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V102: B.Sc. (Hospitality Studies and Catering Services)

HTS 512: CATERING SCIENCE

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CATERING SCIENCE

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C O N T E N T S

UNIT 1 : INTRODUCTION TO CATERING SCIENCE AND NUTRITION

1.00 BEFORE WE BEGIN

Today Hospitality Industry has widened its wings all over the world. We are now being aware about the various sectors of Hospitality Industry related to catering. Hence we find that there are various Hotels of different categories offering various facilities to the guest. There are now various innovations been made in various types of lodgings properties.

According to the guests needs, different types of lodgings therefore have come into existence, such as- Budget Hotels, Conventional Hotels, Resorts, Motels, Specialty Restaurants, Fast food outlets of International standards, hence due to this various needs & the different eating habits the catering Industry has now started introducing many dishes which attract to the guests, making the Industry recognized by the same. Catering is divided into 2 sectors: One is profit making & the other is the Semi or Non Profit making Industry. Hence we find that catering also comes up in different roles such as the Welfare Catering, Industrial Catering, School Canteens, and Hospital Catering, where the minimal charges or no charges are taken from the concerned.

We also find Catering in the transport Section: Where Airlines/ Flight kitchen, Ship Catering, Rotels, Railways Catering which are movable but the food is catered to the guests.

Many hotels provide facilities such as Banquets to accommodate as much guests as they can according to their space availability, hence we find small conference halls utilized for a smaller ceremony- buffets are organized for the same, likewise the corporate sectors are now becoming equipped with all the food service outlets till the conference halls to cater their employees & give them a better service in-house the company so that the Employees find themselves comfortable & give a better performance in their work& feel happy to work. Hence the importance of hygienic practices are also increased, lot of hygienic practices are required to avoid certain hazards caused due to the negligence towards the cleanliness & hygiene related to the health of the customers. In this industry the food handlers thus have to play a vital role.

A food borne disease is transmitted to people through the food they eat. Diseases caused by microorganisms such as bacteria, viruses and parasitic infestations are communicable. They are generally transmitted through the food handler who is either suffering from the disease or is a carrier of disease producing microorganisms. Sometimes they are transmitted by cross-contamination. Diseases are transmitted by direct or indirect transmission and they result in contamination of food. Food may just serve as a vehicle of transmission of disease or microorganisms may rapidly grow in food and cause either food poisoning or food infection. Food poisoning is caused by the toxins produced by bacteria and food infection is caused by living bacteria creating an infection in the intestinal tract. Food may also cause disease because of presence of non-microbial agents like poisonous plants and animals, toxic metals and chemicals or because of allergens. Common symptoms are nausea, vomiting, diarrhea and weakness. These diseases pose a constant threat to the food industry. They can be prevented by practicing the basic rules of hygiene at every stage from food purchasing till serving the food.

Therefore, we find that food is catered to various sectors despite of the limitations, but arrangements are made to cater the food service & hygiene is practiced to prevent the food poisonings.

This requires a lot of Manpower Management & to maintain the highest standards of Quality & Services. Hence a lot of trained manpower is required in these sectors. Therefore, to maintain the highest standards of hygiene & to give a better product of food the importance of Cleanliness comes to priority. This can happen by lot of training given in house the establishments; many Colleges & Institutions have incorporated the syllabus of Catering Science in their studies.

Food is a mixture of many different chemical components. These components are known as food nutrients. These food nutrients supply energy to our body and regulate the various metabolic activities. Nutrients are thus required in our body in a balance way. Apart from the effects of deficiency, excess consumption of any nutrient is also harmful. Hence balanced diet is prescribed in our diet. Our diet should include all types of food groups, whether it is vegetables, non vegetarian food, milk, pulses etc. Various types of age groups require different types of food products to be consumes. The diet is different for different people. Child diet, diet for patients, diet for young people, senior citizens, special population etc. Hence the subject Nutrition has a wider spectrum about food & the consumers. To prescribe a balanced diet, one should have a deeper knowledge about the various Nutrients, its sources, its requirements in our diet, the functions of the nutrients etc.

We will now look further to establish a good knowledge towards Catering Science so that it could be utilized in a better way towards the health of the customers who is treated as God.

1.01 UNIT OBJECTIVES

After studying this unit you will be able to

- Describe the various sectors where catering can be carried out,
- Discuss the importance of catering science,
- Elaborate on layout of catering premises,
- Describe the concepts in colloidal chemistry,
- Explain the importance of nutrition
- Describe the components of nutrition like protein, carbohydrates and lipids.

1.02 INTRODUCTION TO THE CATERING PREMISES

When we talk about the Hospitality Industry related to the Catering part, we think about how the food must be handled. Who are the people who cook it? In which circumstances do they cook the food, how do they store the food, how do they re-use the left over? & many more questions arise for the same.

Thus we all know that there is a department called as **Food Production** where the food is prepared.

There are various sections to prepare the food. These sections depend upon the food catered & the type of customers availing that facility. If this is a Five Star Hotel, then the Food production department should be very well organized with its sub-sections or departments.

The sections could be divided into Hot or Cold sections & hence designed accordingly. This could be Sauce Section, Soup Section, Cold Food Section, Butchery Section, Garde Manger section, Bakery section, Frying section, Pantry for snacks products etc.

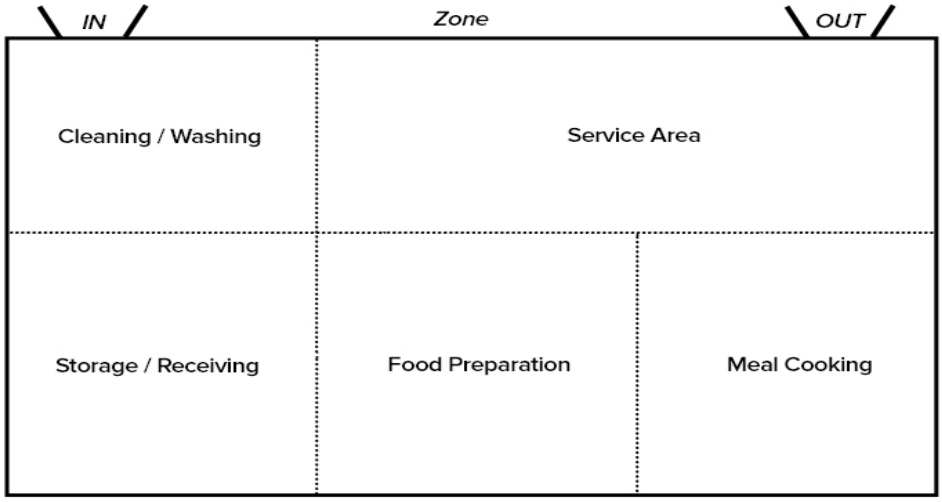


Fig 1.01: Layout of catering premises

Every section of the department is headed by a Separate Cook called as the Head of the department or the Chef de Partie. These Chef de parties are assisted by the various levels of Expert cooks called as Commis who actually cooks the food.

In this department you will find that the vegetarian & non-vegetarian food is cooked or prepared separately, their storage is also done separately.

