruits are generally a blend of sweet and sour taste. Each fruit has a distinctive flavour and taste and as a group, fruits add a rich variety of refreshing flavours to our dietary.

Attempts have been made to identify flavour compounds from fruits and to synthesize these in the laboratory. Pineapple, orange, strawberry essences are available but it has not so far been possible to duplicate the natural fruit flavour and capture the true flavour synthetically.

Colour Fruits contribute a variety of colours to the dietary and add to its eye appeal. The plant pigments, carotenoids (mangoes, oranges), anthocyanins (*jamun, karvande*, blue grapes) and anthoxanthins and flavones (apples) are present in combination in fruits. The yellow orange cream—white and various shades of red blue pigments predominate in the fruit kingdom. Chlorophyll (raw mango, banana) is found only in the peel.

The pigments may be affected by preparation. Table 13.3 lists the changes that occur in plant, pigments due to heat, acidity and solubility, during preparation. This information may guide in retaining colour of fruits during preparation. It may be noted that use of acid fruits help to intensify the red colour of anthocyanins in fruits, e.g., *amrut kokam, jamun* squash etc.

Some colour changes, which occur in fruit after cutting and peeling are not desirable and efforts are made to minimise these. For example, apples and some bananas tend to brown when cut fruit is exposed to air. This is due to oxidation and it may be retarded by covering the cut fruit with acid (lemon juice) or sugar syrup.

Ripening of Fruit

Ripening of fruits is accompanied by changes in colour, texture and flavour. There is development of colour, the sequence of changes being distinct for each variety of fruit. There is change in texture due to change of protopectin to pectin in the cell walls. Varying amounts of sugars are formed from starch, which increase the amount of soluble solids. The fruits, which have a high amount of sugars formed during ripening, soften with ripening, e.g., banana, mangoes, papaya etc. In some fruits, the skin wrinkles and the fruit becomes soft with ripening.

The flavour changes include increase in sugar content, decrease in acidity, decrease in astringency (tannins) and development of aromatic flavour components during ripening. Usually white, green or yellow colour changes to pink dark yellow, orange or deep red, texture softens with ripening, e.g., banana, mangoes, papaya, etc. Wrinkles are formed and the fruit becomes soft, e.g., ripe mango and ripe papaya.

TABLE 13.3 Colour Changes in Preparation

Food source	Pigment	Colour	Change on exposure to			
			air	acid	alkali	excessive heat
Mango Orange	Carotene	Orange yellow	No	No	No	May darken
Jamun	Anthocyanin	Red	No	Bright red	Bluish purple	Little
Apple, Banana	Flavones	Cream white	Brown	White	Cream yellow	May darken

Some fruits, such as bananas, mangoes, papaya, are picked when mature and allowed to ripen in storage; while oranges do not ripen in storage and must be picked when ripe.

Preparation of Fruits

Fruits should be thoroughly washed before use, as residues[1] of insecticides may be adhering to the fruits. The fruits may have dust particles from atmosphere sticking to them. Washing helps to remove all such undesirable particles from the fruit surface.

Fruits are best eaten without cooking, as they have been customarily eaten in the tropics for centuries. For example, bananas are eaten right after peeling, oranges, *mosambis* and pummelo (*papanas*) are sucked after removing the rind. Mangoes and cashew apples are sucked to get the

1. As you may be aware the fruit trees are sprayed with insecticides sprays to protect the fruits from insect damage.

juice. In this manner of use, no loss of nutrients occurs (especially vitamin C), as the fruit is not exposed before eating.

Fruit salad is a colourful, refreshing and light dessert. It is very popular in the warm weather. It should not be prepared too long before serving, as the appearance, acceptability and nutrient content (especially vitamin C) may decrease. Some of the fruits, such as apples and bananas, used in fruit salad tend to darken (brown) on exposure to air. A dressing of lime juice or a light syrup helps to prevent contact of cut surfaces with air and thus delays the browning reaction.

Some fruits are cooked to add variety to the diet. A familiar example is the boiled plantain served in Kerala. It can be boiled, pressure cooked or roasted. Another fruit preparation is apple sauce. In all such preparations, it is important to use minimum amount of water for cooking and cook the fruit to *just done stage* to retain the delicate flavour and nutrients. It is important to use minimal amounts of sugar in fruit preparations, as excess tends to mask the delicate fruit flavour.

A number of fruit preparations are made such as squashes, jams and other preserves. These are included in the chapters on beverages and home-scale food preservation. The methods used in preservation of fruits are dealt with in Chapter 17 on **Food Preservation**.

Points to Remember

Fruits are mature ovaries of plants, which soften with change in colour and flavour on ripening. Classified according to the number of ovaries and flowers from which it develops into simple, multiple, aggregate fruits, drupes and pomes.

Fruits contain a large amount of water, very little fat and proteins and minerals. Starch and sugar content varies from 3 to 20 per cent and fibre upto 3 per cent.

Fruits contribute a quick source of energy. *Amla*, guava, cashew, apple and citrus fruits are very good sources of vitamin C. Supply fibre also.

Flavour components include sugars, organic acids (malic, citric, tartaric etc.) and their esters, tannins and mineral salts blended uniquely to give each fruit variety its individuality.

Colour pigments present in fruits are carotenoids (yellow-orange), anthocyanins (red-blue) and anthoxanthins and flavonols (cream-white); chlorophyll occurs mainly in peel.

Ripening is accompanied by change in colour, softening of texture and flavour. Fruits are best eaten as such, served as salad, juice, or baked. Fruit preserves include squashes, jams and others.

Study Questions

1. What is a fruit? How are fruits classified?

2. Match the following to indicate composition of citrus fruits:

Citrus fruits	Per cent composition
Water	0.5 per cent
Protein	7–11 per cent
Fibre	0.4–0.8 per cent
Fat	0.3–1.0 per cent
Carbohydrates	74–96 per cent
Minerals	0.4–0.0 per cent

3. Indicate the nutrients supplied by fruits in our dietary.
4. What are the flavour components in fruits?
5. List fruit colours and their properties.
6. What pigments do we find in fruits? List one fruit at least which contains each of these pigments.
7. List the recipes you make with fruit. Indicate the steps you take to retain the colour of the preparation.
8. What are the changes that occur when a fruit ripens?

14

Beverages—Tea, Coffee, Fruit Juices and Others

In medieval times, the term beverage was used to indicate alcoholic drink. In this century, a variety of drinks have been developed, which are non-alcoholic and the word beverages is now used to indicate all foods, which are consumed in liquid form. In fact, even water is included in this group as it is a universal beverage.

It is very essential to drink enough water and other beverages to meet the needs of the body. This is especially important in the dry hot climate found in some parts of India.

Beverages are liquid foods, which are served as drinks, with or without other foods.

There are distinct regional patterns in use of beverages in India. Tea is popular in the North, East, West and Central India, while in the South, it is coffee.

The use of beverage is determined by season, time of day and atmospheric temperature. For example, a hot cup of tea is enjoyable in the winter mornings when ambient temperature is below 20°C, but in the hot summer months *lassi* is served in Punjab, when temperatures are in the range of 40°C.

Beverages help not only to quench thirst, but aid the movement of food in the body. It would be difficult to swallow bread without a cup of tea. Traditional food combinations include liquids, which help smooth transport of food, e.g., rice—*dal*, rice—*kadhi*, *chapati*—*amti*, *idli*—*sambar* etc. Beverages such as fruit juices and soups are also used as appetizers before a meal. Beverages are included in the diets for invalids, small children and aged persons, as these are easy to digest.

As mentioned earlier, food has been a central part of our social life. Beverages have an important role in our social encounters e.g., tea/coffee is served at most meetings. Beverages are served to guests as a part of hospitality to express welcome. Thus, beverages have been a part of our food culture.

There is a variety of beverages, which we consume daily. Beverages are served either hot or cold.

Hot beverages include tea, coffee, soups, milk, cocoa and chocolate and other malt flavoured milk etc.

Cold beverages include fruit juices, drinks, milk, *lassi*, sherbets, soft drinks etc.

Some of these beverages are taken for their stimulating or refreshing effects, while others are taken as nourishment. For example, tea, coffee are the stimulating drinks, fruit juices, sherbets are refreshing beverages, whole milk, milk shakes, soups, eggnog, *lassi* or buttermilk are nourishing drinks.

Beverages are excellent stimulants or appetizers, which play an important role in our daily diet.

Beverages, which are prepared from fruit or vegetable contain vitamins and minerals and those prepared from meat, milk, egg or legume or cereal or millet provide some protein in addition to vitamins and minerals.

Tea, coffee, cocoa, chocolate, soups are hot beverages. Hot beverages should be served steaming hot.

Tea

The quality of a cup of tea depends on:

(a) the quality of the ingredients used–e.g., tea leaves, milk, sugar and water,
(b) the amount of tea leaves used per cup and
(c) the time of extraction or steeping the tea leaves

The soluble substances of the tea leaves constitute the beverage. Majority of persons do not like a very bitter cup of tea, therefore, it is necessary to limit the time of steeping tea leaves in boiling water between one and three minutes to get the desired strength of beverage. The tea should be strained at the end of steeping into the teapot for serving to avoid excess bitterness in later portions of tea. The quantity of tea leaves varies with taste. One teaspoon for three cups gives a very light golden coloured tea; one teaspoon per cup is used when a strong dark extract is desired.

Tea Three types of tea is available in the market—tea leaves, partially broken tea leaves, and powder. A number of blends of these are available under a number of brand names. The choice of the blend is made, based on the flavour, body and taste of the brew.

Milk Milk is normally added to tea in India. Its composition and freshness affects the quality of tea made from it. The type of milk used (cow's or buffalo's) is a matter of individual taste. It is observed that the amount of milk needed to produce an acceptable colour is smaller if whole milk is used. It is important to use just boiled milk to get the best product. This is understandable, for the fat of milk tends to separate with repeated heating of milk and this affects the quality of tea made from it.

Sugar Any impurities in the sugar affect the flavour of tea adversely.

Water Soft water is preferable to hard water in preparation of tea or coffee. The water should be freshly boiled to avoid a flat taste.

Tea can be prepared by introducing tea leaves into boiling water in a kettle or by pouring boiling water over the tea leaves in the preheated teapot and letting it steep. The time of steeping depends on the strength of beverage desired and the quantity of tea leaves used.

Tea can be prepared by pouring boiling water over a cheesecloth or paper bag holding the tea leaves. In this method, known as *tea-ball method*, it is easy to remove the tea leaves when the desired strength is reached. Now tea bags are available in the market and employ the same principle of making tea as the tea-ball method. The tea bag is dipped in boiling water for a short period of time to obtain the desired strength and flavour.

Coffee

Good coffee must be freshly made, with the same attention to quality as in the case of tea.

The soluble extract of roasted, ground coffee beans constitute the beverage. It is necessary to avoid loss of flavour substances by using temperature between 90 and 100°C. The time of extraction should be carefully controlled to avoid extraction of undesirable amount of bitter substances.

Coffee can be prepared by—

(a) Filtration or (b) Percolation

(a) *Filtration* This is a very common method used to prepare coffee. A coffee filter as shown in the figure is used (Fig. 14.1). Coffee powder is placed in the top part of the filter and covered with a disc, which is perforated. Boiling water is poured over the coffee powder and it drips through it, and extracts the flavour and aroma.

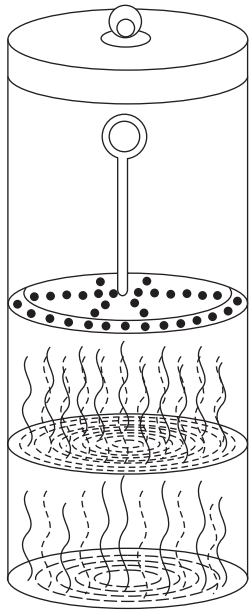


Fig. 14.1 Coffee Filter

The size of the grind used depends on the kind of filter used and perforation.

(b) *Percolation* In this method, the heated water is forced upward through a tube into the coffee compartment. When it filters through, it extracts the coffee flavour. The water filters through coffee several times, before the desirable strength is obtained.

The coffee prepared in either way needs to be served quickly to avoid loss of aroma. It is not advisable to reheat coffee.

Instant coffee powder is now available in the market. It is prepared by pouring boiling water over the instant coffee powder placed in a dry cup. The water cools a little due to loss of heat to the

container, so that the temperature is between 90°C and 95°C, which is ideal for retaining the aroma. *Never* boil coffee, as it results in loss of aroma and flavour.

Coffee is served as such or with addition of hot milk and sugar as desired.

Coffee, tea and carbonated drinks provide us with caffeine; Cocoa provides us with the obromine. Both are stimulants. Consumption of caffeine increases output of work but accuracy is decreased. Caffeine content of beverages is indicated in Table 14.1.

Excessive intake has adverse effects on the health of a person. In pregnant women, excessive intake can affect their foetus.

Chocolate, Cocoa, or other Beverages

These are popular flavours added to milk and served hot or cold as a beverage with addition of sugar as desired. These are soothing and are beverages with high nutrient content, when dissolved in milk.

TABLE 14.1 Caffeine Content of Beverages[1]

Beverage	Caffeine in mg/140 ml
1. Coffee	90
2. Cocoa	19
3. Chocolate	20
4. Tea	30
5. Instant coffee	66–74
6. Percolated Coffee	90–120

1. Jour. Am. Med. Assn. 229–337 1974.

Chocolate

Chocolate is manufactured from cocoa beans. Pods from cocoa trees which, contain the beans are split open, the beans with the adhering pulp removed, allowed to ferment for several days. The liquid formed during the fermentation is drained off and the bean residue along with the pulp are roasted and broken into small pieces. The husk is removed and the roasted bean known as *nibs* is used to manufacture either cocoa or chocolate. The nibs which contain cocoa and cocoa butter (50 per cent) are finely ground to produce a brown liquid known as *cocoa mass*. Cocoa powder is manufactured by squeezing out part of the cocoa butter from the cocoa mass and powdering the residue. Chocolate is produced by mixing the cocoa mass, cocoa butter and finely powdered sugar. For milk chocolate production, either milk solids or full cream condensed milk may be incorporated.

Soups

Soups are prepared with vegetables, pulses, poultry and meat. The food, which is to be used for making soup is cooked thoroughly in plenty of water. When only the water, in which food has been

cooked, is used, it is known as *clear soup.* It contains the soluble nutrients of the food. In preparation of cream soup, cooked vegetable is blended with the cooking water and white sauce is added to the blend to obtain thick consistency. *Cream soups* are very nourishing, as these contain the cooked food and milk in the white sauce.

Sometimes vegetables, meat, bread cubes or other pieces are added to soups which you can chew. Such soups are known as *chowder soups*.

Hot soups are usually served before meals. In summer, *cold* soups are served as appetiters or as a first course in a meal.

Soups provide us with a variety of nutrients depending on the foods used in making these. Soups help to enhance your appetite. Vegetable soups can add colour to the meal.

Water

Water is the best natural drink. Water has very natural and acceptable taste. Water has gases like oxygen and carbon dioxide dissolved in it.

Besides these dissolved gases, there may be minerals, salts dissolved in it. This is the reason why taste of water varies from one source to another, for example, water from a well, a river, a spring have their individual distinct taste and is different from that of tap water. The water, which is distributed in cities, is normally treated to render it safe for human consumption. The treatment modifies the taste of the water to a certain extent.

Salts and minerals, which are dissolved in the water, impart a subtle, characteristic taste to the water. Water from natural springs has some mineral salts dissolved in it and is known as *mineral water*. This water is bottled and sold as mineral water. Taste of mineral water changes from place to place.

Fruit Juices

Juicy fruits can be pressed to obtain fruit juices. The most common fruit juices prepared in Indian homes are orange, musumbi and mango.

The natural colours of fruits are judiciously blended to make attractive fruit cocktails. The knowledge of reactions of plant pigments gained in Chapter 13, is helpful here.

Traditionally acid fruits are used to prepare *fruit drinks* with addition of water and sugar or jaggery e.g., *ratanbi panhe* or *mango panhe.* In some regions, salt is added to these fruit drinks. A variety of *fruit squashes* are made from many fruits by combining sugar syrup and fruit juice. Squashes have a long shelf-life, if these are prepared and bottled asceptically and sealed.

These juices provide us some vitamins, minerals and sugar, depending on the fruit used to prepare these.

Fruit pulp can be combined with cold milk and sugar to make a variety of milk shakes, e.g., banana, *chiku,* papaya or mango milk shake.

Synthetic Fruit Flavoured Drinks

A number or synthetic fruit flavours and colours are available in the market. These are used in fruit flavoured drinks available in the market. These may be in the form of powder, which are dissolved in water and served, or in the form of bottled syrups in which synthetic fruit flavours and colours are added.

Most of these drinks are mainly sweet, coloured and flavoured water.

It is important to distinguish these from fruit squashes, which are made from fruit juice.

The synthetic drinks may or may not have vitamin C added to it. *Do read the label* carefully to know what the ingredients are.

Carbonated Drinks

These are manufactured by combining water, sugar, citric acid, various flavours and/or colours. Finally the mixture is charged with carbon dioxide and bottled under pressure to make an effervescent drink.

The main nutritional contribution of such drinks is supply of energy from sugar in it.

Alcoholic Beverages

Toddy, beer and a variety of wines are included in this group. Wines are made mainly from grapes, toddy from palm exudate. Tribal people make wine from flowers of the mahua tree.

Controlled fermentation of sugar is the main process used in the making of alcoholic beverages. It is usually made from glucose or any sugar naturally present in the food. Different food stuffs can be used in the making of various alcoholic beverages like wine, cider, brandy, whisky etc.

The merits and demerits of consumption of alcoholic beverages have always been a disputed question. It must be noted that alcohol is a narcotic, a drug, a sedative. It provides energy to some extent.

It is very rapidly absorbed in the body. Dilation of blood vessel occurs due to its rapid absorption and as a result blood flows towards the surface. It may be emphasized that alcohol does not cure any disease, or infection.

It is not advisable to take alcoholic drinks on an empty stomach. The use of these beverages needs to be moderate, in view of its rapid absorption and sedative properties. It is advisable to serve snacks with the beverages. Snacks help to modify the effect of alcohol on the system. Individuals vary in their reactions to these beverages.

Points to Remember

Beverages are hot or cold liquid foods, served as drinks used to quench thirst, refresh, appetise.

Form a part of social and cultural food pattern.

Hot Drinks Tea, coffee, cocoa flavoured drinks, soups.

Cold Drinks Water, fruit juices, fruit squashes, fruit flavoured drinks, carbonated drinks, alcoholic drinks, *lassi*, butter milk.

Tea A stimulant. Quality depends on quality of ingredients, quantity of tea leaves per cup and time of steeping the tea leaves. Serve hot.

Coffee A stimulating drink. Extract flavour with boiling water in a filter or percolator. Serve hot, with hot milk and sugar, as desired. Do not reheat beyond 90°C.

Instant Coffee Place powder in a dry cup and pour boiling water over it.

Soups Prepared with vegetable, pulses, milk, poultry or meat. Clear soups are extracts and provide only soluble nutrients. Cream soups are blends of cooked food with white sauce and are very nourishing. Chowder soups contain pieces of cooked vegetables, meat or bread.

Provide variety of colours and nutrients.

Water Best natural drink. Quenches thirst. Taste affected by dissolved gases and minerals.

Fruit Juices Obtained as extract or blend of juicy flesh of fruits. Fruit squashes are extracts of acidic fruits with addition of sugar and water.

Synthetic Fruit Flavoured Drinks Made with synthetic flavours and colours added to sugar or syrup.

Carbonated Drinks Bottled by charging a blend of sugar, flavours and colours with carbon dioxide under pressure.

Alcoholic Drinks Made by fermentation of sugar to produce products with varying amount of alcohol and flavour components.

Is absorbed rapidly and needs to be taken in moderation to avoid adverse effects. Serve with snacks to dilute the effect on the system.

Study Questions

1. What are the different kinds of beverages served? Give examples.
2. What is the importance of beverages in our meal?
3. Indicate the factors which affect the quality of a cup of tea.
4. What are different ways of making coffee?
5. List the different kinds of soups.
6. What is the difference between a fruit flavoured drink and a fruit squash?
7. What is responsible for the stimulating action of tea, coffee and cocoa?

15

Spices and Flavouring Agents

India is known as the 'Home of Spices' all over the world. There are about 70 different kinds of spices grown in the world. Many of these are grown in India. There are many other tropical countries where spices are grown. Spices constitute an important group of agricultural products. Many countries depend on India for their supply of spices. Spices constitute an important part of India's exports.

Spices form an indispensable part of our cultural food pattern. The term 'spices' applies to natural plant or vegetable products or mixtures of these, in whole or ground form. These are used as seasoning, for imparting flavour, aroma and piquancy to foods.

As the definition indicates, spices may comprise of plant components or parts such as:

The floral parts, such as cloves, saffron.
The fruits, chillies, tamarind, cocum, cardamom.
The berries, black pepper.
The seeds, mustard, cumin, coriander, fenugreek.
The rhizomes, turmeric, ginger.
The roots, horseradish, loveage.
The leaves, mint, 'tejpat', bay leaves, curry leaves, coriander leaves.
The kernel, nutmeg.
The aril, mace.
The bark, cinnamon, cassia.
Exudate of bark asafoetida.

Figure 15.1 depicts some of the common spices used.

Spices impart a subtle flavour to foods. Their presence is evident by their irresistible aroma, which whets our appetite. They add zest and tang to otherwise insipid foods. Since minute amounts of spices are used in food preparations, the nutrients contributed to the meal are negligible.

Most spices are marketed as dry products. Spices may be used in whole or ground form. Some of the spices that are used in the whole form are mustard seeds, cumin seeds, cloves, black pepper. Mustard seeds and cumin seeds are added as seasoning in *dals.* Cloves and black pepper is used in some rice preparations such as *pulao, khichadi* etc. Most of the whole spices like pepper, cardamom, cinnamon, chilli, clove are also available in the powdered form. Some of these, like cumin seeds are roasted before being powdered.

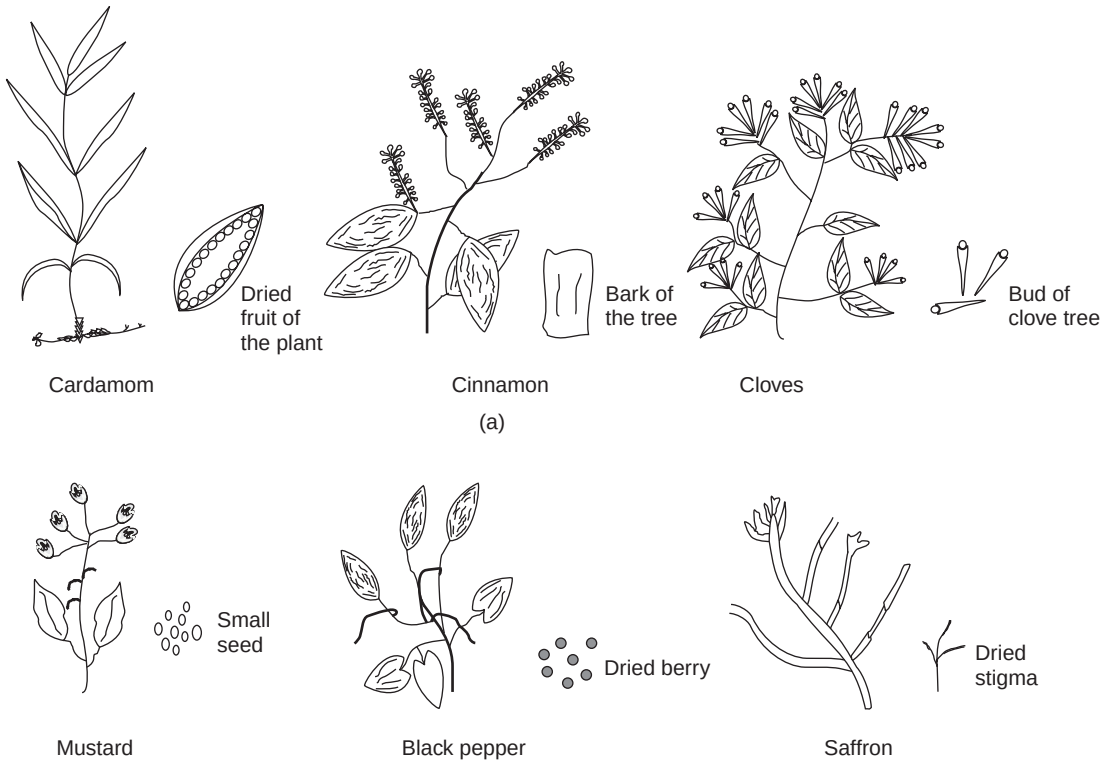


Fig. 15.1 Some Common Spices

Powdered mixes of spices are also available. They can be made at home, just before use or made in large quantities and kept aside for future use. Most of the constituents of these mixes are roasted, ground and mixed. More often than not other ingredients are also added to the mix like dehydrated coconut, roasted chana dal and urad dal. These additions not only balance the flavour, but also help in dispersing the powdered spice evenly in the food, in which it is to be added.

Spices that are used as colouring or flavouring agents should not be used in larger quantities than necessary as they may mask the original flavour and colour of the food. Examples of powdered spice mixes used in the home are '*sambhar powder*', '*garam masala*', '*dhana jeera*' etc.

Role in Cookery

Spices are used in small amounts in cookery as flavouring, colouring, appetizing and stimulating agent.

As a flavouring agent The flavour of spices is due to the presence of flavour compounds and essential oils which are volatile. For example the characteristic pungent flavour of chillies is due to an alkaloid called 'capsaicin'. The alkaloid piperine is responsible for the characteristic flavour of

black pepper. Almost all spices are used as flavouring agents. They may be used in the whole or powdered forms or mixed with other species. Species such as *tejpat*, cumin seeds, cinnamon, cloves, mustard seeds may be used in the whole form. Spices are usually added to hot oil as a seasoning or 'vaghar' or 'tadka' before being dispersed in the food. Oil acts as an effective solvent for the flavour components present in the spices. However, ground spices may also be added to the food directly e.g., pepper, cardamom, pepper, jeera powder etc. Spices mix well with the food.

Almost all spices used in Indian food preparations act as flavouring agents. Two flavouring agents not mentioned earlier are *tamarind* and *cocum*, both of which are used to impart a sour flavour to *dals*. Tamarind pulp and/or its extract is commonly used in South India. The food industry now manufacturers tamarind powder or extract which is readily incorporated into the food mixture. *Cocum* is widely used in western parts of India.

Other flavouring agents include vanilla, and fruit flavourings like lemon, orange, strawberry, rose etc., which are used in sweet preparations such as *halwas*, *ladus, cakes, ice creams* etc.

Sometimes, an extract of the flavour may be used. For instance, in the making of ketchup, the freshly mixed and ground spices are put in a muslin bag, which is dipped into the ketchup. The flavours are extracted from the spices which are not in direct contact with the food. In such cases, only a mild to moderate flavour is desired.

Colouring agents Turmeric is a common spice which imparts a yellow colour to foods, in which it is used. Saffron, which is the stigma of a flowering plant, imparts an orange colour to food. As it has an intense colour, saffron is needed in very minute quantities. The colouring matter is readily dispersed in oil or water. If these spices are used in excess, they impart an intense colour to the food, which is undesirable.

Appetizing and stimulating action A judicious use of the right kind of spices in a particular dish works wonders in improving its palatability. The attractive colour, stimulating odour and flavour literally makes one's mouth water. Spices stimulate the secretion of salivary juice, thus having an appetizing effect. Again, if used in amounts more than required, spices may on the other hand decrease the palatability of a food and thereby impair the appetite.

Thickening action Spices by themselves do not act as thickening agents unless they contain some starch. Spices that are roots of plants contain starch. This starch may be responsible for the slight thickening effect noticed when the spices are added to foods. Starch may also be added to a mixture of powdered spices as in 'sambhar powder' in the form of chana dal. However the main purpose of adding starch to a spice-mix is not to thicken the food in which it is to be used but to disperse the spice evenly in the food, e.g., as in dals and curries.

There are some points to remember in using spices and flavourings. Flavourings should be used in very small amounts as excessive use retards the flavour of the food product. The flavour components present in spices and flavourings are volatile organic compounds, soluble in oil, and very sensitive to high temperature. Therefore, it is advisable to add these to the food preparation almost at the end of the cooking process. The use of oil or fat in the preparation helps in retaining the flavour.

Excessive use of oil results in dulling the flavour. Excessive boiling the food may result in loss of flavour.

Ground spices being relatively low in moisture content, should be stored in air-tight bottles to prevent absorption of water, loss of flavour and spoilage.

Points to Remember

Spices 70 different kinds of spices grown in the world. India grows and uses most of these and exports some. Used in whole or ground form to impart flavour and aroma to foods. Powdered mixes of spices are marketed.

Roles in cookery—

As a flavouring agent
As a colouring agent
As an appetising agent
As a thickening agent

Spices should be stored in airtight bottles to prevent absorption of water and loss of flavour.

Study Questions

1. What are the different spices used in our foods?
2. In what forms are spices added to foods?
3. What roles do spices play in food preparation?
4. What are the flavouring agents? List some common flavouring agents used in foods.
5. What precautions should be taken when using spices in foods?

16

Food Preservation

Food preservation can be defined as the science, which deals with the prevention of decay or spoilage of food, thus allowing it to be stored in a fit condition for future use. The process used varies with the length of storage intended. It may be as simple as boiling milk so that it may keep for 24 hours or pickling of mango or lemon where the intended period of storage may be as long as a year.

Importance of Food Preservation

Food supply has to keep pace with the needs of the population. There is always a shortage of food in developing countries like India because of the demands of the increasing population. Increasing food production to meet this shortage results in wastage due to inadequate facilities available for storage and preservation. It is therefore, important to improve and expand facilities for the storage and preservation of food. Preservation of food helps in:

1. increasing the shelf-life of foods thus increasing the supply.
2. making the seasonal food available throughout the year.
3. adding variety to the diet.
4. saving time by reducing preparation time and energy.

Preservation increases availability of foods, thus improving the nutrition of the people. Availability of seasonal foods throughout the year also helps in stabilizing prices of such foods.

Food Spoilage

Food spoils, due to deteriorative changes that occur in it, that make it inedible or harmful. Foods change from the time of harvest, catch or slaughter. These changes may result in making the foods unfit for human beings.

There are several causes of food spoilage. These are

1. Growth of microorganisms, which bring, about undesirable changes.
2. Action of enzymes present in the food.
3. Oxidative reactions in the food.
4. Mechanical damage to the food (e.g., bruising of apples, bananas, mangoes, tomatoes).
5. Damage due to pests (e.g., insects and rodents).

Foods vary greatly in the length of time for which they can be held in their natural form without spoilage. For purposes of food preservation, foods are classified as perishable, semi-perishable and non-perishable. Perishable foods such as milk, meat, sea foods and many fruits and vegetables begin to deteriorate almost immediately after harvest if not preserved. These foods have a high moisture content and are highly susceptible to spoilage.

Microbial Spoilage

A number of moulds, yeasts and bacteria are known to cause food spoilage. Some of the micro-organisms exist both in active (vegetative cells) and dormant (spores) state. Spores, which are dormant cells, are more resistant to heat or other agents used to destroy micro-organisms than the vegetative cells.

Moulds You must have seen the fuzzy or cottony growth on chapati, bread or cooked rice. This is mould growth, which makes the food unfit to eat.

Moulds are plants, with a mass of branching, intertwined, multi-cellular filaments. These form spores, which are very light and coloured. The colour helps to identify the type of mould present. Moulds develop in warm, damp and dark places. Between 25 and 30°C, mould growth is *rapid*. Some mould growth can however, take place at lower temperature, *even* at refrigeration temperatures.

Most moulds are not harmful.

A relatively *small* number of moulds produce toxic materials in food. These toxins are known as *mycotoxins*. *Aflatoxins* are an example of this group. Aflatoxins are produced in harvested crops, such as groundnuts, wheat, millet and rye if these are not dried promptly after harvest and stored.

Yeasts grow usually on foods, such as fruits which have sugar and water. The musty smell of spoiled grapes is due to the growth of yeasts *on them*. Yeasts have usually spherical to ovoid cells and they reproduce by *budding* of these cells. Many yeasts grow best in acid medium and in the presence of ample oxygen. The growth is most rapid between 25°C and 30°C. Foods are often contaminated with yeasts and they can cause spoilage by conversion of the sugar present in the foods to alcohol and carbon dioxide. Foods liable to be spoiled by yeasts are fruit juices, syrups, molasses, honey, jams and jellies.

Bacteria are unicellular organisms and are much smaller in size than either yeasts or moulds. They occur in different sizes and shapes and are classified as coccus (spheroidal), bacilli (cylindrical) or spirillae (spirillar) on the basis of their shape as seen under the microscope. Bacteria vary in their requirements for food, moisture, acidity, temperature and oxygen. Bacteria can grow and develop rapidly between 20°C and 53°C. Bacteria usually cause spoilage in foods, which are neutral in their reaction, such as vegetables, milk, eggs, meat and fish. Some of them when ingested can be harmful to human beings. A few others can produce toxins in foods.

Bacteria that require for their growth:

1. A higher temperature than 45°C are known as *thermophiles*.

2. Temperatures between 20 and 25°C are called *mesophiles*.
3. Temperature less than 20°C are called *psychrophiles*.

Some of them need oxygen for growth (aerobic) and others grow only in the absence of oxygen (anaerobic). Some of them when ingested can be harmful to human beings.

The effect of different temperatures on microorganisms has been depicted in Fig. 16.1.