Various large equipments such as working tables, Refrigerators, Ovens are used. There are smaller equipments also which are used for the cooking purpose.

Every section of the department has its own working area, storage facilities & a team of experts. This team of experts are well qualified & basically recruited from the Catering Colleges. Hotels also do have their own programs in which special training is provided to the new entries & hence a special training is provided to such employees who do not have any special knowledge of hotel management.

All the necessary standards are maintained in this department regarding the cleanliness, hygiene & safety of the employees. You will find that the proper ventilation arrangements are provided, the floor is of hard flooring, insect killing machines are installed, exhaust machines are provided to eradicate smoke from the kitchen, various cold rooms are provided to store the vegetables or the cooked food. A proper store room for perishable &nonperishable products is available. The raw material is ordered in advance from the Main store room & then stored in the in-house storage rooms. There are separate working tables for the respective sections, separate chopping boards for veg &non veg are used. A proper hygiene is maintained. Drainage facility is provided; a separate team of kitchen stewarding is present who looks after the cleanliness of the same. Separate area is designed for the cleaning of utensils, mechanical equipments are also available to clean the cutlery & crockery.

Gas ranges or high pressure & low pressure is installed with a secured gas pipeline. A proper cycle of Food preparation is carried out. Hence you can see that the raw material is ordered from the stores, it is received by the particular section head, then it is cooked according to the standard specifications so as to give a better quality using highest standards of cleanliness, then it is dished out i.e. prepared.

Food is then served to the customer's plate in the specific dining areas. During this cycle the food preparation staff has to be very careful to give a better product in terms of color, quantity, texture, consistency & taste so that the customer gets satisfied.

CHECK YOUR PROGRESS

1. How is the Food preparation area divided?
2. Explain about the storage of the Food in the Kitchen.

1.03 IMPORTANCE OF CATERIG SCIENCE IN HOSPITALITY INDUSTRY

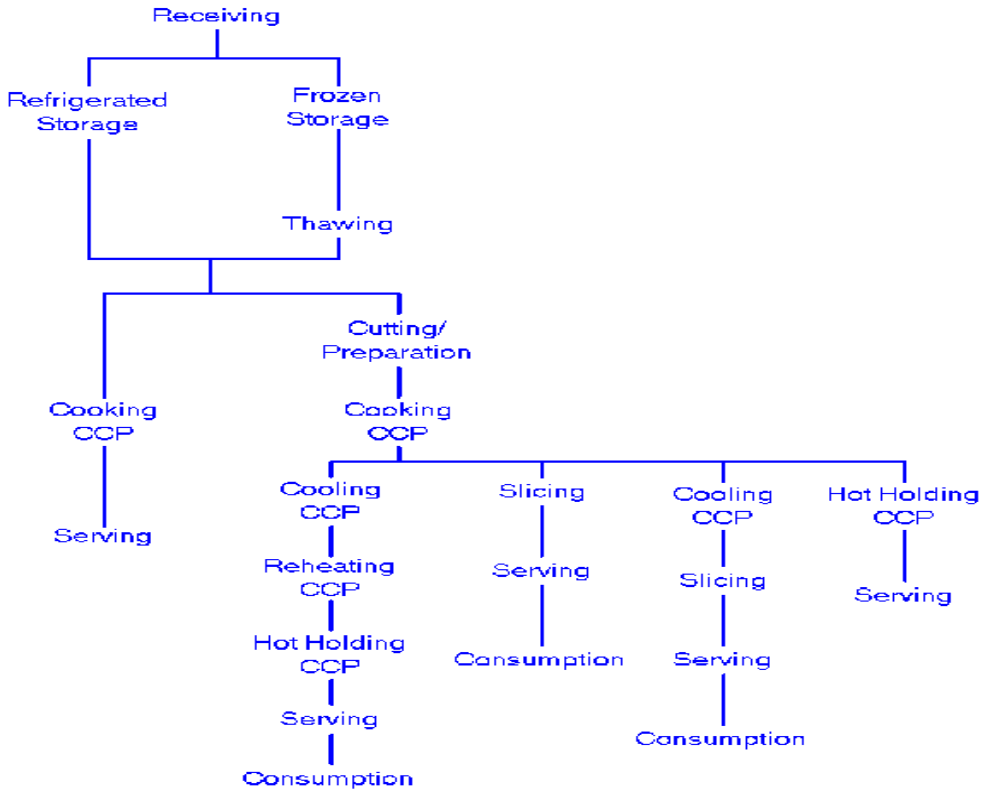


Fig 1.02: Channeling of raw material

As we all have gained knowledge about the various sectors of this Hospitality Industry, we also have acquired the knowledge of the Catering aspects related to this industry.

It is thus very necessary as to know the Importance of the Catering Science into this Industry. Why Catering Science was held up to such importance & why it is to the prime priority. The reason behind it is the health aspect of the customers.

We find that the food could be perishable or it could be semi or non-perishable.

Most of the food when they are in a raw state has to be handled carefully before they are used in the actual preparation, otherwise they get spoilt easily. Some food stuffs are to be stored only under specific temperatures & some could be stored at room temperatures also. After this the food is sent for the processing or the cooking stage. At this stage also the food handler should take utmost care in handling the same. Sometimes the food prepared has to be held for a certain period, hence this period is also very crucial & a specific arrangement has to be made to hold the cooked food. All these stages are now prominently coming into practices keeping in the rules & regulations of the World Health Organizations.

Many establishments are now very keen in maintaining the standards of hygiene.

The Food & Drugs Association has strict rules & regulations for the same. If the rules are violated, the licenses can be cancelled of the food establishment or the Hotel, or heavy penalty, imprisonment is carried out.

Hence we see that before the actual preparation/ handling of the raw material, many people handle the raw products while harvesting, transporting, and packaging. Due to this lot of contamination is observed. By the period it is received at the production unit it is contaminated quite heavily, hence the raw material has to be handled according to the standard hygienic practices.

The raw material has to be stored properly in the respective store rooms with the required temperature it needs.

During the actual preparation the food has to be cooked very carefully. The utensils used for cooking should be clean. If it contains any residue of any cleaning agent it could be hazardous enough for the customers consuming it. The chopping boards, knives used for the non-vegetarian should not be used with the vegetables as various micro-organisms could get transferred hence utmost care should be taken.

While storing food one should be aware that the actual temperatures should be maintained properly. Various methods of cooking play an important part, some food stuffs require boiling method while some require frying or stewing, one should know how the color of the vegetable changes? Why a chicken has to be marinated or how the mayonnaise gets curdled? In how many ways eggs could be cooked? Hence this technical knowledge is quite important because the ultimatum is that the food should be free of microorganisms & safe to consume.

As a student of Catering Science we should know the study of various food additives which are permissible to use in the food. Hence utmost care should be taken while using the additives. We should also be aware about the purity of the food products hence a basic knowledge of Adulterants is required.

Hence handling of food is very important, many food borne diseases occur due to the above mal practices in the cooking areas; hence by knowing the Science of Catering one can easily overcome the problems like food poisoning, infections due to consumption of the contaminated food.

Keeping the areas clean, carrying out regular safe pest control activities, proper storage practices can minimize and control the hazards involved in the nuisance.

There are various sectors related very closely with the Catering & hence a proper well designed area should be planned out. Necessary trainings should be given to the Employees handling the food. Sanitary facilities, separate locker rooms, laundry facility, medical facility, disinfectants etc. should be provided so that the employees could work in a clean & healthy atmosphere.

Garbage disposal is one of the important aspects to be taken care of. This should be managed effectively.

Hence a well-balanced food cooked with a proper technical knowledge of the Nutrients, knowledge of the proper methods of cooking in the right hygienic way will help the guest stay fit & enjoy the world of tastes.

CHECK YOUR PROGRESS

Explain the importance of Catering Science in Hospitality industries.
What is the role of Food and Drug Administration?
Why is it important to know the rules of FDA?

1.04 COLLOIDAL CHEMISTRY AND FOOD

Fig 1.03: Milk is an emulsified colloid of liquid butterfat globules dispersed within a water-based solution. (Wikipedia)

In chemistry, a colloid is a mixture in which one substance of microscopically dispersed insoluble particles is suspended throughout another substance. Sometimes the dispersed substance alone is called the colloid; the term colloidal suspension refers unambiguously to the overall mixture (although a narrower sense of the word suspension is distinguished from colloids by larger particle size). Unlike a solution, whose solute and solvent constitute only one phase, a colloid has a dispersed phase (the suspended particles) and a continuous phase (the medium of suspension). To qualify as a colloid, the mixture must be one that does not settle or would take a very long time to settle appreciably.

The dispersed-phase particles have a diameter between approximately 1 and 1000 nanometers. Such particles are normally easily visible in an optical microscope, although at the smaller size range ($r < 250$ nm), an ultramicroscope or an electron microscope may be required. Homogeneous mixtures with a dispersed phase in this size range may be called colloidal aerosols, colloidal emulsions, colloidal foams, colloidal dispersions, or hydrosols. The dispersed-phase particles or droplets are affected largely by the surface chemistry present in the colloid.

Some colloids are translucent because of the Tyndall effect, which is the scattering of light by particles in the colloid. Other colloids may be opaque or have a slight color.

Colloidal suspensions are the subject of interface and colloid science. This field of study was introduced in 1861 by Scottish scientist Thomas Graham. (Wikipedia)

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

- Solids
- Solutions
- Colloids

Forms of food	Description	Examples
Solid	Have a fixed shape, possesses all the properties of a solid structure	Sugar, fibre.
Solution	Homogenous mixture of two or more substances. The dissolved substance is known as solute and the dissolving substance is the solvent	Liquid portion of canned fruits, soups.
Colloid	If the particles range in size from 1nm to 0.5mm, they can remain dispersed for long time without precipitation and constitute a colloidal system.	Milk, mayonnaise, butter.

Table 1.00 Forms of Food

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

1. Crystalloids- These solutions readily diffuse through a parchment mem-brane. Examples are sugar, urea, sodium chloride, glucose, and fructose.

2. Colloids- The substances whose solutions do not diffuse or diffuse very slowly through parchment membrane are called colloids. Examples are glue, gelatin, albumin, starch, gum, proteins.

Characteristics of Colloids

The characteristics of the colloids are as follows:

- The particle size ranges from 50 to 2000 A.
- Particles themselves are invisible and the light scattered can be seen by an ultra-microscope.
- They are generally transparent.
- They diffuse slowly through the parchment membrane.
- Ordinary filtration is not possible while ultra-filtration is possible.
- Colloids may show Tyndall effect, (they look translucent due to scattering of light)
- Colloids show Brownian Movements.

Classification of Colloids

Colloids may be of two types depending upon the affinity of the dispersed phase for the dispersion medium. They are lyophilic or reversible and lyophobic or irreversible. ('Lyo-means the dispersion medium). When water is the dispersion medium the terms used are hydrophilic (do not have affinity for water) and hydrophobic (water loving or have affinity for water).

Properties of a Colloidal system.

The properties of a colloidal system are as follows:

- It is made up of two phases- 1) The dispersed phase and 2) The Continuous Phase.
- The dispersed phase may be crystals, liquid droplets, gas bubbles, while the continuous phase may be either water or an edible oil.
- When the size of the dispersed particles exceeds 0.5mm, then it is known as coarse dispersion of suspension.
- There may be two or more phases present in the system.

Dispersed Phase	**Continuous Phase**	**Name of the Colloidal System**	**Examples**
Solid	Liquid	Sol	Skimmed milk, starch, suspension
Liquid	Liquid	Emulsion 1. Oil in water 2. Water in Oil	French Dressing 1. Milk, Cream, ice cream, salad dressing etc.

			2. Butter, Margarine etc.
Gas	Liquid	Foam	Meringue cake, bread, ice cream.
Gas	Solid	Solid Foam	Foam Confectionery
Solid	Gas	Aerosol	Smoke for flavoring food

CHECK YOUR PROGRESS

CHECK YOUR PROGRESS

Elaborate the definition of Colloid.
Describe with examples the features of food in solid state.
Describe with examples the features of food in solution form.
Describe with examples the features of food in colloid form.
Define crystalloid and colloid solutions.
Give characteristics of colloidal mixtures.
Elaborate on the classifications of colloids.
Explain the properties of colloids.
Discuss the features of emulsions as colloids.
Discuss the features of foam as colloids in terms of continuous and dispersed phases and examples.
Discuss the features of sol as colloids in terms of continuous and dispersed phases and examples.
Discuss the features of solid foam as colloids in terms of continuous and dispersed phases and examples.
Discuss the features of aerosol as colloids in terms of continuous and dispersed phases and examples.
Discuss the features of foam as colloids in terms of continuous and dispersed phases and examples.

1.05 CONCEPT S OF FOOD SCIENCE

Food science is the applied science devoted to the study of food. The Institute of Food Technologists defines food science as "the discipline in which the engineering, biological, and physical sciences are used to study the nature of foods, the causes of deterioration, the principles underlying food processing, and the improvement of foods for the consuming public". The textbook Food Science defines food science in simpler terms as "the application of basic sciences and engineering to study the physical, chemical, and biochemical nature of foods and the principles of food processing"

The study of the nature of food and its constituents with its importance in human diet is called as the Food Science.

The study of food science involves understanding changes that occur in these components during its handling, cooking, storing and its final presentation. These reactions may be the result of interaction between components with the medium of cooking, environmental condition such as heat, cold, light and air to which they are subjected during cooking, processing, preservation and consumption of food. Thus food science is a broad discipline which contains within it many specializations such as food

microbiology, food engineering and food chemistry, food psychology, food biochemistry; thus it becomes a chain such that there is close relation between food science and nutrition.(Wikipedia)

Fig 1.04: A food science laboratory (Wikipedia)

Fig 1.05: Food Scientists working in laboratory in Australia (Wikipedia)

Food science is important in biochemistry as it includes the study of raw, cooked, and processed foods and factors affecting the nutritive value. The use of an artificial sweetener instead of sugar highlights the importance of chemistry in food science. Some applications in food science includes the development of palatable, nutritious, low cost food, improvement of existing and developing new food products, altering the nutritive content of the food, adding desirable vitamins and minerals to food i.e. the fortification process.