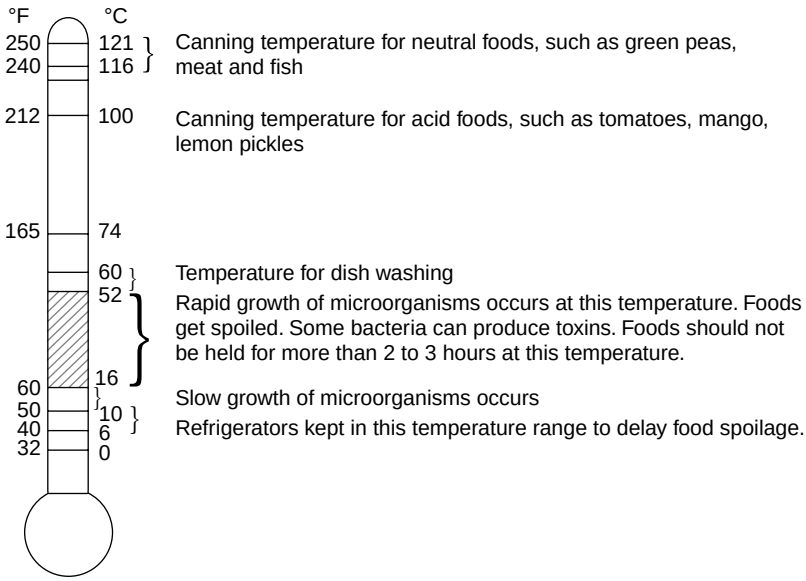


Fig. 16.1 Temperature of Food and Control of Microorganisms

Spoilage by Enzymes

Enzymes are organic catalysts produced by living cells. Many reactions in plant and animal tissues are activated by enzymes. They are proteins and hence are denatured by heat. The changes in foods during storage can be produced both by enzymes present in the food or by enzymes from micro-organisms that contaminate the food. A good example is the ripening of banana in which the enzymes present in the fruit hasten the ripening process. Beyond a certain stage, the enzymes can render the fruit too soft and unfit to eat. If there is a bruised spot in the fruit, yeasts could grow and produce enzymes, which could spoil the fruit. Enzymes can act from 0°C to 60°C. Their optimum temperature of reaction is usually 37°C, their rate of reaction varies directly with temperatures. All enzymes are inactivated by temperatures above 80°C.

Spoilage by Insects

Worms, bugs, weevils, fruit flies, and moths may damage food and reduce its nutrient content and render it unfit for human consumption.

It is thus evident that unless foods are handled, prepared, and preserved carefully they are susceptible to contamination and spoilage.

Food Preservation

Food preservation is the science which deals with the process of prevention of decay or spoilage of food.

Many physical and chemical changes—deteriorative and otherwise—begin to take place in foods from the time of their harvest to the time they are prepared, consumed and stored. Therefore it is essential that food be stored in ideal conditions of storage to prevent undesirable changes and to preserve its quality.

In order to preserve food, processing directed at inactivating or controlling microorganisms and enzymatic activity is necessary. However, it must be remembered that no method of preservation will improve the original quality of the product.

Principles of Food Preservation

The principles on which food preservation is based can be classified as follows:

1. Prevention or delay of microbial decomposition.
   (a) By keeping out microorganisms (asepsis).
   (b) By removal of microorganisms, e.g., by filtration.
   (c) By hindering the growth and activity of microorganisms, e.g., by use of low temperatures, drying anaerobic conditions or chemicals.
2. By killing the microorganisms, e.g., by heat or radiations.
3. Prevention or delay of self-decomposition of the food.
   (a) By destruction or inactivation of food enzymes, e.g., by blanching or boiling.
   (b) By prevention or delay of purely chemical reactions, e.g., prevention of oxidation by means of an antioxidant.
4. Prevention of damage by insects, animals, mechanical causes etc.

Let us examine each one of these principles with examples.

1. (a) *Asepsis*: Examples of asepsis (keeping out microorganisms) are many in nature. Shells of nuts such as almonds and walnuts, skins of fruits such as bananas, oranges, shells of eggs and the skin or fat on meat and fish are typical examples. Packaging prevents entry of microorganisms into food. A can of peas stays without spoiling because microorganisms can not enter the sealed can. Use of clean vessels and hygienic surroundings help prevent spoilage of milk during collection and processing by keeping out microorganisms.

(b) *Filtration*: This method can be used to remove microorganisms. Its use is limited to the preservation of clear liquids. The liquid is filtered through a "bacteria proof" filter made of asbestos pads, unglazed porcelain or similar materials and the liquid is allowed to percolate through with or without pressure. This method can be used successfully with water, fruit juices, beer, soft drinks and wine but is not very popular in industry because of its cost. Bacteriological filters are used for sterillsing water in households. Here the "candles" used for filtering the water are made of unglazed porcelain.

Fig. 16.2 Refrigerator—for Low Temperature Storage of Perishable Foods

(c) Hindering the growth and activity of microorganisms. Use of low temperature increases the lag phase of many microorganisms and thus prevents their growth in foods. A good example of this can be seen in the preservation of milk at refrigeration temperatures. Figure 16.2. Drying removes moistures from foods and microorganisms even if present in the food cannot grow due to lack of minimum moisture. Noodles, *papad* and raisins are examples of foods in which drying has been used as a method of preservation. Maintenance of anaerobic conditions in which there is no oxygen or only minimal amount of air present in the food hinders growth of many bacteria which need oxygen. Anaerobic bacteria and their spores which may be present have, however, to be killed or inactivated to prevent the food from being spoiled. Canned peas or aseptically packed fruit juices in hermetically sealed containers are good examples.

2. (a) *Heat*: Exposing food to high temperatures kills most of the microorganisms present and helps preserve food if it is not allowed to be recontaminated.

   (b) *Irradiation* irradiation of foods, which consists of exposing the food to either electromagnetic or ionizing radiations destroys the microorganisms present but has to be used with caution as it may render the food radioactive. An example of irradiation is the use of ultraviolet lamps in sterilising slicing knives in bakeries. Ionising radiations like α, β and γ rays have been used successfully for the preservation of vegetables, fruits and sea foods.
3. (a) *Blanching*: A good example of the destruction of enzymes to prevent self-decomposition of the food is the mild heat treatment given to vegetables before either canning or freezing called blanching. This can be carried out either by dipping the vegetables in hot water or by exposing them to steam for a few minutes. Heating milk is another example. Here the heat inactivates the enzymes present in the milk and extends its shelf-life.

   (b) *Prevention of oxidation*: Foods like oils and fats can turn rancid and become unfit to eat because of oxidation. This can be prevented by addition of small quantities of chemicals which prevents the oxidation of the fats. These chemicals are called "antioxidants".

Methods of Food Preservation

Food preservation methods can be broadly divided into two categories:

1. Bacteriostatic method in which microorganisms are unable to grow in the food, e.g., in dehydration, pickling, salting, smoking, freezing etc.
2. Bactericidal methods in which most of the microorganisms present in the food are killed, e.g., in canning, cooking, irradiation etc.

Bacteriostatic Methods

Altering environmental conditions so as to prevent growth of micro-organisms can help preserve food. Such conditions are called bacteriostatic (number of bacteria remaining static) and can be created by removal of water, use of acid, use of oil and spices, use of chemical preservatives and use of low temperatures.

Dehydration (removal of water)

Microorganisms need moisture to grow. When the moisture in the food is removed and the concentration of water brought below a certain level, they are unable to grow and spoil the food. Moisture can be removed by the application of heat as in sun-drying and in mechanical heating or by binding the moisture with addition of sugar or salt and making it unavailable to the microorganisms.

Sun Drying

In tropical countries like India, direct rays of the sun are used for drying a variety of foods. Vegetables and fruits are washed, peeled, prepared and placed on flat bottom trays under the sun. Vegetables like beans, peas, potatoes, cauliflower, lady's fingers, garlic, onion, and all leafy vegetables can be sun-dried. Fruits like apricots, bananas, dates, figs, grapes (raisins) raw mango (*amchur*), peaches, pears, pomegranate seeds (*anardana*) are also preserved by sun-drying. Fish (Bombay duck-bombil) and shrimp are dried by exposing them to the sun on the seashore. Preparations using cereals and pulses are also sun dried. An example is *papad,* which is a very popular snack throughout the country. As foods dried this way are exposed to dirt, insects and to the air, there is always a risk of contamination and spoilage.

Smoking

Foods can also be dried by exposing them to smoke by burning some special kinds of wood. In this method, while the heat from the smoke helps in removal of moisture, exposure to smoke imparts a characteristic flavour to the food. Fish and meat are the foods usually preserved by this method.

Mechanical Drying

Dehydrators and spray driers are examples of mechanical devices used for drying food. These are either heated electrically or by steam. Temperature and humidity are controlled in such equipment and hence a product of superior quality (better colour, correct texture and the right flavour) is obtained. Vegetables such as green peas, onions, soup mixes are usually dried in dehydrators. Milk powder, infant foods, instant coffee, and malted cocoa mixes are examples of spray dried products.

Addition of Salt or Sugar

Tying up (binding) moisture by addition of solutes such as salt or sugar also prevents growth of microorganisms and helps preserve foods. Dry salting is used in India for the preservation of tamarind, raw mango, *amla*, fish and meat. Lemon, mango and other such pickles also owe their keeping quality partly to the large amount (15 to 20 per cent) of salt added.

Jams and marmalades are prepared by boiling the fruit pulp or shredded fruit peels with sufficient quantity of sugar (about 55 per cent by weight) to a reasonably thick consistency, firm enough to hold the fruit tissues in position. They are later packed hot into glass jars or tin cans and sealed. The same process is used for jellies except that fruit juices are used in place of fruit pulps. The high concentration of sugar and other solids (about 68 per cent) binds the moisture making it unavailable for microorganisms to grow. Anaerobic conditions prevail on sealing and the application of heat kills most of the yeasts and moulds. All these factors contribute to an increased shelf-life of the product.

Use of Oil and Spices

A layer of oil on top of any food prevents growth of microorganisms like moulds and yeasts by preventing exposure to air. Thus, certain pickles in which enough oil is added to form a layer at the top can be preserved for long periods. Spices like turmeric, pepper, and asafotida have little bacteriostatic effect and their ability to prevent growth of microorganisms is questionable. Their primary function is to impart their characteristic flavour to the food.

Use of Acid

Acid conditions inhibit growth of many microorganisms. Organic acids are added or allowed to form in the food to preserve them. Acetic (vinegar), citric (lime juice) and lactic acids are commonly used as preservatives. Onions are bottled in vinegar with a little salt. Vinegar is also added to pickles, chutneys, sauces and ketchups. Citric acid is added to many fruit squashes, jams and jellies to increase the acidity and prevent mould growth. Lactic acid is usually produced from lactose by the action of lactic acid bacteria in the food. Formation of *dahi* from milk affords a good example of lactic acid produced from lactose increasing its shelf life.

Use of Chemical Preservatives

Certain chemicals when added in small quantities can hinder undesirable chemical reaction in food by:

(i) interfering with the cell membrane of the microorganism, their enzyme activity or their genetic mechanism;
(ii) acting as antioxidants.

Maximum amounts allowed to be added to each type of food is regulated by law because higher concentrations can be a health hazard. Benzoic acid in the form of its sodium salt is an effective inhibitor of moulds and is used extensively for the preservation of jams and jellies. Some of the other chemical preservatives used are:

(i) Potassium metabisulphite;
(ii) Sorbic acid;
(iii) Calcium propionate;
(iv) Sodium benzoate.

The development of off-flavours (rancidity) in edible oils is prevented by the use of butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT), lecithin, which are some of the approved antioxidants.

Use of Low Temperatures

Microbial growth and enzyme reaction are retarded in foods stored at low temperatures. The lower the temperature, the greater the retardation. Low temperatures employed can be

1. Cellar storage temperatures (about 15°C).
2. Refrigerator or chilling temperature (0°C to 5°C).
3. Freezing temperatures (–18°C to –40°C).

Cellar storage (about 15°C): Temperatures in cellars (under ground rooms) where surplus food is stored in many villages are usually not much below that of the outside air and is seldom lower than 15°C. The temperature is not low enough to prevent the action of many spoilage organisms or of the plant enzymes. Decomposition is, however, slowed down considerably. Root crops, potatoes, onions, apples and similar foods can be stored for limited periods during the winter months.

Refrigerator or Chilling temperatures (0°C to 5°C): Chilling (refrigerator) temperatures are obtained and maintained by means of ice or mechanical refrigeration. Fruits and vegetables, meats, poultry, fresh milk and milk products, fish and eggs can be preserved from two days to a week when held at this temperature. In addition to the foods mentioned above, foods prepared for serving or left-overs may also be stored in the household refrigerator. The best storage temperature for many foods, eggs, for example, is slightly above 0°C. The optimum temperature of storage varies with the product and is fairly specific for any given food. Besides temperature, the relative humidity and the composition of the atmosphere can effect the preservation of the food. Commercial cold storages with proper ventilation and automatic control of temperatures are now used throughout the country (mostly in cities) for the storage of semi-perishable products, such as potatoes and apples. This has made such foods available throughout the year and has also stabilised their prices in these cities.

Use of freezing temperature or Cold storage temperatures: At temperature below the freezing point of water (–18°C to –40°C) growth of micro-organisms and enzyme activity are reduced to the minimum. Most perishable foods can be preserved for several months if the temperature is brought down quickly (called quick freezing) and the food held at these temperatures. Foods can be quick frozen in about 90 minutes or less by

(i) placing them in contact with the coil through which the refrigerant flows:
(ii) blast freezing, in which cold air is blown across the food;
(iii) by dipping in liquid nitrogen.

Quick frozen foods maintain their identity and freshness when they are thawed (brought to room temperature) because very small ice crystals are formed when foods are frozen by these methods. Many microorganisms can survive this treatment and may become active and spoil the food if the foods are held at higher temperatures. Frozen foods should always, therefore, be held at temperatures below –5°C. Enzymes in certain vegetables can continue to act even after being quick frozen and so vegetables have to be given a mild heat treatment called blanching (above 80°C) before they are frozen to prevent development of off flavours.

Frozen green peas, poultry, fish and meat are now available in stores. Frozen shrimp and lobster tails are exported to Japan and U.S.A. Frozen meat is exported to the Middle East.

Freeze Drying: In this method, the food is frozen and the water from the food removed under vacuum. The water sublimes, i.e., it is converted into vapour without passing through the liquid stage. The food is preserved in its natural state without any loss of texture or flavour. The food is packed in plastic or aluminium foil packets in an atmosphere of nitrogen. Some foods, like instant coffee may be packed in bottles. Foods preserved by this method can be stored at room temperature. However, correct packaging of freeze dried food is important as air and moisture must be excluded. Some of the foods which can be preserved by this method include prawns, greens peas, potatoes and instant coffee.

Use of High Temperatures

Coagulation of proteins and inactivation of their metabolic enzymes by the application of heat leads to the destruction of microorganisms present in foods. Further, exposure to high temperatures can also inactivate the enzymes present in the food. Heating foods to high temperatures can, therefore, help preserve them. The specific heat treatment varies with

(a) the organism that has to be killed,
(b) the nature of the food to be preserved and
(c) other means of preservation that may be used in addition to high temperature.

High temperatures used for preservation are usually classified for convenience as follows:

1. Temperatures below100°C. (pasteurisation).
2. Temperature of boiling water (100°C).
3. Temperature above 100°C.

Pasteurisation (Temperatures below 100°C)

Pasteurisation is the name given to the method employing temperatures below 100°C for the preservation of food. It is used where drastic heat treatment may bring about undesirable changes in the food. It is usually supplemented by other methods to prolong shelf life. However, pasteurisation temperatures are so calculated as to kill all the pathogens that may be present in the food. Pasteurisation is used widely in the treatment of market milk and other dairy products. Milk is now-a-days mostly pasteurised by the high temperature short time (HTST) method. Here, the milk is heated to 72°C or higher and kept at that temperature for at least 15 seconds. After pasteurisation, the milk is rapidly cooled to 10°C or lower and held at that temperature. This temperature inhibits the growth of microorganisms that may have survived. Beer, fruit juices and aerated drinks are also preserved by pasteurisation. Dried fruits like raisins (dried grapes), apricots and dates can also be pasteurised in the package.

Boiling

Cooking of rice, vegetables, meat etc. at home is usually done by boiling the food with water and involves a temperature around 100°C. Boiling the food at 100°C kills all the vegetative cells and spores of yeasts and moulds and only the vegetative cells of bacteria. Many foods can be preserved by boiling at home, e.g., milk. Usually cooked food can be preserved from 12 to 24 hours at room temperature.

Treatment with flowing steam or boiling the cans in water is also used for canning acid foods like tomatoes, pineapple and cherries. The yeasts and moulds that grow on acid foods such as tomatoes have low resistance to heat and are destroyed at boiling water temperature. Bacteria though not killed at this temperature are not able to grow in an acid medium without oxygen and thus cannot spoil the food.

Canning

Canning usually employs temperatures above 100°C to kill spoilage organisms and to inactivate enzyme action, though in certain acid foods as seen above, the temperature of boiling water is sufficient to do this. The food is sealed in sterile, airtight containers and then subjected to temperatures above 100°C. Low acid foods such as fish, poultry, meat and most vegetables have to be processed at temperatures higher than 100°C. Temperatures above 100°C can only be obtained by using steam pressure sterilisers such as pressure cookers or autoclaves. The time and temperature necessary for sterilisation vary with the type of food. Most of the bacteria and their spores are killed during the course of this treatment and any surviving spores are not able to grow because of the anaerobic conditions prevailing in the can. Some of the vegetables canned using temperatures above 100°C are green peas, lady's fingers, and beans. Examples of canned fish are shrimp, sardines and mackerel, that of poultry is chicken noodle soup; and that of meat, canned ham.

Points to Remember

Asepsis—This refers to keeping out micro-organisms from food, and thus prevent food contamination.

Food Spoilage—Occurs due to growth of microorganisms, action of enzymes present in the food, mechanical and insect damage to the food.

Microbial Spoilage—Caused by moulds, yeast and bacteria. Moulds grow in warm damp conditions, in foods, such as bread. Yeasts grow in acid medium in fruits with sugar and water. Bacteria cause spoilage in foods such as vegetable, milk and meat which have a neutral pH. All grow best between 25–50°C.

Spoilage by Enzymes—Are present in the food and/or microorganisms. They are proteins and are thus destroyed by heat. Grow best at 37°C.

Spoilage by Insects—Include worms, bugs, weevils, flies. Damage the food.

Food Preservation—Deals with prevention of spoilage in foods. Increases their shelf-life. Directed towards inactivating or controlling microbial and enzymatic activity. Methods include bacteriostatic and bactericidal methods.

Dehydration—refers to removal of water. This prevents microbial growth. Water can be removed by sun-drying, mechanical drying or binding moisture with addition of salt and sugar. Products include papads, smoked fish, milk powder, pickles and jam.

Use of Acid—Inhibits mould growth, may be added to the food or present in food e.g., curd.

Use of Chemical Preservatives—In small amounts, hinder undesirable changes in food. Include sulphur compounds, acids such as sorbic and benzoic, propionates, and antioxidants such as BHA, BHT, lecithin.

Use of Low Temperatures—Retards microbial growth and enzymatic activity. Temperatures employed are 15°C, or cellar storage, 0–5°C or refrigerated storage and from –18°C to –40°C or frozen storage. Frozen foods should be thawed before use.

Use of High Temperatures—Kills microorganisms and inactivates enzymes. Methods include:

(a) temperatures below 100°C, as in pasteurization
(b) boiling temperatures, 100°C, as in cooking rice, vegetables etc.
(c) temperatures above 100°C, as in canning.

Study Questions

1. Why do we preserve food?
2. List the causes of food spoilage.
3. Write short notes on: moulds, yeasts and bacteria.
4. What are the principles involved in food preservation?
5. List the methods of food preservation.
6. Write short notes on: asepsis, dehydration and pasteurisation.

17

Home Scale Methods of Food Preservation

Some of the practical methods which can be used for home preservation of food are

(i) drying,
(ii) pickling with salt, spices and/or oil,
(iii) making jams, jellies, marmalades, murabbas, and such preserves using sugars,
(iv) bottling of squashes and juices,
(v) freezing.

It must be emphasized at this point that aseptic measures at all stages of handling food must be followed. It is very necessary to use *clean* hands, spoons and bowls while handling the preserve. It is a common practice to spoon out small amounts of the preserve from its bottle for daily use. Contamination at this stage is very likely if dirty hands or spoons are used. Hands must be washed and dried well. Clean dry spoons and bowls must be used.

Drying

Drying as a natural means of food preservation has been used for many foods—cereals, legumes, nuts and oilseeds—all of which are dried in large quantities after harvesting, usually under the sun. The sun drying of food products for home use has been used from time immemorial in the tropics. Products prepared at home include various types of *papads*, dried vegetables, jackfruit, *amchur*, potato, banana, tapioca and sago wafers, mango and jackfruit pulp, spiced vegetable scrapings and chillies, *amla supari*, *amsul*, tamarind pulp etc.

In sun drying, there is no possibility of temperature and humidity control. The hottest days in summer are, therefore, selected to sun dry foods and food products. This helps the foods to dry much faster, preventing them from getting spoiled due to "souring". Souring or turning acidic is usually due to growth of micro-organisms which act on the carbohydrates and release acid. Removal of moisture quickly, which can be done by exposing the food to the sun on hot days, prevents growth of microorganisms.

The general steps taken for the home drying of foods are as follows:

1. Various containers used for preparation, drying and storage are cleaned thoroughly and dried by placing in the sun.
2. In making products, prepared from flours of legumes, cereals such as *papads*, the flour is mixed with clean, sterile water, salt and other ingredients, rolled into thin layers and placed in the sun. The preparation is usually scheduled in the morning so that the products are dried in a day.
3. The fibrous parts of the vegetables are removed and the vegetables cut according to the desired size. It is then "blanched" by dipping in boiling water for one to three minutes depending on the type and size of the vegetable. It is cooled immediately in cold water and then spread in thin layers for drying in the sun. Certain vegetables like the potato retain their original colour without darkening if a sulphite dip is given to the vegetable before drying.
4. Fruits are also dried in the same way as vegetables except that these are not blanched before drying.
5. Fish like Bombay duck (*bombil*), are cleaned and then dried in the sun.

The dried food is cooled thoroughly and packed in insect proof and moisture proof containers such as tins, bottles, thick polythene bags etc. The tins and bottles are tightly closed with lids whereas the polythene bags are heat sealed. Packing in small polythene bags would be advisable as the dried food could be used up quickly.

Pickling

Most of the pickles use salt as a preservative. In addition to salt, several spices and oils could be used to suit varied tastes while making pickles. Some of the vegetables and fruits, which lend themselves to pickling are raw mango, various varieties of limes, gooseberries (*amla*), ginger, turmeric and green chillies.

The fruits are washed, pared, halved or quartered, the seeds removed and then either dry salted or mixed with a strong solution of brine. In villages, this is usually done in large wooden jars. Spice mixtures and/or oil are then added and the fruit allowed to ferment for a month or so. The fermentation process renders fruits soft and the fruit takes on the aroma and flavour of the spices. Mould growth is prevented by covering the top with a layer of salt and a tight lid. In some pickles, a layer of oil at the top prevents spoilage (Fig. 17.1). In both these conditions, air is prevented from entering the system. Pickles are made in large quantities and only at certain fixed intervals are these removed for household use. In many families, only an elderly person is allowed to handle the main stock of pickles, obviously to prevent contamination during handling. In cities, glass jars with tight lids are used for storing pickles. Aseptically prepared and stored pickles can last up to a year or more without spoilage.

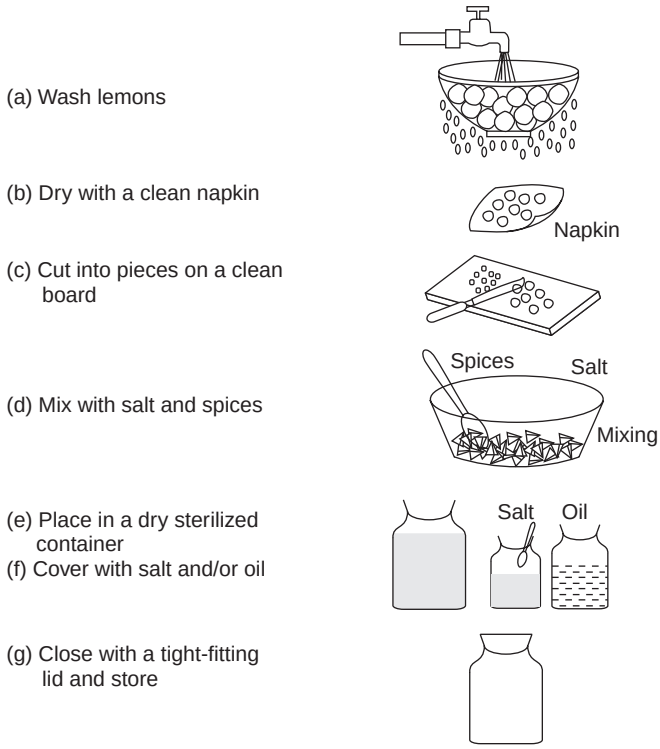


Fig 17.1 Steps in Pickling

Jams, Jellies and Marmalades

Jam is made by boiling fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, till it is firm enough to hold the fruit tissues in position. The fruit is mashed, cut or shredded depending on the kind of fruit being used to prepare the jam. About 45 per cent of fruit and 55 per cent of sugar are usually combined together so that the final concentration of soluble solids is not less than 68.5 per cent.

If the fruit is not acidic in taste, addition of lime juice improves the flavour of the jam and its setting property. Tropical fruits, which are good for making jams include papaya, pineapple, and raw mango. Some tropical berries are also good for making jams, e.g., gooseberry. When the fruits from which jams have to be made do not contain sufficient pectin or are not acidic enough, pectin and/or acid has to be added to help the jam set.

Jellies are prepared by boiling the fruit with or without water, straining, mixing the strained and clear juice extract containing pectin and acid with sugar and boiling the mixture to a stage at which it will set to a clear gel. A perfect jelly should be transparent, well set, but not too stiff, and should have the original flavour of the fruit. It should be of attractive colour and should keep its shape

when removed from the mould. When cut, it should retain its shape and show a clear cut surface. It should be tender enough to quiver but should not flow.

Some fruits have both acid and pectin. Some need one or the other to be added. For example, gooseberries and apples have both pectin and acid. But guavas contain a high concentration of pectin but little acid. The acid can be added in the form of lime juice or pure citric acid.

Marmalade is fruit preserve in which the slices of the fruit peel are suspended. The term "marmalade" is generally associated with the product made from citrus fruits like oranges and lemons in which shredded peel is included as the suspended material. The fruit slices or peels are cooked, sugar added to the mixture of juice and peels and the boiling continued till the mixture reaches a jelled stage. It is then poured into sterilized jars and capped.

Murabbas are made by dipping gooseberries, raw mango, pineapple and such fruits in strong sugar solutions and allowing them to become soft. They are popular as food adjuncts especially for eating as a side dish with *chapatis*, *puris* etc.

Bottling Fruit Juices or Squashes

This is a practical method of preserving fruit juices or purees. The term squash refers to a fruit juice, preserved by the addition of concentrated sugar solution. The bottles used for storage should have a narrow mouth with a tight fitting lid. The lid or cap should be sealed if possible with a hand sealer.

A canner is needed to bottle juices and squashes. A large aluminium pan with a lid which has a thick bottom and is tall enough to hold the bottles upright can be used. The pan must have a rack which can hold the bottles in position. The bottles must not touch the bottom of the pan, to avoid breakage. The rack can be made of wire (galvanized) or wood. The canner should have a loose fitting cover. The bottles, caps, the juicer and the funnel are all sterilized in this canner by boiling them with hot water for at least ten minutes. They should then be cooled before being filled with juice. The working surface should be cleaned with soap and water and then wiped with a cloth dipped in hot water just before use.

Orange squash can be prepared from tight skinned oranges like malta and also from loose-jacketed oranges such as the Nagpur and Coorg varieties. The juices are extracted by means of a hand juicer made of glass or food grade non-corrosive plastic. It is then filtered through a muslin cloth to remove all the coarse tissue and seeds. Sugar, citric acid and water are mixed together, heated, cooled and filtered through the cloth. The amount of sugar used varies from 40 to 60 per cent whereas that of water can vary from 10 to 30 per cent depending on the acidity and the sugar content of the juice. About 1.25 to 1.75 per cent of citric acid is added. The clear syrup is mixed with the juice. About 0.06 per cent of potassium metabisulphite dissolved in a small quantity of juice or water is added at this stage. The squash is then filled into washed and sterilized bottles leaving a little head space (about 5 cm) at the top. The bottles are closed with sterilized crown corks and stored in a cool, dry place. If crown corking is not possible rubber stoppers covered with aluminium foil can be used. Squashes thus prepared can last for six months or more. Other fruits from which squashes could be prepared in a similar manner are grapefruits, limes and mango.

Tomato Juice or Tomato Puree: For the preparation of juice or puree, the longitudinal variety of tomato (also known as the Italian variety) is used because it has more total solids, has thicker consistency than round variety and has also the deep red colour characteristic of tomato. It can also be prepared from ripe juicy tomatoes which have a deep red colour. The tomatoes are cut into small pieces and simmered in a very small quantity of water till they are cooked. They are then crushed by rubbing them against a metallic sieve using wooden implements and then filtered through the sieve to give a rich deep red juice. About one-fourth teaspoon of salt per cup of juice (2.5 per cent) is added and the juice boiled again. The juice or puree is filled into sterilized bottles and sealed with crown corks. The bottles are then heated in boiling water in the canner for about ten minutes, cooled, dried, labelled and stored in a clean, dry place.

Mango Juice: Mango varieties like the Totapuri, Begumpalli have been found to give excellent results. In the preparation of mango juice, the mangoes are washed and peeled to remove the skin. Any bruised or worm infected parts are cut out and rejected. The mango pulp is then removed from the seed and crushed and mixed with sugar solution so as to have an overall content of five to ten per cent of added sugar. The amount of sugar added depends on the acidity and sugar content of the mango juice. The mixture of juice and sugar is boiled and then filled while still hot into sterilized bottles, sealed with crown corks and then again boiled for ten minutes in boiling water in the canner. The bottles are then cooled, dried, labeled and stored in a clean, dry, place.

The fruits meant for juice making should have very little fibre and have a golden juice of thick consistency.

Freezing

Home scale freezing of fruits and vegetables can be of great benefit during the glut season. However, this needs the use of a refrigerator with a freezing compartment or a mechanically operated freezer. If properly frozen and kept at temperatures between –10°C and –15°C, the frozen foods can last for a period of about six months.

The vegetable is washed to remove all the adhering soil and dirt, cut into the desired size and then blanched in hot boiling water for one to three minutes depending on the nature of the vegetable and the size to which it is cut. It is then cooled immediately by dipping in ice and then packed into appropriate containers (usually polythene bags). The packets are then frozen by placing them in freezing compartment. It is wise to pack in small polythene bags, quantity enough for the family for one meal.

The same procedure is followed for fruits except that no blanching is needed.

The vegetables which could be conveniently frozen thus are green *tur*, peas, carrots, cauliflower, blackeyed peas, french beans, cluster beans, spinach etc. Tomatoes and cabbage do not lend themselves to freezing. Fruits which could be preserved in a frozen condition are mango, pineapple, peaches, strawberries etc.

Practical Work

1. ***Test for pectin***

This test is designed to show whether fruit pulps contain any pectin. Advantage is taken of the property of pectin clotting on addition of methyl alcohol. The test is as follows:

(i) Place a teaspoon of fruit pulp in a glass.
(ii) Pour 3 teaspoons of methylated spirit.
(iii) Leave undisturbed for a few minutes for pectin clot to form.
(iv) Lift fruit pulp in the spoon to check condition of clot.

In the pectin precipitates in a solid mass, it is present in sufficient amounts to form a jelly. Insufficient pectin is indicated by the presence of small coagulated clumps and the lack of precipitation. (*This mixture is poisonous and under no circumstances should be tasted*).

2. ***Preparation of Fruit Squashes***

A number of fruits can be used for making fruit squashes. These should be bought during the season as they will not only be cheap in price but also be of good quality. The details of making fruit squashes are as follows:

(i) Clean narrow mouthed bottles of 400 ml capacity with soap and wire brush and rinse with water to ensure that all the soap has been removed and that the bottle is perfectly clean. Rinse the bottle again with water at about 80°C to 90°C.
(ii) Extract the juice from the fruit by any convenient method. Some of the methods that could be used are:

   (a) Use of stainless steel hand extractor for lemon.
   (b) Use of blendor for mixing the fruit pulp with water and sugar. Mango pulp and pineapple pulp could be extracted this way. Mango pulp can be prepared by skinning the mango and removing the meat adhering to the kernel by a knife. Pineapple pulp can be prepared by removing the skin and the eyes and then blending the chunks of the pineapple in an electric mixer.

(iii) Mix all the ingredients as shown in the chart below for each fruit squash, quantity of the juice and water to be taken will depend on the number of empty bottles available.
(iv) Fill the mixed ingredients into the clean bottles.
(v) Cap the bottles with pilfer proof seal. If this is not possible, crown corks can be used. For capping with pilfer proof seal or with crown cork hand operated equipment, which are not expensive are available.
(vi) Pasteurise the bottles in a water bath at 100°C for ten minutes.
(vii) Dry the bottles on the outside. Label them with the name of the squash and date of preparation.

TABLE 17.1 Chart for Preparation of Fruit Squash

Ingredients	Lemon	Mango	Plum	Lichi	Pineapple
Juice/Pulp	100 g	100 g	100 g	100 g	100 g
Sugar	200 g	100 g	200 g	200g	100 g
Water	100 g	100 g	100 g	100 g	100 g
KMS*	—	A few grains	—	A few grains	A few grains
Citric acid	—	3 g	2–3 g	3 g	3–4 g
Sodium benzoate	—	—	A few grains	A few grains	—

*Potassium metabisulphite food grade.