One of the most important role of food science with food microbiology includes the prevention of the food poisoning & introducing of new techniques and products emerging from the field of genetic engineering and biotechnology.

While the role of food science in concern with food processing includes the improving or maximizing the nutrient contents during food processing keeping in mind the various food laws and food standards. It is also related with the proper storage of the food product, its preservation methods or techniques.

Thus other important contribution of food science includes the development of systems which can recycle food for space voyages, prevention of food by toxic substances such as pesticides, removal of ions from liquid food through the process called as electro-dialysis. Thus Scientists are also involved in promoting the world trade by establishing international food standards. Food scientists also work in conjunction with nutritionists to develop standards for optimal nutritional content.

Nowadays Food scientists are also involved in developing nutraceuticals which reduces disease symptoms & help improving the nutritional balance of the individual.

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

CHECK YOUR PROGRESS

Explain what is meant by Food Science as per definition given by Institute of Food Technologists.
Elaborate on the various branches of Food Science.
Explain the importance and role of Food Science in Food Processing industries.

1.06 IMPORTANCE AND FUNCTIONS OF FOOD

Food plays a very important role in human diet. Food is the prime necessity of life. The food includes nutrients like proteins, fats, carbohydrates, vitamins and minerals. The food we eat is digested and assimilated in the body and used for its maintenance and growth. Food is a primary source of energy. Food also provides energy for doing work. The metabolism takes place after the intake of food. Food balances the nutrients in human body. This balanced diet keeps the body fit and develops a good resistance or immunity power. The food we consume undergoes complex digestive processes to yield energy. Thus the basic function of food is to yield energy.

Various activities of the body are regulated by the food. These activities include the beating of the heart, temperature regulation of the body, regulation of the nervous system, muscle contraction, blood clotting, immunity and so on.

Food gives a feeling of satiety or satisfaction. Food has also acted as one of the most important sources to bind people. Family get together or social gatherings, or even at sad occasions are incomplete without the presence of food. Food festivals are good sources of getting people come together on social grounds. International food festivals are organized in the world for the people of any origin as a matter of fraternity.

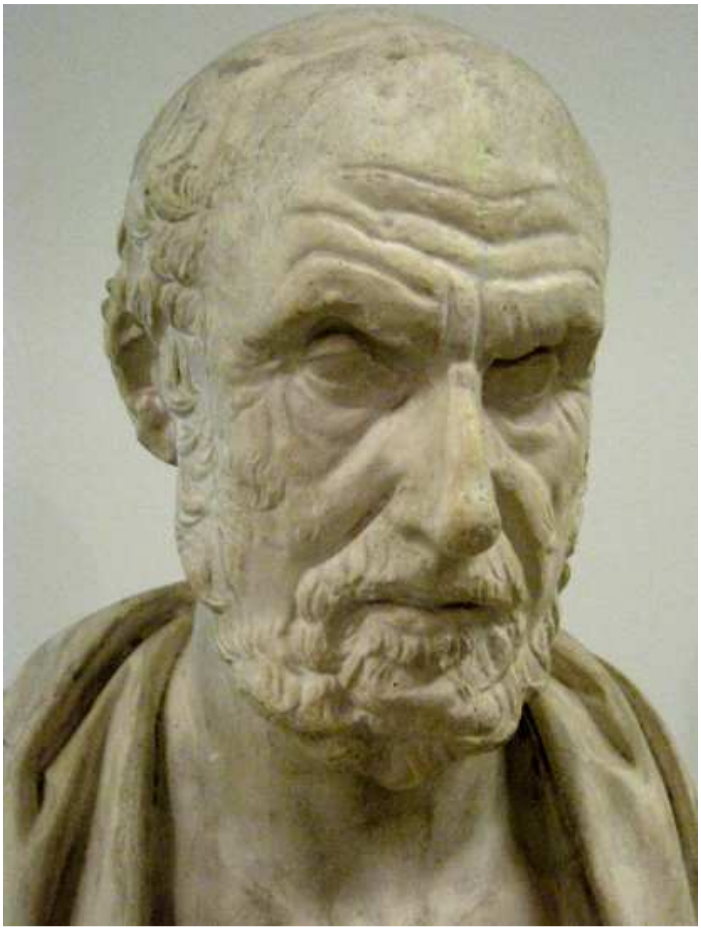


Fig 1.06: Hippocrates lived about 400 BC, and Galen and the understanding of nutrition followed him for centuries.(Wikipedia)

CHECK YOUR PROGRESS

Explain the function of food.
Elaborate on the importance of food.

1.07 CONCEPT OF NUTRITION

Nutrition is the science that interprets the interaction of nutrients and other substances in food in relation to maintenance, growth, reproduction, health and disease of an organism. It includes food intake, absorption, assimilation, biosynthesis, catabolism, and excretion.

The diet of an organism is what it eats, which is largely determined by the availability and palatability of foods. For humans, a healthy diet includes preparation of food and storage methods that preserve nutrients from oxidation, heat or leaching, and that reduce risk of food borne illness.

In humans, an unhealthy diet can cause deficiency-related diseases such as blindness, anemia, scurvy, preterm birth, stillbirth and cretinism, or nutrient excess health-threatening conditions such as obesity and metabolic syndrome; and such common chronic systemic diseases as cardiovascular disease, diabetes, and osteoporosis. Under nutrition can lead to wasting in acute cases, and the stunting of marasmus in chronic cases of malnutrition. (Wikipedia)

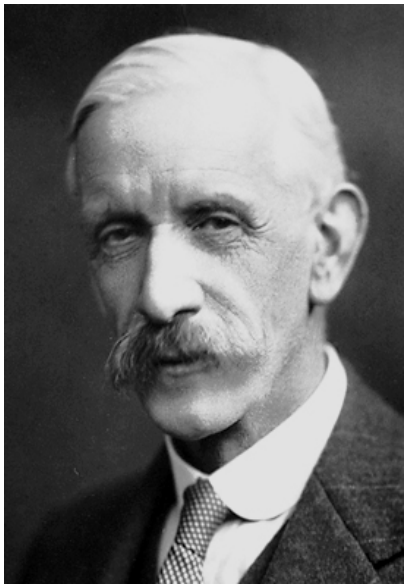


Fig 1.07: Frederick Hopkins discovered vitamins, for which he shared a Nobel prize with Eijkman (Wikipedia).

Food is a prerequisite of nutrition. Man needs all the nutrients, i.e. proteins, vitamins, fats, carbohydrates and minerals in different amounts to grow live and thrive. Since man derives all the nutrients he needs through the diet he eats. His diet must be well balanced to provide all the nutrients in proper proportions. In planning a diet for the community, foods have to be chosen in proper amounts to provide all the nutrients in required amounts to provide all the nutrients in required amounts and also keeping in view the dietary habits and availability of foods. Such a diet should be eaten in sufficient quantity daily to provide the needed energy and also to ensure supply of at least a minimal quantity of essential nutrients to maintain the body functions in a proper working order.

In addition, nutrition must be concerned with social, economic, cultural and psychological implications of food and eating. According to the American Heritage Science Dictionary, nutrition is the scientific study of food and nourishment, including food consumption, dietary guidelines and the roles that various nutrients have in maintaining health. For maintaining the health of the body and keeping the cells under normal functioning, good nutrition is very essential. Good nutrition provides both macronutrients and the micronutrients in adequate and balanced amounts. The macronutrients include carbohydrates, proteins and fats and the micronutrients include vitamins and minerals. A good nutrition is also known as adequate or optimum nutrition. In contrast, malnutrition is a condition that results from inadequate or excessive intake of nutrients (over nutrition), imbalance between the nutrients, digestive difficulties, inability of the body to metabolize and absorb nutrients and other medical conditions. Primary malnutrition is observed as a result of inadequate supply of nutrients to the body as a result of poverty, famines, insufficient crop production etc. The most common examples of primary malnutrition are protein energy malnutrition (PEM). This includes two sub-types kwashiorkor and marasmus. Secondary malnutrition results because of the presence of some diseases, eating disorders or some disturbances in the digestive system. Diseases like cancer are the example diseases that lead to secondary malnutrition. Eating disorders include anorexia and bulimia. The diseases caused because of deficiency of vitamins (likeberiberi) and minerals (like goiter) also lead to secondary malnutrition.

CHECK YOUR PROGRESS

Explain the concept of nutrition.
Elaborate on the consequences of consuming unhealthy diet and explain how study of nutrition can help us avoid preparation and consumption of such consequinces.
Discuss why nutrition must be concerned with social, economic, cultural and psychological implications of food and eating.

1.08 NUTRIENTS

Nutrients are components of food that must be supplied to the body. These are needed by the body in adequate amounts in order to grow, reproduce and lead a normal healthy life. Nutrients include proteins, fats, carbohydrates, minerals and vitamins. Water and fiber are also important components of food. Basically nutrients are the chemicals that are needed for the growth and development of the body.

The nutrients are further classified as essential and non-essential nutrients. The essential nutrients are those which cannot be synthesized by our body and need supplementation through the diet. These include essential amino acids, essential fatty acids, vitamins and certain minerals; the list also includes water. The non-essential nutrients can have significant impact on health. This impact can be either beneficial or toxic. For example, the fibers present in the food are neither digested by the human gut nor do they give energy, but in spite of that they facilitate and affect the digestion of other substances.

The list of nutrients that people are known to require is, in the words of Marion Nestle, "almost certainly incomplete". As of 2014, nutrients are thought to be of two types: macro-nutrients which are needed in relatively large amounts, and micronutrients which are needed in smaller quantities. A type of carbohydrate, dietary fiber, i.e. non-digestible material such as cellulose, is required, for both mechanical and biochemical reasons, although the exact reasons remain unclear. Some nutrients can be stored - the fat-soluble vitamins - while others are required more or less continuously. Poor health can be caused by a lack of required nutrients, or for some vitamins and minerals, too much of a required nutrient.

Macronutrients

The macronutrients are carbohydrates, fiber, fats, protein, and water. The macronutrients (excluding fiber and water) provide structural material (amino acids from which proteins are built, and lipids from which cell membranes and some signaling molecules are built) and energy. Some of the structural material can be used to generate energy internally, and in either case it is measured in Joules or kilocalories (often called "Calories" and written with a capital C to distinguish them from little 'c' calories). Carbohydrates and proteins provide 17 kJ approximately (4 kcal) of energy per gram, while fats provide 37 kJ (9 kcal) per gram, though the net energy from either depends on such factors as absorption and digestive effort, which vary substantially from instance to instance. Vitamins, minerals, fiber, and water do not provide energy, but are required for other reasons.

Molecules of carbohydrates and fats consist of carbon, hydrogen, and oxygen atoms. Carbohydrates range from simple monosaccharides (glucose, fructose and galactose) to complex polysaccharides (starch). Fats are triglycerides, made of assorted fatty acid monomers bound to a glycerol backbone.

Some fatty acids, but not all, are essential in the diet: they cannot be synthesized in the body. Protein molecules contain nitrogen atoms in addition to carbon, oxygen, and hydrogen. The fundamental

Fig 1.08: Colorful food may be source of healthy diet (Wikipedia)

components of protein are nitrogen-containing amino acids, some of which are essential in the sense that humans cannot make them internally. Some of the amino acids are convertible (with the expenditure of energy) to glucose and can be used for energy production, just as ordinary glucose, in a process known as gluconeogenesis. By breaking down existing protein, the carbon skeleton of the various amino acids can be metabolized to intermediates in cellular respiration; the remaining ammonia is discarded primarily as urea in urine.(Wikipedia)

CHECK YOUR PROGRESS

Discuss the concept of nutrients.
Explain the concept of essential and nonessential nutrients.
Elaborate what is meant by macronutrients and explain major macronutrients types.
Explain the difference between “Calorie” and “calorie” indicating which of these is used in context of food and nutrition.

1.09 CLASSIFICAION OF FOODS

Nutritional Classification of Food

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

- Energy yielding food: Foods rich in Carbohydrates and fats are called energy yielding foods. Cereals, roots and tubers, dried fruits, sugars and fats are included in this group.
- Body building foods: Foods rich in proteins are called as body building foods. Milk, meat, fish, eggs, pulses, nuts are included in this group.
- Protective Foods: Foods rich in proteins, vitamins and minerals are termed protective foods.

Food Groups

It is the method of classification of various foods that human beings consume daily, based on the nutritional properties of the foods. To facilitate the study of nutrients experts from different food agencies have classified foods under various groups.

FOOD GROUPS	MAIN ITEMS
CEREALS AND GRAINS Rice, wheat, bajra, jowar, barley	Energy protein, invisible fat, vitamin B1, Vitamin B2, Folic acid, iron, Fiber
PULSES AND LEGUMES Bengal gram, black gram, green gram, red gram, lentils, cow peas, rajmah, soya beans, beans	Energy, protein, invisible fat, vitamin B1, Vitamin B2, Folic acid, Iron, Calcium, Fiber.
MILK& MEAT PRODUCTS Milk, curd, skimmed milk,cheese, meat, chicken, fish, eggs	Proteins, Fats, Vitamin B12, Calcium
FRUITS & VEGETABLES Mango, guava, papaya, orange, sweet lime, water melon. Vegetables like amaranth, spinach, drumsticks, coriander leaves, mustard leaves, fenugreek leaves, carrots, brinjal, ladys finger, capsicum, beans, onions, cauliflower	Carotenoids, Vitamin C, Fiber. Invisible fats, carotenoids, Vitamin B2, Folic acid, Calcium, Iron, Fiber. Carotenoids, folic acids, calcium, fiber.
FATS & SUGARS Butter, ghee, hydrogenated oils, cooking oils like groundnut, coconut, mustard. Sugar, Jaggery	Energy, Fats, Essential Fatty acids Energy.