3. Preparation of squashes, jams and pickles.

4. (a) Selection of food for preparation of jams, jellies, murabbas, pickles and squashes.
   (b) Sundrying of fruits and vegetables.
   (c) To prepare labels for processed and preserved foods.

Points to Remember

Home scale methods of preserving food includes

(a) drying
(b) pickling with salt, spices and/or oil
(c) making jams, jellies, murabbas
(d) making squashes and fruit juices
(e) freezing

Aseptic measures at all stages of food handling is very important.

Drying—Sun drying of foods in the summer is an age-old method of preserving foods. Home-made sundried products are *papads*, *dried vegetables*, supari, potato wafers etc. Main steps include cleaning, trimming and sometimes blanching followed by drying, cooling and packing.

Pickling—Salt is used as a preservative. Mangoes, lemons, goose berries, green chillies and other vegetables and fruits and fish and meat are also pickled. Main steps are—washing, paring, cutting. Spice mixtures and/or oil are optional ingredients. Food softens and develops an attractive aroma and flavour.

Jams, Jellies, Marmaladas and Murabbas—In these, sugar acts as a preservative by making moisture unavailable to the microorganisms. Fruit pulp is used to make jam. Jellies are made from fruit

extract. Appropriate amount of sugar, acid and pectin needed to set jams and jellies. Maramalade is a fruit preserve in which slices of the citrus fruit peel, contribute the tangy flavour. Murabbas are syrupy fruit preserves.

***Fruit Juices and Squashes*—**Squashes are fruit juices preserved with sugar syrup. Shelf-life depends on sanitary handling and storage.

***Freezing*—**Temperatures employed range from –10°C to –15°C. Food selected is washed, cut and sometimes blanched. Then cooled and packaged immediately. Packages stored in freezing compartment of the refrigerator. Peas, carrots, cauliflower and mango, pineapple, peaches are frozen successfully.

Study Questions

1. List the methods used to preserve food in the home and give one example of each.
2. Describe the process used to prepare jam.

18

Food Sanitation and Hygiene

Food sanitation is concerned with cleanliness in the storage, handling, preparation and service of foods and water meant for human consumption. A number of factors can contribute to food contamination. These include the storage room and containers, the food handlers, the equipment (utensils, knives, wooden boards) used in preparation, the tables and other surfaces which come in contact with food during preparation, the food ingredients, water, air, and the cutlery and serving dishes used in food service. Food sanitation is an essential aspect of food preparation. It is important to ensure cleanliness and sanitation during food storage, and at every stage of handling, preparation and service.

Thus, food sanitation involves the following aspects:

1. Maintenance of clean premises.
2. Health and cleanliness of people who handle food.
3. The provision of potable water supply.
4. Cleanliness in handling and storage of raw foods.
5. Prevention of contamination of the foods at all stages in preparation from equipment personnel and vermin.
6. Cleanliness in service of food.
7. Safe disposal of food wastes.

Inculcation of hygienic habits would help in preventing foods from being contaminated during handling.

Water

Water is essential in food preparation. It is used to wash food before cooking, it is used as a cooking medium, it is used to clean the containers of food before and after preparation and it is used also as the most important beverage. Therefore, it is essential that all water meant for drinking and cooking purposes should be free from pathogenic bacteria. Water used for making ice must also be potable. The ice may be used to cool foods or added to cold drinks. Thus it is important to ensure that the ice we sometimes buy be made from potable water. Some of the diseases, which can be spread by the use of contaminated water are cholera, typhoid, paratyphoid, bacillary dysentery and amoebic dysentery (Fig. 18.1).

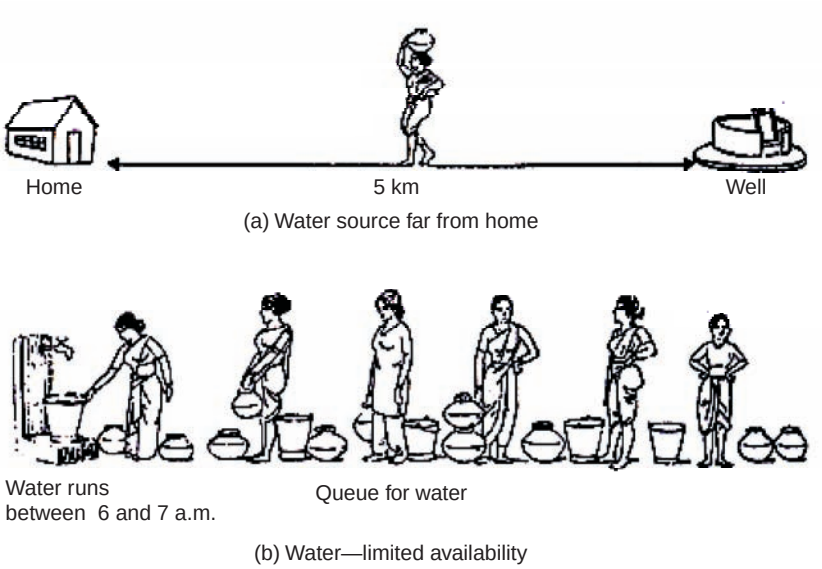


Fig. 18.1 When Water is Scarce, Sanitation Suffers.

Potable Water

Water, which is free from pathogenic bacteria and is palatable, is known as *potable water*. The necessity of a potable water supply in the home and place of work can never be overemphasized. It is also important in institutions preparing, processing and serving food.

Apart from the primary precaution to ensure that water be free from harmful bacteria, it is also necessary to make it palatable. For example, water may contain dissolved salts or minerals, which may give it a brackish taste. For specific uses, such as chemical analyses water may have to be given special treatment with resins to remove dissolved impurities or salts. We will concern ourselves mainly with the treatment of water to render it safe for potable purposes.

In India, even though the necessity of using 'pure water' has been known for centuries[1], there was no safe and protected water supply up to 1949 for as much as 81 per cent of the population who stay mostly in the villages.

The National Water Supply and Sanitation Programme was launched in 1954 as a part of the Health Plan to assist the States in their urban and rural water supply and sanitation schemes so as to provide adequate water supply and sanitation facilities in the whole country. By 1979, 2, 108 towns had been provided with water benefiting an urban population of one hundred million people.

1. In some of the Sanskrit texts written around the year 2000 B.C., it has been stated that 'it is good to keep water in a copper vessel, to expose it to sunlight and to filter it in charcoal'. Similarly, another text says, 'Water should be purified by boiling over fire, by heating in the sun, or by dropping a heated iron in it and then allowing it to cool; or it may be purified by filtering through coarse sand gravel.'

217 towns with a population of forty million people (about 36 per cent of the urban population) had been covered by partial sewerage system. Of the 5,76,000 villages, it is estimated that more than two lakh problem villages remained to be covered with potable water supply as on April 1, 1980. Efforts are being made to meet the water and sanitation needs of the entire country[1].

Even today, the average Indian, educated or uneducated, a villager or a city-dweller, is very particular about seeing that the vessels used for storages of water is not contaminated in the home. So, it is not use in the home, but the source of the water supply which may be suspect.

Sources of Contamination of Water

The usual source of contamination of water is through the seepage of sewage.

Sewage can be a carrier of many pathogenic bacteria because many healthy persons may be the 'carriers' of pathogenic bacteria without being affected themselves. Persons, who are suffering from enteric diseases will also contribute to the presence of bacteria in sewage. The disposal of sewage is not paid much attention to especially in the rural communities, where human excreta is deposited near shallow wells, ponds or even rivers; contamination from this source is widespread.

In cities, the huge influx of population, which results in rapid formation of hutment dwellings without proper sanitary and water facilities, develop into a health hazard. Sufficient water is not available usually at such dwellings and the use of water from any source is resorted to, sometimes even gutter water being used. It is not that the hutment dwellers are not aware of the hazards involved, but they have no other alternative.

There is no facility for drainage and the used water and sewage stand, encouraging breeding of mosquitoes and flies. These pests carry and spread pathogens from sewage to nearby localities, thus creating health problems. Exposed ready-to-eat foods sold in such localities may be contaminated by the flies.

Another difficulty experienced in cities with protected water supplies is the difficulty of maintaining a positive pressure in all pipelines. In cities, many of the pipelines have become very old and unless there is a continuous flow of water into them with a positive pressure there is a possibility of seepage of bacteria, from sewage into water pipes. With limited supply of water available in many Indian cities, all the pipes can never be holding water all the 24 hours. This is a problem, which does cause concern.

The effluents from many industries, which are at present mostly discharged into rivers are another source of contamination; this problem is assuming serious proportions. Many of these effluents use up much of the oxygen from the water with the result that fish and other aquatic animals are unable to survive.

Foul smell emanates from such streams, due to anaerobic decomposition (putrefaction) of dead fish, thus making the water unfit for human consumption.

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1. *Source: India, Reference Manual*; Ministry of Information, 1981.

Treatment of Water

It is thus essential that water used for potable purposes be free from pathogenic bacteria. The best precaution one can take is to prevent the source of water from contamination with sewage.

In villages, this can be done by constructing cement sides to deep wells to prevent bacteria from seeping through the soil and gaining entrance in the water. Well water, which may be contaminated can be purified by the addition of bleaching powder. A simple and inexpensive gadget using this principle has been fabricated by the Central Public Health Engineering Research Institute (CPHERI). Bleaching powder on reaction with water releases chlorine which is capable of killing pathogenic organisms. In villages where there is no treated water, drinking water should preferably be boiled and then cooled. This would destroy all the pathogenic bacteria. Water used for cooking need not be boiled, as it would be boiled anyway during cooking. Water used for washing, cleaning need not be boiled as long as it is not foul smelling and does not contain any suspended impurities.

In cities and towns where it is necessary to supply a large population with water, effective methods have to be used for the purification of water. The source of water is usually a lake in which the water is allowed to stand. This results in most of the suspended impurities settling down. Further, the action of sun-light and the paucity of food results in the destruction of bacteria. In the next stage, which may consist of a filtration through sand most of the bacteria are eliminated. As an added precaution, water supplies to cities are chlorinated. This may either be done by the addition of bleaching powder, or as is done in most of the cities, by the injection of liquid chlorine. To make sure that the bacteria which may have entered into the pipelines through seepage when there is no positive pressure, additional chlorination is resorted to at different locations during the transportation of water from the lake to city reservoirs. This is understandable when it is realized that the source of water may be 60 to 70 km away from the city. Water may be rendered potable by the use of water filter in the home (Fig. 18.2).

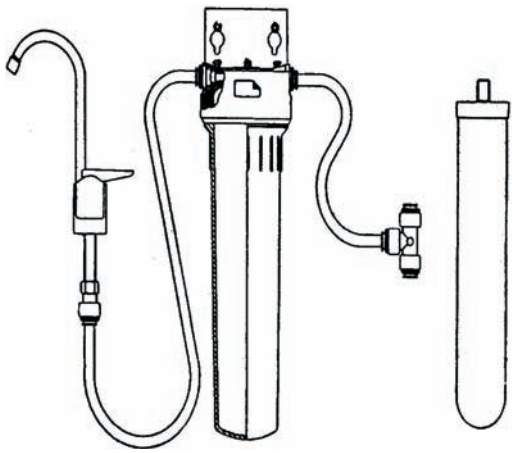


Fig. 18.2 Water Filter

What you can do about pesticide residue

Pesticide residue can pose a serious problem in the diet. There are certain precautions which you can take to reduce dietary exposure to this hazard. These are

1. Thoroughly rinse and scrub fruits and vegetables. Peel them if appropriate.
2. Remove outer leaves of leafy vegetables, such as cabbage and lettuce.
3. Trim fat from meat, poultry and fish, discard oils and fats in broths and drippings.
4. Throw back the big fish—the little ones have less time to take up and concentrate pesticides and other harmful residues.

Food

All vegetables and fruits either from bazaar or grown in one's own farm would have to be cleaned, and prepared for either eating directly or cooking. The dirt or dust which we find on foods as we buy them can be carrier of spores of micro-organisms. Therefore, all exposed food must be washed with clean water before use. Outer layers, skins of plant material contain thousands of microorganisms and must be washed thoroughly before use. If any parts of fruits and vegetables and bruised these should be trimmed to reduce contamination.

The skin, hair, feathers, intestines of animals harbour a number of microorganisms. It is, therefore, necessary to remove these, before animal products are prepared for human consumption.

Food Handling

Food comes into contact with human hands during harvesting, storage, preparation and service. It is important that food handlers be free from any communicable diseases—colds, any other respiratory ailment, cuts or boils, as they may be responsible for transferring these to the food thereby spreading the infection to persons consuming the food.

Human hair, nasal discharge, skin can also be source of microorganisms. Therefore, persons handling food, must wash hands with soap before starting preparation, and refrain from touching hair or wiping nose during food preparation.

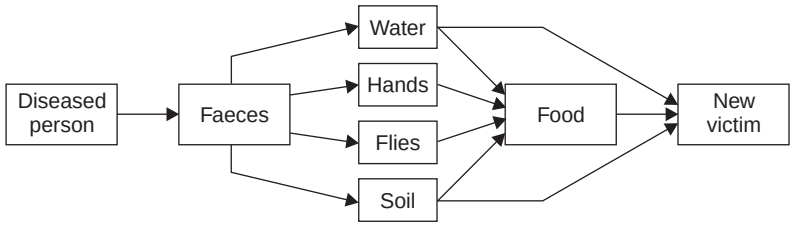


Fig. 18.3 Spread of Diseases through Faecal Contamination

Food sanitation is a way of life. It can never be overemphasised. A number of gastrointestinal disorders, such as diarrhoea, cholera and communicable diseases such as typhoid, septic sore throat,

diphtheria, dysentery etc. are communicated by the use of contaminated water or food (Fig. 18.3). Therefore, it is very important that sanitary handling of food and water is religiously adhered to (Fig. 18.4).

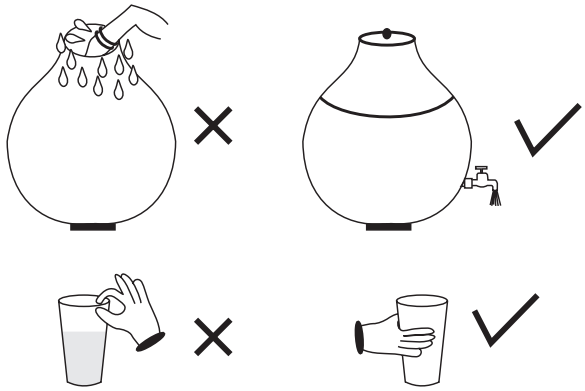


Fig. 18.4 Sanitary Handling of Food

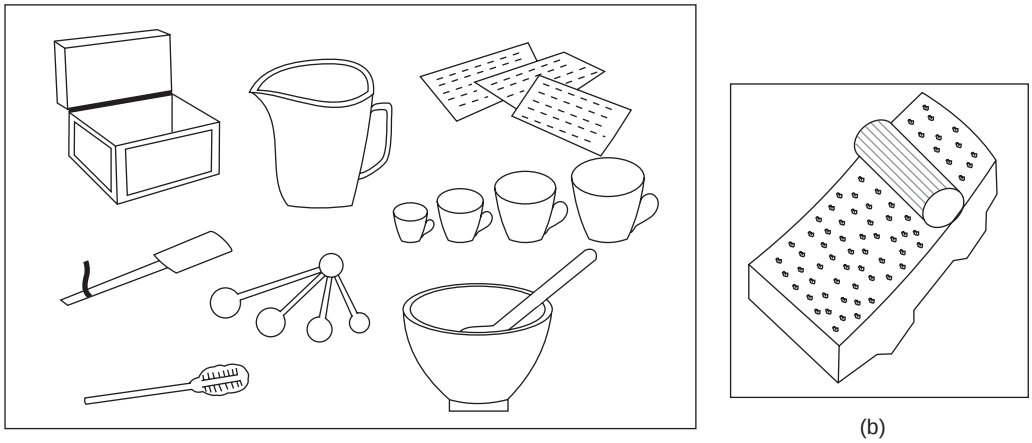
Food Contamination

Food may be contaminated if the

1. Water used for washing or cleaning is not potable.
2. Soil adhering to foods grown close to ground is not completely removed.
3. Containers or utensils used for storage and preparation are not clean.
4. Person handling food have unhygienic habits.
5. Person handling food suffer from communicable diseases.

Equipment

It is necessary that all equipment coming in contact with food be kept clean (Fig. 18.5). This includes knives, meat mincers, blenders, rolling pins, wooden boards, metal and porcelain dishes, utensils etc. They should be scrubbed, cleaned with detergent and water and then rinsed with potable water. It is a good practice to see that such equipment are dipped in hot water at 80°C for at least 30 seconds or more and then allowed to drain dry. This sanitary step is especially important during epidemics such as infective hepatitis (infective jaundice), cholera etc. Parts of blenders, mixers etc. should be inspected after cleaning to ensure that there is no food material adhering to the blades. If allowed to remain they could allow harmful microorganisms to grow and spoil the food. Equipment made of plastic and other such material which can not withstand high temperatures need not be given the dip in hot water but should be given the other treatments and then allowed to drain dry.



(a) (b)

Fig. 18.5 Some Sources of Food Contamination

In villages, it is a common practice to scrub utensils and dishes with ash and then rinse them with water. The utensils and dishes are then allowed to dry in the sun. The alkaline ash acts as a good agent for killing any microorganism adhering to the utensils and a sanitary effect is produced by drying in the sun both because of heat and the ultraviolet rays of the sun.

Control of Insects and Rodents

One of the common insects contaminating foods is the housefly. These have minute hair on their legs and thus can be the carriers of harmful bacteria depending on where they come from. It is possible that they may carry faecal matter or other such sources of pathogenic bacteria and deposit it on the food.

Another insect which can also be a source of contamination in the same way as the housefly is the cockroach. These insects, which usually prefer darkness, have been known to cause diarrhoea and dysentery.

Apart from these two common ones, there are innumerable insects ranging from the larvae found in wheat and rice to locusts, which can cause serious damage to food.

Rodents, which include rats, mice and bandicoots, not only consume large quantities of food, thus contributing to the overall shortage of food in the country, but may also be the carriers of diseases such as plague.

The presence of insects, insect fragments, rodent excreta and other matter of insect and rodent origin (even though it may not necessarily be dangerous to health) is aesthetically resented by consumers. Health authorities condemn such food as unfit for consumption because it indicates poor practices of sanitation where the food was prepared.

It is thus essential that preventive measures be taken to exclude the entry of insects and rodents in the house, especially in the cooking and serving areas.

This can be done by

(i) keeping the prepared food in cupboards with wire-netting,
(ii) filling cracks, fissures in the walls and flooring which are usually the places where insects breed and multiply.
(iii) covering drains, holes etc., with wire gauze so as to prevent the entry of rodents.

Precautions such as these if taken in villages and small towns where people normally stay in independent homes would certainly prevent the entry of insects and rodents. In large cities, however, where each building may have many apartments, unless measures are taken by the whole community, there is always a danger of insects and rodents travelling from one apartment to another.

The control of insects and rodents can be carried out in several ways of which the most common one practised in the home is spraying or dusting with an insecticide. Fumigation may be resolved to in large godowns, factories etc., as it destroys insects and rodents.

Sprays or dustings make use of chlorinated hydrocarbons (such as DDT, TDE, aldrin, dieldrin, etc.) and the organic phosphorus compounds (such as Parathion, Malathion, Systrex etc.) as the active ingredient for killing the insect. Baits in which chemicals may be mixed with food are also successful in getting rid of pests. Examples of these are "Tygon" in which a chemical is mixed with sugar and a home-made mixture of boric powder and bengalgram *dal* flour, which when ingested by cockroaches results in their death. Warfrain may be mixed with food and used as a bait for the elimination of rodents.

It must be noted that insecticides are poisonous, and must be used in very small amounts only where needed. If used indiscriminately these are likely to enter our bodies and harm us after a period of time. It is important to store these out of reach of children and away from food, to prevent accidents.

Practical Rules for Good Sanitation

1. Tie hair neatly before starting food preparation. Use hair net or cap if necessary. Wash hands thoroughly with soap and water before starting preparation.
2. Wash fruits, vegetables, cereals and beans thoroughly before preparation with potable water. Boil milk in a clean container as soon as possible after receipt and keep covered. Bottles of milk need to be rinsed thoroughly with water and then washed with soap and water.
3. Use potable water in food preparation.
4. Boil water used for drinking or for preparation of cold beverages, if the purity of water is not guaranteed.
5. Utensils and equipment used for preparation should be scrupulously cleaned.
6. Cooked food should be stored covered, preferably in the container in which it is cooked.
7. Left over foods such as rice, vegetables, should be stored either in a refrigerator or kept in a pan of cold water. Reheating before use is advisable.

Laboratory Work

1. Cleaning of work surfaces, storage space and floors.
2. Demonstration on cleaning of equipment.
3. Labelling of containers and their proper storage.
4. Use of proper apron, hair-net or head cover etc.
5. Expose sterile nutrient agar to various contaminants and observe the microbial growth.

Practical Work

(a) To show slides of microorganisms causing food infections if possible.
(b) To make visual charts to emphasise Rules of Sanitation.
(c) Visit municipal quality control laboratory if possible.
(d) Simple tests to detect adulterants in various foods.

Points to Remember

Food Sanitation Implies cleanliness at every stage of food handling and preparation i.e. production, preparation, storage, service and disposal. The following items need special attention. Safe and potable water supply, wholesome ingredients, hygienic handling of food, clean equipment, and clean surroundings.

To prevent infestation by insects and rodents:

(a) Cover the foods during storage.
(b) Fill up cracks and fissures in walls or floors.
(c) Cover drains and holes to prevent entry of pests.

Study Questions

1. What is food sanitation? Why is it important?
2. What is potable water? List the sources of contamination of water and how to prevent such contamination.
3. How does food get contaminated? List the steps to be taken to prevent contamination of food?
4. List effective means of control of household pests.

19

Food Borne Diseases

While food is necessary for sustaining life, it could also be a cause of illness. There is a general misconception that if a food is 'natural', it must be 'safe'. Unfortunately the fact that many toxins occur in natural plant foods, falsifies this naïve view. Most of these endogenous toxins are in plant foods and a few in animal foods.

Toxins from Plants

Solanine of potatoes is one of the best known plant toxins. It is a steroid which occurs in potatoes and other members of solanaceae family (e.g., aubergine) and the highly poisonous nightshades. Normally potatoes contain 2–15 mg per 100 g (fresh weight).

When potatoes are exposed to light and turn green, the level of solanine can be as high as 100 mg per 100 g. It is mostly concentrated under the skin. Potato sprouts may contain even higher amounts. Solanine can cause abdominal pain and diarrhoea, if injested in large amounts.

Solanine is an inhibitor of the enzyme acetyl choline esterase, which is a key component of the nervous system. Ingestion of solanine have been reported to lead to signs of neurological damage.

As there is a general public awareness of the health hazards of eating green potatoes, the incidence of potato poisoning is low.

Solanine is **not lost** during normal cooking as it is insoluble in water and is heat stable.

Caffeine is a purine alkaloid. **Theobromine** is another important member of this group. These occur in tea, coffee, cocoa and cola beverages, which are regarded as stimulants.

But there are three good reasons for treating these as toxins. Firstly, these could never be regarded as nutrients, secondly they are addictive in nature and thirdly their physiological effects are dependent on the amount ingested.

Phenylethylamine found in chocolate brings on migraine headache in susceptible persons. Phenylethylamine and **serotinin** are vasopressor amines, which occur in plant foods, or are formed during fermentation in cheese and wine. Constriction of blood vessels, especially in brain is the usual effect of these amines. Hence there is a need to minimise the intake of these.

Hydrogen cyanide released from glycosides in foods can be toxic. When there is tissue damage of tapioca during harvest or preparation for cooking hydrogen cyanide is formed from amygdalin, a glucoside in tapioca. Therefore, tapioca varieties, rich in cyanogenic glucosides need to be fermented

in preparation to release HCN as a volatile gas and thus make it safe for consumption, as is done in West Africa in preparation of "Garri", a staple of that region.

In spite of this, chronic cyanide poisoning occurs in tapioca eating persons, due to habitual low level intake of cyanides. One of the common diseases in such conditions can lead to neurological degeneration and a form of blindness.

Lima beans also contain generous amounts of glycosides. It is difficult to cook lima beans so as to eliminate their toxicity; so bean varieties with low levels of glucosides are being produced by breeding.

Besides cyanogens, legumes contain *inhibitors* of trypsin and chymotrypsin. Peas, beans, soybeans and groundnuts contain protease inhibitors (the proteases are trypsin and chymotrypsin). The inhibitors in most legumes are inactivated by cooking except in soybeans, which have to be autocalved to achieve the same.

Some plants when consumed can cause food poisoning. Certain varieties of mushrooms are very poisonous and could even be fatal if consumed. Snakeroot poisoning could result from drinking milk from cows that have fed on this weed.

Lectins or **haemoglutinins** present in kidney beans are also toxins. The name haemoglutinin indicates that these toxins bind to the surface of red blood cells and cause them to clump. These are destroyed during cooking. There is massive breakdown of lectins when beans are germinated.

The vogue of eating raw foods poses a potential hazard, especially if the diet consists of *only* raw foods. The lectins are toxic in the region of 0.5 mg/kg.

Myristicin, a toxin occurs in significant amounts in nutmeg and smaller amounts in black pepper, carrots and celery. 10 g of nutmeg contain enough myristicin to produce initial euphoria, hallucinations and narcosis, just like a heavy dose of alcohol. Since nutmeg is used in very small amounts as a flavouring only, it only induces sleep. But it is not advisable to eat nutmeg flavoured foods in pregnancy.

Toxins from Animals

Tetrodotoxin is a toxin, which occurs in the organs (liver, ovaries) of the puffer fish. The muscles and testes of puffer fish is a popular delicacy in Japan. As the minimum lethal dose of tetrodotoxin lies between 1.5 and 4.0 mg. Great skill is needed by food handlers to separate the deadly parts of fish from edible ones. Expert cooks have to be strictly licensed, but fatalities occur regularly.

The toxin blocks movement of sodium across the membranes of nerve fibres, disrupting transmission of nerve impulses. A number of nervous symptoms develop leading to total paralysis and respiratory failure. Death occurs within 6 to 24 hours. No effective treatment has been found so far.

Other toxins find their way into shellfish such as mussels, cockles, clams and scallops due to a type of plankton, at certain times of the year. Some of these planktons are red coloured and proliferate in coastal waters. When these occur, these are called *red tides*. Hence, coastal communities have

avoided fishing during red tides. But in cooler parts such as Alaska and Scandinavia, the planktons are not coloured. Hence, routine checks are carried out on toxin levels of shellfish in these regions.

Sea food such as mussels and clams sometimes contain a poisonous alkaloid and could cause food poisoning symptoms.

A different type of poisoning occurs when fish from the family *Scrombridae* (including tuna, sardines, mackerel) are held above 10°C for some hours, due to formation of high levels of histamine from tryptophan in the muscle. This reaction is catalysed by the decarboxylase produced by bacteria present in the fish. High levels of histamine (100 mg/100 g) are produced before the putrefaction occurs. Susceptible persons suffer from headaches, palpitations, gastrointestinal upsets, skin flushes, and erethrema. The symptoms are relieved by taking antihistamine drugs. The residents of the areas where such poisonous plants and animals are found usually know about the hazard and guard against it.

Mycotoxins

Toxins produced by moulds are known as *mycotoxins*. There are over 150 mould species, which produce toxins when grown on foods. Of these, two important ones are **ergot** and **aflatoxin**.

Ergotism is a disease known since the Middle Ages when it occurred in epidemic proportions in Europe due to infected rye which was used as a staple food. When rye and other cereals are infected by the mould *Clariceps purpurae* or *ergot*, at one stage in its life cycle, it produces hard, purplish black masses of dormant cells called *sclerotia*.

These have the same size as a cereal grain. If the sclerotia are not removed by sorting before milling, these are milled with the cereal into flour. The sclerotia contain 20 different toxic alkaloids, *ergotamine* being the most abundant one. The effects of these alkaloids on the body are not well understood, but depend on the kinds and amounts produced by the moulds present. Symptoms include burning pains in hands and feet, loss of sensation in the limbs, followed by gangrenous withering, blackening and loss of the limbs. Simultaneously, there is mental derangement and gastrointestinal failure. Finally the victim dies.

The disease is rare now due to reduction of infected plants with the use of fungicides, application of modern drying methods to prevent post harvest growth of microorganisms and the use of mechanical grain cleaning methods, which separate heavy grains from the light sclerotia formed.

Of the three genera *Fusarium*, *Penicillium* and *Aspergillus*, which infect foods, especially cereals, *Aspergillus* is the most dangerous one.

A flavus produces aflatoxins, which are carcinogens. **Aflatoxin** B_1 is one of the most potent liver carcinogens known. Use of mouldy cereals containing 0.2 to 20 mg per kg aflatoxin have led to many fatalities in the tropics. The level of aflatoxin in staple foodstuffs has been found to be positively correlated to incidence of liver cancer.

Groundnuts and their products from the third world countries are potential sources of aflatoxin in the diet. When these contaminated feeds are used as cattle feed 1% of the aflatoxin is found in milk but not much comes through in the meat.

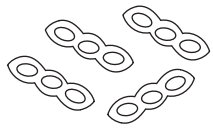


Fig. 19.1 Groundnuts

Aflatoxin can be easily detected and quantified by using a fluorimeter.

Production of aflatoxins can be prevented by discarding mouldy cereals and nuts. In traditional foods, which need ripening by moulds, pure starter cultures of safe mould strains are used instead of 'natural' inoculants. Prevention of mould contamination from factory walls, plant and machinery and employees is essential.

Toxic Agricultural Residues

Residues of pesticides which are toxic may enter the food when used in agriculture for killing weeds, insects and microflora. **DDT** a pesticide used for killing mosquitoes has been found in many foods in proportions far exceeding the safety threshold. Some of the other pesticide residues found in food include **dieldrin**, **lindane** (**BHC**) and **malathion**, which are used for spraying on fruits and vegetables to control insects and microflora. Many of these pesticides have been banned. But their use for many years has left an appreciable amount in the soil, which find their way through the crops into human diet (Table 19.1).

A second source of residue are **sterols**, used for increasing growth in animals raised for meat. Residues of these sterols may be present in meat of these animals. Some of these sterols have been shown to be carcinogenic.

The final type of agricultural residue are **antibiotics**. For example, **penicillin** is used to treat cows with masitis. Milk from treated cows must be discarded, but it may not be. The penicillin in milk can cause allergic reaction in sensitive persons. It will also interfere with manufacture of curd and cheese. **Antibiotics** are also used as growth promoters in animal feed. Animals fed antibiotic may develop resistant strains of bacteria, which may infect humans and cause untreatable disease. Therefore, the unscrupulous use of antibiotics in animals needs to be prohibited.

Poisoning by Chemicals

Toxic metals may reach our food from a number of sources. The most important sources include water used in food processing and cooking, soil on poorly washed vegetables, water pipes (lead), equipment, containers and utensils used for processing, storage and cooking of food.

TABLE 19.1 Common Pesticide Residues in Meat, Fish and Poultry[1]

Pesticide	Content (p.p.b.[3])	Intake (p.p.b.)	ADI[2] (p.p.b.)
DDT	<1	0.034	5
Alpha BHC (benzene hexachloride)	<1	0.011	
Gamma BHC (lindane)	<1	0.003	10
Malathion	<1	0.203	20
Polychlorinated biphenyls	2	0.008	

1. Based on survey done in U.S.A in 1980.
2. Acceptable Daily Intake recommended by FAO/WHO μg/kg/day.
3. Parts per billion.

Lead the use of lead piping and tank in water supply can lead to a higher level of lead, if water is soft. Lead contamination of beverages is restricted to illicitly produced alcoholic drinks, as also poorly glazed pottery used to store acidic beverages. Use of lead-based solder can be a source of lead contamination in canning. As most foods are subject to regulation of lead content, the likelihood of lead poisoning is not very common.

However, symptoms of chronic lead poisoning such as anaemia, poor I.Q. performance etc. may be found in children from congested city environment, living in dwellings that have peeling, deteriorated lead surfaces. They may eat paint chips, breathe air-borne dust particles released from paint before remodeling. In addition, food and water contribute to daily lead intake. The lead pigment used to print labels on soft plastic food packaging can also be a source, especially as families reuse the bag for food storage.

The tetraethyl lead in exhaust fumes may be an additional source of lead. For example, studies in U.S.A. showed that absorption of lead in children is eight times greater than adults and tends to accumulate in their bodies. The brain-damaging effects of lead poisoning in young children is associated with anaemia, fatigue, poor attention span and learning ability. Hence, there is a need for a vigorous plan of prevention to eradicate this serious problem.

Mercury Inorganic mercury compounds reach our food from two sources – cereal seed grains treated with antifungal mercury compounds, meant for planting, being mistakenly used as food and industrial pollution of coast water contaminating fish and other seafoods with alkyl mercury compounds. Recently, there was a case reported in Ootacumund, Tamil Nadu of metallic mercury poisoning due to contamination of water from the effluent in a factory manufacturing thermometers.

The symptoms of mercury poisoning are variable but all point to damage to the central nervous system. In all situations, children, being vulnerable, are more sensitive to the exposure.

Arsenic is widely distributed in nature and may contaminate chemicals used in food processing and thus finds its way into food. For example, the use of sodium phosphate contaminated with arsenic trioxide as stabilizer in milk powder led to the poisoning of 12,000 infants in Japan, who were fed the formula made from that milk powder; at least 120 died.