Table 1.00: Food Groups

CHECK YOUR PROGRESS

Explain the nutritional classification of food.
Explain the food groups with examples.

1.10 CARBOHYDRATES

Carbohydrates are composed of carbon, hydrogen and oxygen. They are the cheapest source of energy. Each gram of carbohydrates yields 4 Kcal. In abnormal balanced diet 70% of the total calories are attained from carbohydrates.

Classification of Carbohydrates

Carbohydrates may be classified as monosaccharides, disaccharides, or polysaccharides depending on the number of monomer (sugar) units they contain. They constitute a large part of foods such as rice, noodles, bread, and other grain-based products, also potatoes, yams, beans, fruits, fruit juices and vegetables. Monosaccharides, disaccharides, and polysaccharides contain one, two, and three or more sugar units, respectively. Polysaccharides are often referred to as complex carbohydrates because they are typically long, multiple branched chains of sugar units.

Traditionally, simple carbohydrates are believed to be absorbed quickly, and therefore to raise blood-glucose levels more rapidly than complex carbohydrates. This, however, is not accurate. Some simple carbohydrates (e.g., fructose) follow different metabolic pathways (e.g., fructolysis) that result in only a partial catabolism to glucose, while, in essence, many complex carbohydrates may be digested at the same rate as simple carbohydrates. The World Health Organization (WHO) recommends that added sugars should represent no more than 10% of total energy intake.

The term ‘saccharide, meaning sugar or sweetness, is related to the characteristic taste of many of the simple carbohydrates.

1. Monosaccharide: These are the simplest form of carbohydrate and they cannot be hydrolyzed or broken further. They include glucose, galactose and fructose.

Glucose- It is known as dextrose or corn sugar, it is less sweet and composed to corn sugar and it is soluble in hot and cold water. It is found in fruits like grapes, vegetables like corn or carrot. It is commercially prepared from corn syrup and it is the crystallized form.

Fructose- It is highly soluble and available in crystalline form, it is sweeter than cane sugar and is found in honey and ripened fruit. It is the product formed after hydrolysis of sucrose.

Galactose- It does not occur in free state but occurs in combined state, lactose (milk sugar) is a compound of glucose and galactose. It also occurs in cerebrosides.

2. Disaccharide: These are formed by the condensation of two mole-cules of monosaccharide with the elimination of water. They come in three forms- Maltose, Sucrose and Lactose.

Maltose- They are known as malt sugar and found in germinating seeds. Glucose + Glucose + Maltose.

Sucrose- It is also known as Table sugar and found in sugar cane and beetroot. It is formed by the condensation of one molecule of glucose and one molecule of fructose. Glucose + Fructose = Sucrose.

Lactose: It is found in Human & Animal milk. This is not found in any plant product. It is synthesized in the mammary gland by the glucose supplied by the blood. Formed by the condensation of one molecule of glucose and galactose with the elimination of one molecule of water. Lactose is hydrolyzed to glucose and galactose by the enzyme lactase present in the intestinal juice.

3. Polysaccharides

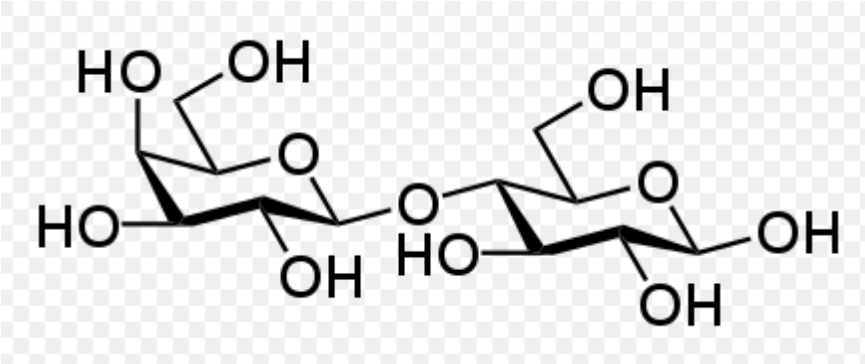
This takes a long time for digestion. They include starch, cellulose, hemi cellulose, & pectin. When more than 1 molecule of monosaccharide combine together it releases a molecule of water forming polysaccharide.

Starch

Occurs widely in the vegetable kingdom. Important sources are cereals, millets, roots and tubers. It is a white tasteless powder insoluble in cold water. When boiled with water forms a paste. When acted upon amylase (present in saliva or pancreatic juice), it is converted to maltose. During this hydrolysis, certain intermediate products called dextrin are formed.It is used in the manufacture of glucose, dextrins, custard powder and sago.

4. Complex Polysaccharides

Hemicelluloses, gums, mucilage and pectin.



Fih 1.00: Lactose is a disaccharide found in animal milk. It consists of a molecule of D-galactose and a molecule of D-glucose bonded by beta-1-4 glycosidic linkage. It has a formula of C12H22O11.(Wikipedia)

Sources of Carbohydrates

Synthesized by plants and occur in several forms. In plants it is found in the form of starch and sugar.

Starch: Cereals, pulses, roots and tubers.

Starch is used in the manufacture of glucose, dextrins, custard powder and sago.

Sugars: Fruits, Honey, Plant sap or juice (sugarcane, beetroot and palm) corn, peas.

In Human beings it is most commonly found in the blood (as glucose) and liver & muscles (glycogen). In other parts of the body it may be found as complex polysaccharides.

Functions of Carbohydrates

1. They supply energy for body functions and for doing work.

2. They are essential for the oxidation of fats.

3. They exert a sparing action on proteins.

4. They provide the carbon skeleton for the synthesis of some non-essential amino acids.

5. Some carbohydrates are present in some tissue constituents.

6. They add flavor to the diet.

7. Starch which forms the main source of carbohydrates in the average diets has a bland taste and is nonirritant and hence it can be consumed in large amounts to provide major part of the energy requirements of the body.

Dietary Fiber

Dietary fiber is a carbohydrate that is incompletely absorbed in humans and in some animals. Like all carbohydrates, when it is metabolized it can produce four Calories (kilocalories) of energy per gram. However, in most circumstances it accounts for less than that because of its limited absorption and digestibility. Dietary fiber consists mainly of cellulose, a large carbohydrate polymer which is indigestible as humans do not have the required enzymes to disassemble it. There are two subcategories: soluble and insoluble fiber. Whole grains, fruits (especially plums, prunes, and figs), and vegetables are good sources of dietary fiber. There are many health benefits of a high-fiber diet. Dietary fiber helps reduce the chance of gastrointestinal problems such as constipation and diarrhea by increasing the weight and size of stool and softening it. Insoluble fiber, found in whole wheat flour, nuts and vegetables, especially stimulates peristalsis;– the rhythmic muscular contractions of the intestines, which move digest along the digestive tract. Soluble fiber, found in oats, peas, beans, and many fruits, dissolves in water in the intestinal tract to produce a gel that slows the movement of food through the intestines. This may help lower blood glucose levels because it can slow the absorption of sugar. Additionally, fiber, perhaps especially that from whole grains, is thought to possibly help lessen insulin spikes, and therefore reduce the risk of type 2 diabetes. The link between increased fiber consumption and a decreased risk of colorectal cancer is still uncertain. (Wikipedia)

Dietary fiber or roughage is the indigestible portion of plant foods. It pushes the food into the gut, absorbs water and makes the defecation easier. It consists of polysaccharides (other than starch). The common dietary fibers are cellulose, dextrin, insulin, lignin, waxes, chitins, pectin, beta-glucans etc.