Therefore, it is important to check for arsenic contamination in food additives.

Cadmium Contamination of foods from cadmium can occur from three sources. The first is use of contaminated water (e.g., water from mine operation as occurred in Japan in 1960) for the irrigation of paddy. Second is use of cadmium plated components in food processing machinery. The third is zinc plating or galvanizing of containers used to store acid foods. Usually zinc contains some cadmium, which may get dissolved with zinc and enter food products.

All these metal contaminants **lead**, **mercury**, **arsenic** and **cadmium** are bivalent, similar in some ways to nutrient mineral like iron, calcium and zinc. If the diet is low in bivalent nutrient metals (calcium, iron) the contaminants may enter the vulnerable systems (nerves, kidney, bone marrow), accumulate and disturb their function. There is a need to monitor the environmental contamination of foods by these metals.

Food Poisoning by Bacteria

There are two chief kinds of food poisoning caused by bacteria:

(i) **Botulism** caused by the presence of toxin in the food produced by *Clostridium botulinum* and
(ii) **Staphylococcus poisoning** caused by a toxin produced in the food by *Staphylococcus aureus*.

Botulism *Clostridium botulinum*, is a spore forming, anaerobic microorganism found in the soil. Foods such as corn, beans, peas, meat, fish are likely to be contaminated with the spores of this organism. If these contaminated foods are not given adequate heat treatment during canning, these spores survive and the *Clostridium botulinum* multiplies in the can, as it is an anaerobic organism. During the process of growth, some strains of this organism produce a toxin in the food, which is a potent poison. If the food containing the toxin, is consumed without heating, it can cause paralysis of involuntary muscles and may ultimately lead to death due to respiratory failure. This effect is known as **botulism**. The toxin is, however, destroyed on heating. Any suspected food should, therefore, be boiled for at least 15 minutes before it is consumed. The incidence of botulism is, however, very rare as all commercially heated processed foods manufactured by reputable companies are always given approved heat treatment which is enough to kill pathogenic bacteria that may be present in the food. It is likely to occur if neutral foods are inadequately processed at home and consumed by families.

Staphylococcus Food Poisoning The causative organism of staphylococcus poisoning is *Staphylococcus aureus*. Staphylococcus contamination of the food may either be from human or animal sources. The nasal passage of many human beings, especially those with sinus infection contains many such *staphylococci*. Similarly, boils and infected wounds are potential sources. Cows

affected by a disease called *mastitis* could discharge *staphylococci* into the milk. Environmental conditions such as temperature (37°C), presence of an abundance of protein and starch, are conducive to growth of *staphylococci*. Some strains of *Staphylococcus aureus* can produce an enterotoxin. Enterotoxin is a toxin produced by an organism outside the cell-wall and can thus be produced in the food even when the microorganism is living. In contrast, endotoxins are produced inside the cell-wall and can only permeate the food or the body when the organism is killed.

Foods containing **staphylococcal enterotoxin** when consumed can cause salivation, nausea, vomiting, abdominal cramps and diarrhoea. Recovery takes about a day or two and mortality is very low. The time between the consumption of the food and the appearance of symptoms can range from 1–6 hours.

Precautions should thus be taken to prevent entry of *staphylococci* into foods if such food poisoning is to be avoided. Employees suffering from *staphylococcal* infections such as colds, boils should not be allowed to handle foods. Refrigeration of foods immediately after preparation prevents growth and formation of enterotoxin by *staphylococci.* Pasteurisation kills all the *staphylococci* that may be present in foods.

Food Infections

In contrast to food poisoning, food infection can be caused by organisms growing in food in large numbers. One such organism which has been known to cause symptoms very similar to the *staphylococcal* poisoning seen earlier is the *salmonella bacillus*. The various species of *Salmonellae* vary in their degree of infectiveness. Some like *Salmonellae enteritidis* can cause infection when a few organisms (about a million or so) are consumed whereas with other less infective species such as *Salmonellae pullorum* hundreds of millions of the organism would have to be ingested before they can cause infection.

The incubation period of *salmonella* infections is longer than that for staphylococcal poisoning, the period being usually between 12 and 24 hours.

The symptoms observed in **salmonellosis** are nausea, vomiting, abdominal pain and diarrhoea. The recovery is usually uneventful even though it may take two to three days. Some of the persons attacked by the organism after being cured become carriers of the microorganism.

People can be prevented from being infected by the disease by: (i) avoiding foods which are contaminated by the organism through diseased human beings and animals, e.g., eggs, which are broken in transit are also prone to contamination by the organism (ii) by preventing the growth of the organism by adequate refrigeration after the food has been prepared, and (iii) by pasteurising the food at such temperatures and times to kill all the pathogens present.

Other Infections

Besides salmonellae, other organisms such as the *streptococci* can also cause infections by growing in sufficient numbers in the food.

Foods can act as carriers of certain microorganisms causing diseases such as typhoid, paratyphoid, bacillary and amoebic dysenteries but none of these organism grow in the food as such. Usually, such contamination may occur due to poor handling after preparation.

It is essential, therefore, that in eating establishments and food processing factories, workers handling food do not suffer from communicable disease or are carriers of infections.

Points to Remember

Many toxins occur in plant and animal foods.

Toxins from plants include solanine (potatoes), caffeine (tea, coffee), phenylethylamine (chocolate), hydrogen cyanide (tapioca,/cassava) and trypsin inhibitor in legumes, lectins (kidney beans), myristicin in nutmeg.

Poisonous plants include some varieties of mushrooms and snakeroot.

Toxins from animals include tetrodotoxin in puffer fish, toxins in shellfish from planktons, poisonous alkaloids in muscles and clams etc. Histamine produced in certain fish by bacterial action is also toxic.

Mycotoxins prominent ones are sclerotia from ergots (a mould) in infested cereals and aflatoxins from infected groundnuts and cereals, both of these have deleterious effects on health.
Toxic agricultural residues include pesticide residues, sterol residues in meat and antibiotic residues in milk and meat

Poisoning by chemicals Lead, mercury, arsenic, cadmium enter human body through food, water and environmental contamination. These enter vulnerable body systems and disturb their function.
Bacterial food poisoning occurs due to bacterial toxins e.g., botulism and staphylococcus enterotoxin.
Food infections are caused by ingestion of large number of bacteria (salmonella and streptococci).

Knowledge of these can help us to prevent these.

Study Questions

1. What is botulism? How can it be prevented?
2. Discuss the steps to be taken during preparation and storage of prepared foods to prevent staphylococcus food poisoning.
3. What is food infection? How can it be prevented?

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Food Laws and Food Standards

Most persons in India, spend more money for food than any other item. Dietitians and nurses at work and in their social contacts are constantly asked about the comparative merits of foods available.

As food accounts for a large part of the family budget (expenditure), the homemaker tries to be selective in her purchasing. She would like to compare the available products not only in quantity but also in its nutrient contribution. Many consumers are also concerned about the additives in foods and would like to know if these additives are safe and are necessary. Other persons may need to follow a diet, which is modified in terms of fat content, cholesterol content etc.

These and many consumer problems are solved through knowledge of laws that protect the quality of food supply as well as the requirement that advertisers make no false claims for their products. Finally, the consumers need information concerning how to select food wisely within the available food groups.

One of the most common problem of food marketed is adulteration. The consumers like to get maximum quantity for as low a price as possible. The sellers must meet the needs of the buyers to be able to sell. In addition, the sellers have to be able to make a profit to be able to exist. This is a vicious cycle. When the price of food production is higher, than the price which the consumer is prepared to pay, the seller is compelled to supply a food product of inferior quality. Thus, adulteration occurs.

Adulteration is defined as the process by which the *quality* of the product is reduced through addition of *baser* substance or removal of a *vital* element. For example, water may be added to milk to increase its volume *or* fat may be removed from it.

It was to check such malpractices that the first central act called the Prevention of Food Adulteration Act was passed in 1954 and came into force from June 1, 1955. The PFA pertains to food sold and defines what may be considered as adulteration. It requires that foods be pure, wholesome and honestly labeled.

Food Laws

The Government of India is fully alive to the possibilities of food being adulterated. It has, therefore, empowered several agencies and promulgated a number of acts and orders to counteract this menace. Agencies and institutions have also been created to lay down standards for the quality of foods. The manner in which the food is processed and packaged is also covered by a number of

regulations. A brief description of the various government acts, agencies and institutions involved in laying down the standards and their implementation is given below:

Prevention of Food Adulteration Act

One of the early acts to be promulgated in this connection was the Prevention of Food Adulteration Act (PFAA) of 1954, which has been in force since June 1, 1955. The objective of this act was to ensure that food articles sold to the consumers are pure and wholesome. It is also intended to prevent fraud or deception and encourages fair trade practices. The act was amended in 1964 and again in 1976 in the light of experience gained, to plug loopholes of escape in the Act and to ensure stringent punishment for those indulging in nefarious practice.

The act defines in specific words what is meant by a food adulterant and what shall be deemed to be an adulterated food. According to the Act, food can be considered to be adulterated when any one of the following modes (acts) are resorted to:

(i) Admixture of inferior or cheaper substance, (ii) extraction of certain quality ingredients from the food, (iii) preparing or packing under insanitary conditions, (iv) sale of insect infested food, (v) obtaining the food from a diseased animal, (vi) incorporation of a poisonous component, (vii) entry of injurious constituents from the container used, (viii) use of colouring matter other than or in greater quantities than that approved for the food, (ix) sale of substandard products which may or may not be injurious to health. These are all prohibited practices under the Prevention of Food Adulteration Act.

If persons are found guilty of selling such adulterated food, the persons involved can be convicted. Severity of sentence would depend on the gravity of the offence. For example, a vendor found adulterating the food with ingredients injurious to health would be liable for a much heavier sentence than a vendor involved in only mixing an inferior ingredient not injurious to health.

The Fruit Products Order

The Government of India promulgated a Fruit Products order in 1946. In 1955, the order was revised. The Fruit Products Order (FPO) lays down statutory minimum standards in respect of the quality of various fruits and vegetable products and processing facilities. Packing fruits and vegetables of a standard below the minimum prescribed standards is an offence punishable by law. Periodic inspection by government inspectors in registered establishments is carried out to ensure conformity of standards by processors.

Meat Products Order

This makes it illegal to transport meat unless it has been prepared and processed according to the provisions of the order and carries the mark of inspection. It provides for means to:

(a) detect and destroy meat of diseased animals.
(b) ensure that the preparation and handling of meat and meat products be conducted in a clean and sanitary manner.

(c) prevent the use of harmful substances in meat foods.
(d) see that every cut of meat is inspected before sale to ensure its wholesomeness.

The Order also lays down rules and conditions for procedures to be adopted for the selection of disease-free animals, slaughter house practices and further treatment of the meat so as to maintain the meat in a wholesome manner, devoid of pathogens (disease producing organisms).

Amendments: The Fruit Product Order (FPO) was revised in 1955. Prevention of Food Adulteration Act (PFA) has been amended several times, the latest amendment was made in 1975.

Enforcement: The FPO and PFA, are enforced by the Department of Health. Under the law, slaughter houses, markets, factories, warehouses and other establishments involved in food trade, may be inspected to ascertain that the raw materials as well as processing, packaging and storage facilities are sanitary and the ingredients meet the minimum standards prescribed by law. Adulterated and misbranded products may be seized by inspectors; destroyed or relabelled, and legal action be taken depending upon the nature of the offence. Serious violations of the law may result in the imposition of fine or imprisonment or both by the court.

Interpretation of the Law: A food is adulterated if any foreign or baser material is added to it or some vital element is removed from it; if it contains dirt, filth, decomposed material or a substance harmful to health; if it is prepared, packaged or stored under unhygienic conditions; if it is made from diseased animals; if it contains additives, which conceal the poor quality of the food; if it contains additives which are harmful, uncertified food colours, or insecticide or pesticide residues in excess of tolerances and/or, if the packaging contains substances injurious to health.

Misbranding: It is also forbidden by law. A food may be considered as misbranded if it has a label, which gives false or misleading information about the product. Failure to specify weight, measure, names of additives (colour, flavourings, preservatives), limitations in use of the product, name of the manufacturer, as well as misleading the consumer in terms of size are all considered as misbranding of food.

In addition to the *mandatory* acts and orders cited above, agencies such as Indian Standards Institution, the Directorate of Marketing and Inspection have also laid down quality standards for foods. These are, however voluntary.

ISI Standards

Various committees, including representative from the government, consumers and industry, formulate the Indian Standard Institution (ISI) Standards for vegetable and fruit products, spices and condiments, animal products and processed foods. Once these standards are accepted, manufacturers whose products conform to these standards are allowed to use an ISI label on each unit of their product. The products are checked for quality by the ISI in their own network of testing laboratories at Delhi, Mumbai, Kolkata, Chennai, Chandigarh and Patna or in a number of public and private laboratories recognised by them.

The Agmark Standard

This was set-up by the Directorate of Marketing and Inspection of the Government of India by introducing an Agricultural Produce Act in 1937. This act defines quality of cereals, spices, oilseeds, oil, butter, ghee, legumes, eggs etc., and provides for the categorisation of commodities into various grades depending on the degree of purity in each case. The grades incoporated are grades, 1, 2, 3, and 4 or special, good, fair and ordinary. These standards also specify the types of packaging to be used for different products. The physical and chemical characteristics of products are kept in mind while formulating the Agmark specification.

The ISI Standards and the Agmark Standards have benefited both the producer and the consumer. It is possible for the producer to realise better prices for the product with these certification marks, as it ensures quality and guarantees the wholesomeness of the product for the consumer.

Export Inspection Council

The Council has been constituted to check the quality of a number of food materials meant for export. The Council has powers to reject any food which does not measure up to the standards prescribed for the food. Canned food such as mango juice, pineapple juice, frozen food such as shrimp, pomfrets are subject to scrutiny by this body before export.

Standards of Weights and Measures

The Standards of Weights and Measures Act (SWMA) (1985) contains provisions for effective legal control on weights, measures and weighing/measuring instruments used in industrial production and protection of public health and human safety. Vendors and manufacturers of food products can be prosecuted if their weights and measures are not certified by the Inspector of weights and measures. This ensures that the consumer gets the correct weight and measure of the food product bought in the market.

Food Adulteration

Adulteration is defined as the process by which the quality or the nature of a given substance is reduced through (i) the addition of a foreign or an inferior substance, and (ii) the removal of a vital element.

A good example is (i) addition of water to milk and that of (ii) removal of fat from milk.

Adulteration may be intentional or incidental. The former is a wilful act on the part of the adulterator intended to increase the margin of profit. Incidental contamination is usually due to ignorance, negligence or lack of proper facilities.

Adulteration of food may endanger health if the physiological functions of the food are affected due to either addition of a deleterious substance or the removal of a vital component.

Common Adulterants and Their Ill-effects

Addition of adulterants could either be intentional or incidental (Table 20.1). Some of adulterants added intentionally to food products so as to increase the margin of profit.

Table 20.1 Types of Adulterants

Type	Substances added
Intentional adulterants	Sand
	Marble chips
	Stones
	Mud
	Other filth
	Talc, chalk powder
	Water to milk
	Mineral oil to edible oils
	Harmful colours
Incidental adulterants	Pesticide residues
	Tin from can
	Droppings of rodents
	Larvae in foods
Metallic contamination	Arsenic from pesticides
	Lead from water
	Mercury from effluents from chemical industries
	Tin from cans

(a) *Sand*, *marble chips*, *stones*, *earth and other filth*: These are mostly found in food grains, pulses, spices etc. These can be removed by sorting, picking and washing. Stones and sand if present could have an adverse effect on the teeth and soft lining of the digestive tract. Filth could be a carrier of disease producing bacteria.

(b) *Talc and chalk powder*: These could be added to wheat flour, powdered spices which are white and to other such foods. As they cannot be digested by the human system, they could affect normal digestion.

(c) *Water*: Water can be added to milk, and other milk products like curd etc. Addition of contaminated water could result in gastrointestinal disturbances.

(d) *Mineral oil*: Mineral oil may be added to edible oils, thus adulterating it. This could be a health hazard as some mineral oils are toxic.

(e) *Argemone seeds*: These seeds look very much like mustard seeds and are mixed with these as an adulterant. When such a mixture is extracted for oil, it becomes dangerously toxic because consumption of argemone oil can lead to loss of eye-sight, heart disease, epidemic dropsy resembling wet beri-beri.

(f) *Kesari dal*: This could be mixed with other *dals* as an adulterant. This *dal* is able to grow even under adverse conditions and adulteration is much more during famine. Further, it is much cheaper than other *dal*. When more than 30 per cent of the total calories consumed is contributed by this *dal*, it can cause lathyrism, a form of crippling paralysis mainly in boys and men in the age group of 5 to 45 years.

(g) *Toxic colouring*: Rhodamine B, lead chromate, metanil yellow, Orange II, Blue VRS, Malachite green, Congo red are some of the colourings which are used. All these dyes are toxic and intake of them in excess could lead to abnormalities of eyes, bone, skin, lungs, ovaries, testes etc.