The dietary fiber can either be soluble or insoluble in water. The soluble fiber cannot be digested and is fermented by the intestinal bacteria. They have the ability to absorb water and form a gelatinous substance and then pass through the body. On the other hand, the insoluble fiber cannot be fermented by the bacteria.

Soluble fibers are found in peas, soy beans, oats, rye, barley, fruits and fruit juices, broccoli, carrots, Jerusalem artichoke, root vegetables, potatoes, sweet potatoes, onions.

Insoluble fibers are found in whole grain foods, wheat and corn bran, nuts and seeds, potato skins, lignin, skin of tomato and fruits.

Glycemic Index

The glycemic index or GI is a measure of the effects of carbohydrates on blood sugar levels. Carbohydrates that break down quickly during digestion, releasing glucose rapidly into the bloodstream, have a high GI; whereas carbohydrates that breakdown more slowly, releasing glucose more gradually into the bloodstream, have a low GI. A lower GI suggests slower rates of digestion and absorption of the foods' carbohydrates and may also indicate greater extraction from the liver and periphery of the products of carbohydrate digestion.

A mild deficiency of carbohydrate in diet result in utilization of fats for energy purpose. Excess carbohydrates would result in increasing the blood sugar level.

CHECK YOUR PROGRESS

Discuss the concept of nutrients.
Explain the concept of essential and nonessential nutrients.
Elaborate what is meant by macronutrients and explain major macronutrients types.
Explain the difference between "Calorie" and "calorie" indicating which of these is used in context of food and nutrition.

1.11 PROTEINS

Proteins contain carbon, hydrogen, nitrogen and Sulphur and some contain phosphorus. Proteins are large molecules formed from the combination of a number of simpler substances known as amino acids. The nitrogen content of proteins varies from about 14-20% and in most of the proteins; the value is about 16%.

The word protein is derived from the Greek word "proteins' which means 'principal' or 'prime". They are one of the most important constituents of a living cell. It is the most abundant component of the body, next to water. It is found in muscles, bones and cartilages, skin, tissues and body fluids. They are present in both plants and animals. The nucleus and protoplasm of any cell are basically proteins. All the life processes and metabolic activities are controlled by enzymes and hormones that are basically proteins in nature. Apart from these, our immune system is also dependent on the activity of proteins as the antibodies that fight against infection are protein compounds.

Classification of Proteins

Proteins are classified as follows:

1. Simple proteins

2. Conjugated proteins

3. Derived proteins

1. Simple proteins- These include albumins, globulins, glutelins, prolamins, fibrous proteins, histones and protamins.

2. Conjugated proteins- These include nucleoproteins, glyco-proteins, phophoproteins, haemoglobins and lecithoproteins.

3. Derived proteins- These include proteins, metaproteins, coagulated proteins, peptones and peptides.

Amino Acids

In nature about 300 types of amino acids are found of which 20 amino acids are found in proteins. All the amino acids are required by the body but some are known as indispensable nutritionally essential amino acids, as these cannot be synthesized by the body. Their deficiency may disturb the nitrogen

equilibrium, growth, and nutrition, maintenance of the body and life span of the individual. The other amino acids are termed as dispensable or non-essential amino acids as they can be synthesized in the

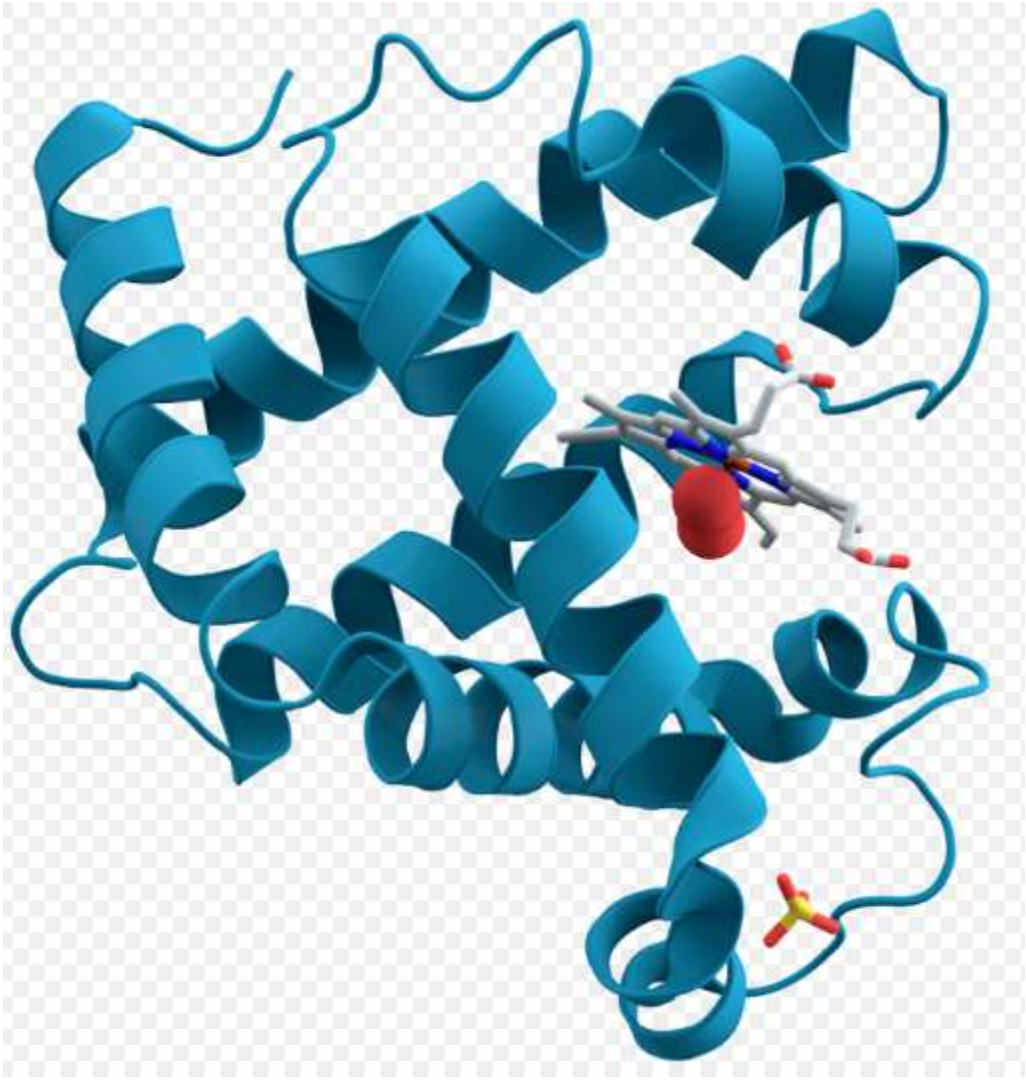


Fig 1.09: Proteins are chains of amino acids found in most nutritional foods.(Wikipedia)

body. It is important to note that they are more important to the cell as compared to the essential amino acids. There are ten essential amino acids for human beings. These include arginine, histidine, leucine, lycine, methionine, phelylannine, threonine, tryptophan and valine. Of these arginine and histidine are considered as semi-essential amino acids, since they are synthesized in the body but their quantities are not enough to meet the growth requirements. The amino acids, cysteine and tyrosine are also considered as essential amino acids as they are synthesized from methionine and phenylamine. The other amino acids are alanine, asparagine, aspartic acid, glutamic acid, glutamine, glycine, proline and serine.