Incidental Adulterants

Use of pesticides has increased the possibility of contamination of foods. If proper care is not taken in using the right kind of tin plate and lacquer for canning foods, metallic contamination of the food could be a problem. Pests like rodents and pesticide residues could also render food unfit for human consumption. Indiscriminate use of all plastic packaging material like polyvinyl and polyethylene material could be a health hazard.

Metallic Contamination

If arsenic, lead or mercury get accumulated in the body they can be harmful.

Arsenic: Arsenic pesticides are the main source of arsenic contamination of foods. For example, fruits such as apples and grapes sprayed with lead arsenate, if eaten without washing, could be harmful. The quantity of arsenic allowed in food products varies from 0.1 p.p.m. (in milk) to 5.0 p.p.m. (in pectins, spices) depending on the food. When arsenic concentration is higher than prescribed, it can cause dizziness, chills, cramps and paralysis.

Lead: Lead could get into food through lead pipes carrying water and from food colours containing lead salts. The quantity of lead allowed in food products varies from 0.5 p.p.m. (in concentrated soft drinks) to 10.0 p.p.m. (in liquid pectin and chemicals not otherwise specified) depending on the food product. If the build-up of lead in blood increases beyond the critical blood level of 40 to 80 mcg per 100 g of blood, mental disturbances and behaviour disorders may be produced followed by muscular paralysis, convulsions and permanent brain damage.

Mercury: It is present in traces in the form of its compounds in all water and food. The effluents from many chemical industries now-a-days have high concentrations of mercury and human beings and animals consuming crops grown with such water or fish from such areas could develop mercury poisoning. Intake of above 0.0033 mg/kg of mercury and methyl mercury per person are harmful. Such intakes of mercury could affect the brain with the patient becoming blind or deaf. Convulsions with intense pain is also one of the symptoms of mercury poisoning.

Tin: Canned food and beverages usually contain small quantities of tin. The maximum tin content allowed in any canned food stuff is 250 p.p.m. High tin content in foods (about two to three grams) may cause severe headache, vomiting vertigo, photophobia, abdominal pain, dehydration and retention of urine.

Contamination by Pests and Pesticide Residues

Pests such as rodents and insects introduce into the food a high degree of filth in the form of excreta, bodily secretions and spoilage microorganisms. For example, rats can transfer salmonella bacteria to the food so that humans consuming it may suffer from salmonellosis.

Pesticides, like DDT, malathion could leave residues on the plant product much more than what is considered safe. The maximum permissible residue allowed for DDT, malathion is 3 p.p.m. For pyrethrum, it is 10 p.p.m. Many times, pesticides residue could be much higher than this figure and could be toxic. However, if precautions are taken to see that all vegetables and fruits are washed with potable water before they are consumed, such cases of poisoning would be reduced.

Packaging Hazards

Polyethylene, polyvinyl chloride and allied compounds are used to produce flexible packaging material. While this method of packaging is very convenient, it must not contain any noxious thermal breakdown products which could be injurious to health. Further, temperatures used for heat sealing, or sterilisation should not result in formation of toxic residues. It has been observed sometimes that in foods like pickles the acid and oil could attack the plastic packaging material and create a health hazard. To avoid such incidences, it is essential that only food grade plastic packaging material be used for packaging foods.

Health Hazards due to Consuming Exposed Snacks

In view of school children being exposed to adulterated products especially when buying snacks from hawkers who are almost always present around every schools, a list of usual items for sale in such areas with the possible hazards involved due to adulteration are given below Table 20.2:

TABLE 20.2 Health Hazards from Snacks

Name of snacks	Adulterants	Health hazards
1. *Pani puri/bhel puri*	Harmful bacteria	Gastro-intestinal infection
2. Sugar-cane juice	Harmful bacteria	Gastro-intestinal-infection
3. *Sherbets*/coloured sweets	Harmful bacteria	Gastro-intestinal infection
	Orange II	Lesions in vital organs
	Malachite green	

Simple Physical Tests for Detection of Food Adulterants

Consumers should be aware of common adulterants and simple visual tests to detect them. A few are enumerated below:

1. Inorganic and organic matter may be present in rice, sugar, pulses, mustards, cumin seeds; wheat, *jowar* etc.
   Inorganic matter consists of matter like sand, gravel, dirt, pebbles, stones, lumps of earth, clay or mud.
   Organic matter could be chaff, straw, foreign edible seeds. Such matter can be observed and removed visually. Presence of these substances is allowed to the extent of two to five per cent depending on the food product.
2. *Kesari dal* in *arhar(tur)*, *masoor, chana dals.*
   Kesari dal has a characteristic wedge shape. There are two varieties. One is small and resembles *masoor dal*. The larger is the size of *arhar* (*tur*). The dehusked *kesari dal* is mixed with *arhar* (*tur*) and *chana dals.* The unhusked one is mixed with black *massor* or Bengal gram. *Kesari dal* can be separated by visual examination.
3. *Ergot seeds in Bajra*: Ergot seeds are lighter than *bajra* seeds and if a small quantity is placed in a glass of water the ergot seeds will float.
4. *Argemone seeds mixed with mustard seeds*: Argemone seeds are small and black in colour resembling mustard but not uniformly smooth and round. They can be identified under a magnifying glass.
5. *Coal tar dye may be present in roasted gram and tea leaves*: Usually this can be detected by visual observation. Depositing the tea on a moistened blotting paper will show coal tar dye presence by the colour spreading into the blotting paper.
6. *Grit in sugar or salt*: Dissolve a little of the sample in hot water, sugar and salt will dissolve whereas grit will not.
7. *Iron filings in suji* (rava) or *tea-leaves*: By drawing a magnet over the sample, iron filings will cling to the magnet, thus revealing their presence.

Simple Laboratory Chemical Tests

Besides these visual tests, certain simple laboratory tests could be devised to detect adulteration in foods. However, it must be stressed that these tests are very elementary and one should not jump to conclusions about the food being adulterated unless it is confirmed by tests carried out in a recognised laboratory. The tests are described briefly below:

1. *Metanil Yellow* in *haldi* powders, *haldi* (whole) and in *gur*. To 2 g of the sample, add 5 ml of alcohol. Shake and add a few drops of concentrated hydrochloric acid. A pink colouration indicates the presence of metanil yellow.
2. *Artificial Colour in Chillies* Rub the outside of a chilli with a piece of cotton soaked in liquid paraffin. If the cotton extracts the colour and becomes red, it is an indication that the sample has added colour.

3. *Addition of Starch to Milk, Butter and Coffee*:
   (a) *Milk and Butter*: Add a drop of iodine solution to a small quantity of the sample. Formation of blue colour indicates adulteration with starch.
   (b) *Coffee Powder*: Make a decoction of the coffee. Decolorise it by adding potassium permanganate solution. Then add a drop of iodine solution. Blue colour formation indicates adulteration with starch.
4. *Argemone Oil in Mustard Oil*: Heat 5 ml of test sample with 5 ml of nitric acid for two to three minutes. A red colour will appear if argemone oil is present.
5. *Rancidity in Oils*: To 5 ml of sample in a test tube add 5 ml of hydrochloric acid. Stopper the test tube and shake vigorously for 30 seconds. Add 5 ml of 0.1 per cent phloroglucinol solution in ether. Shake for 30 seconds and then allow to stand for 30 minutes. A pink or red colour in the acid layer indicates that the oil sample is rancid.
6. *Mineral Acids in Aerated Water*: Prepare metanil yellow paper by soaking filter paper strips in 0.1 per cent aqueous solution of metanil yellow and drying the paper strips. Pour a drop or two of aerated water on one of the paper strips. Mineral acid would colour the paper violet. This is retained even on drying the paper.

Consumer Protection

The ultimate aim of the enactment of all these acts and orders described above is to protect the consumer from adulterated foods. To do so, it would be necessary to find out whether a particular food has been adulterated. A number of laboratories are authorised by the Central and State Governments to collect samples of food suspected to be adulterated and analyse them. They can prosecute the manufacturers of these foods if they find the food to be adulterated. If found guilty, the manufacturer is punished. This affords a great protection to the consumer.

Government Agencies

The various laboratories engaged in the collection of samples and analyses of such foods are:

1. Municipal laboratories in big cities.
2. Food and Drug Administration laboratories of States.
3. Central Food Testing Laboratory of the Government of India.
4. Laboratories of the Export Inspection Council.
5. Central Grain Analysis Laboratory.

A brief description of these testing agencies follows.

Municipal Laboratories

All Municipalities of big cities like Mumbai, Kolkata, Chennai, Delhi etc., have their own testing laboratories headed by a Municipal Analyst. The qualifications and experience, which the Municipal Analyst must have, are prescribed by the Prevention of Food Adulteration Act. He is expected to have good knowledge of chemical and microbiological analyses of all kinds of foods.

The Municipal laboratories in big cities are equipped for carrying out recognised methods of analysis of all types of foods. For example, to name a few, they can determine the fat content of milk, the pesticide residue in parts per million in foods, the number of different types of bacteria present in foods and whether there are any disease producing microorganisms in water and food.

Usually the Municipal laboratory comes under the Department of Health of which the Health Officer, a qualified medical practitioner, is the head. There are several inspectors working under the Health officer. These inspectors make periodic rounds of the various wards to which they have been posted and collect all samples of food suspected to be adulterated. Samples are sealed in the presence of the vendor and witness and sent to the Municipal laboratory for analysis. If the food samples are found to be adulterated on analysis, the Health Officer can prosecute the manufacturer of the food. The manufacturer can defend himself in the court of law. If found guilty, depending on the severity of the crime, he can be punished by a fine or imprisonment or both. This acts as a deterrent and helps in preventing manufacturers from adulterating foods.

Food and Drug Administration

Some State Governments like that of Maharashtra have laboratories throughout the State. The Director of the Food & Drug Administration is empowered through his staff to collect samples which are suspected to be adulterated and have them analysed in the same way as the Health Officer of a Municipality. The Food and Drug Administration has jurisdiction all over the state as compared to municipal laboratories, which work only within city limits.

The Food and Drug Administration also puts up exhibitions in all parts of the state in which the various ill-effects caused by food adulteration are highlighted by posters, talks and meetings. Examples of food adulteration such as the indiscriminate use of banned colours in foods, the mixing of argemone seeds with mustard, the mixing of papaya seeds with pepper are all shown and explained with the help of actual samples. The various reactions caused by the consumption of such adulterated food are also described. Simple methods of detection, form part of such exhibitions.

The Central Food Testing Laboratory

The Government of India has established a Central Food Testing Laboratory (CFTL) in Kolkata for carrying out analyses of all foods. These laboratories are very well equipped and can carry out even sophisticated and sensitive analyses. These laboratories are the ultimate authority in determining whether a food sample is adulterated or not and in cases of conflicting reports of analyses from two laboratories, the authorities concerned usually refer the case to this laboratory. Usually analyses carried out by these laboratories are accepted as the last word in analyses of foods.

Export Inspection Council Laboratory

In view of substantial quantities of food exported, such as frozen sea food and canned fruits and vegetables, the Government of India has made it mandatory for all exporters to have their products analysed. This ensures that the foods exported conform to the minimum requirements as laid down

by the Council. The Council has, therefore, laboratories in all the major ports where samples are analysed. For example, the laboratory in Cochin analyses mostly frozen sea food, which is the major food item exported from that port. This is a protection given to the importer in another country to whom the foods are to be sent. Without a certificate from the Export Inspection Authority, no food can be exported.

Central Grain Analysis Laboratory

This laboratory undertakes analyses of the consignment samples of imported grains besides those of indigenous food grains and their products. This helps the government in checking whether the foodgrains either imported or procured indigenously conform to the specifications laid down by the Storage and Research Division of the Government of India.

Voluntary Agencies

Several voluntary agencies have programmes of educating the consumer so that he can safeguard himself from eating adulterated food. Private food testing laboratories are also available for carrying out food analyses. Most progressive companies have their own quality control laboratory.

Quality Control Laboratories of Companies

Many companies manufacturing food products have well equipped quality-control laboratories to check both the ingredients and the final product to see that the product conforms to prescribed standards. For example, in the manufacture of bread, ingredients like flour, yeast, sugar, hydrogenated oil are examined physically, chemically and microbiologically. The bread is tested for taste, weight, volume, colour of crust, formation of crumb, proper slicing and packaging.

In the dairy industry, microbiological counts of the milk are taken and the fat content determined the former gives an idea of the sanitary conditions under which the milk was collected, the latter whether any cream had been removed. Checking for destruction of the enzyme phosphatase ensures that the milk has been properly pasteurised.

In canning fruits and vegetables, the fresh materials are visually inspected and all the bruised and spoiled ones removed; acidity of fruits like mangoes, cherries, tenderness of vegetables like green peas are determined to estimate duration of processing times; accelerated storage tests at higher temperature are conducted to ensure keeping quality of canned food.

In freezing fish, quality control checks at various stages of processing are carried out to see that the final frozen product conforms to the prescribed microbiological standards; drained weights after thawing are taken to make sure that the customer gets the right weight. Some companies have standards even higher than that of the ISI and are thus very conscious of quality. Some of the industries which are quality conscious are the biscuit, dairy, fruit and vegetable canning industries. Many of them have well equipped laboratories to check standards both of the raw material as well as the final product. Careful quality control by a processor not only help the consumer in getting a

high quality product but also benefits the processor by projecting an image of quality which increases profitability.

Quality Control laboratories of Consumer Co-operatives

Consumer Co-operative societies like Apna Bazar in Mumbai, Super Bazar and Sabka Bazar in Delhi, Chintamani in South also have criteria for selection of food items which they sell in their shops. If they do not fulfil these criteria, they are not accepted by the co-operatives. Many times, co-operatives maintain laboratory facilities to check on the quality of food supplied to them. Most of them now-a-days supply packaged cleaned and weighed foodstuffs to eliminate adulteration and cheating in weighing. There is room for improvement with respect to the procedures adopted by these societies to accept or reject foods.

Private Testing Laboratories

There are a number of private testing laboratories, which carry out tests of all food materials on payment. Manufacturers and exporters take advantage of such facilities to have their products checked to make sure that they conform to the standards prescribed. Some private testing laboratories are recognized by government and certificates given by them are valid for legal purposes. Processors and exporters who do not have their own laboratories for quality control usually take advantage of this facility.

Consumer Guidance Society

A Consumer Guidance Society has been formed in India with Mumbai as its headquarters and with branches in major cities. This society tries to create consumer awareness of the various forms of adulteration and develop consumer resistance to such adulterated food products by giving talks over the radio and using other such mass media and putting up exhibitions in educational institutions. Enlightened consumers form part of the executive of this Society. The Society tries to get food samples tested in laboratories of educational institutions as they do not have facilities of their own. They bring out a publication 'Keemat' in which consumers are kept informed about measures taken to combat all malpractices in respect of food. They also try to educate the consumer about simple method for detecting adulteration in foods.

The Central Government has accorded a high priority to the consumer protection movement. Financial assistance is given to consumer organisations for the protection of consumers. A Consumer Protection Advisory Council has been constituted, which advises the government on all matters pertaining to the interests of the consumer. The success of these measures depends on the participation of consumers.

Points to Remember

Consumer Challenges—about food quality, additives and their safety, food adulteration. To check these Prevention of Food Adulteration Act (PFA Act) passed in 1954.

Food Laws—include PFA Act, Fruit Products Order, Meat Products Order: enforced by Department of Health.
Misbranding and adulteration to be contained by law.

Food Standards—ISI and Agmark-Enforcement Agencies–ISI Laboratories, Export Promotion Council.

Food Adulteration—reduction of quality or nature of food product.

Common Adulterants—sand, earth, filth, chalk, water etc.

Incidental Adulterants—pesticide residues, metals, packages.

Simple Tests to Detect Adulterants—physical and laboratory tests.

Consumer Protection—government agencies and voluntary agencies.

Study Questions

1. List the laws promulgumated to protect the consumer. Discuss their content.
2. What are food standards? Discuss the various food standards and their nature.
3. What is food adulteration? List the adulterants commonly found in foods.
4. How does adulteration affect the consumer?
5. List the adulterants in order to the seriousness of health hazards caused by these.
6. List simple physical tests for detection of adulteration.
7. List simple chemical tests for detection of adulteration.
8. List the agencies engaged in consumer protection and their scope of work.

Appendix

Table of Abbreviations and Table of Equivalence

The abbreviations used in the book and a recipe books are presented in Table A1.1. The coversion table for weights and measures is given in Table A1.2.

Table A1.1 Table of Abbreviations

Abbreviation	Explanation
C	Cupful
T	Tablespoonful
t	Teaspoonful
g	Gram
kg	Kilogram
ml	Millilitre

Table A1.2 Table of Equivalence

	Equivalence
20 drops of water	1 ml
5 ml	1 t
3 t	1 T
16 T	1 C
1 Measuring Cup	240 ml
1 tea cup	140 to 150 ml
1 teaspoon (ordinary)	6 to 7 g
1 oz	28 g
16 oz	1 lb
2.2 lbs	1 kg

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