Sources of Proteins

- Animal proteins

Eggs, milk, milk products, meat, fish.

- Vegetable proteins

Rice, Cereals, Wheat, Maize.

- Pulses

Bengal gram, Red gram.

- Oil Seeds

Groundnut and gingelly.

Functions of Proteins

The important functions of dietary proteins are:

- To replace the daily loss of body proteins
- To provide amino acids for the formation of tissue proteins during the growth.
- To provide the amino acids necessary for the formation of en-zymes, blood proteins and certain hormones of protein nature.
- To provide amino acids for the growth of fetus in pregnancy and for the production of milk proteins during lactation.
- Proteins are not only present in the red blood cells of the blood; they are also present in the plasma. They help in regulating the water balance of the body.
- They also help in maintaining he acid-base balance between the blood and tissues because of their amphoteric nature.

Protein Energy Malnutrition (PEM)

PEM occurs very frequently in infants and pre-school children 2-4 yrs of age. This occurs mostly in the developing countries where the diet is lacked by proteins, calories, vitamins and minerals. Some of the diseases are:

1. Kwashiorkor
2. Marasmus
3. Marasmic-Kwashiorkor

1. Kwashiorkor- The important symptoms of the disease are:

i) Growth failure

ii) Oedema

iii) Muscle wasting

iv) Fatty liver

v) Changes in the color of the skin and hair.

vi) Anaemia

vii) Symptoms of vitamin A deficiency may also be associated with the above conditions.

2. Nutritional Marasmus

This is caused by severe deficiency of proteins and calories in the diet. The important features are:

i) Growth Retardation

ii) Severe wasting of muscle

iii) Skin becomes dry and antrophic.

iv) Eye lesions due to vitamin A deficiency.

v) Anaemia.

vi) Dehydration.

3. Marasmus-Kwashiorkor

Children suffering from this disease show the signs of Kwashiorkor and Marasmus described above.

CHECK YOUR PROGRESS

Explain the structure and composition of protein.
Elaborate on the importance of protein in the anatomy of animals and plants.
How do you classify proteins?
Explain the concept of amino acids.
What is meant by essential amino acid? Why are the called so?
Elaborate the concept of non-essential amino acid clearly indicating whether they are unwanted compounds or do not play any important roles in body function.
What are the sources of protein?
What is the function of protein in body?
Elaborate on Protein Energy Malnutrition with examples.
Explain Kwashiorkor clearly indicating its symptoms and causes.
Explain Nutritional Marasmus clearly indicating its symptoms and causes.

1.12 FATS

A molecule of dietary fat typically consists of several fatty acids (containing long chains of carbon and hydrogen atoms), bonded to a glycerol. They are typically found as triglycerides (three fatty acids attached to one glycerol backbone). Fats may be classified as saturated or unsaturated depending on the detailed structure of the fatty acids involved. Saturated fats have all of the carbon atoms in their fatty acid chains bonded to hydrogen atoms, whereas unsaturated fats have some of these carbon atoms double-bonded, so their molecules have relatively fewer hydrogen atoms than a saturated fatty acid of the same length. Unsaturated fats may be further classified as monounsaturated (one double-bond) or polyunsaturated (many double-bonds). Furthermore, depending on the location of the double-bond in the fatty acid chain, unsaturated fatty acids are classified as omega-3 or omega-6 fatty acids. Trans fats are a type of unsaturated fat with trans-isomer bonds; these are rare in nature and in foods from natural sources; they are typically created in an industrial process called (partial)

hydrogenation. There are nine kilocalories in each gram of fat. Fatty acids such as conjugated linoleic acid, catalpic acid, eleostearic acid and punicic acid, in addition to providing energy, represent potent immune modulatory molecules.

Saturated fats (typically from animal sources) have been a staple in many world cultures for millennia. Unsaturated fats (e. g., vegetable oil) are considered healthier, while trans fats are to be avoided. Saturated and some trans fats are typically solid at room temperature (such as butter or lard), while unsaturated fats are typically liquids (such as olive oil or flaxseed oil). Trans fats are very rare in nature, and have been shown to be highly detrimental to human health, but have properties useful in the food processing industry, such as rancidity resistance. (Wikipedia)

Fat is a complex molecule constituting a mixture of fatty acids and an alcohol, generally glycerol. Like carbohydrates, it contains carbon, hydrogen and oxygen. But it differs from a carbohydrate, in that it contains more carbon and hydrogen and less oxygen. When oxidized it give 9.1 calories per gram fat which are approximately 2 ¼ times more than those supplied by one gram of carbohydrates.

The term 'lipids' applies to a group of naturally occurring substances which are insoluble in water but soluble in no-polar solvents like chloroform, ether, benzene and carbon disulphide. They occur widely in nature in either free form or often associated with other compounds like proteins and carbohydrates.

General Classification

Fats can be classified into three main groups:

1. Simple lipids
2. Compound lipids
3. Derived lipids
4. Unsaponifiable lipids.

1. Simple Lipids- The simple lipids are the neutral fats. These are chemically made up of triglycerides. Triglycerides contain a glycerol base with three fatty acids. These neutral fats make up 98-99% of food and body fats.

2. Compound Lipids- These are chemically made up of simple lipids containing phosphorus, carbohydrates or proteins. Such compound lipids are known as phospholipids, glycolipids and lipoproteins respectively. Lipoproteins are the most important as they are the carriers of lipids in the blood and form cell membranes. Phospholipids are associated commonly with the nervous system (nerve tissue).

3. Derived lipids- They are fat like substances produced from fats and fatty compounds. The important members of this group are glycerol and fatty acids.

4. Unsaponifiable Lipids- These include steroids, terpenoids etc.

Steroids- They are fat related substances containing sterols. The important member of this group is cholesterol.

Classification of Fats.

1. Saturated Fatty acids

The straight-chain (containing only single bond between carbon atoms) or normal chain fatty acid components (that are normally even numbered) make up 10-40 % of the total fatty acids in most natural lipids. The most abundant saturated fatty acids in animal and plant tissues are straight chain compounds with 14, 16, 18 carbon atoms. The fatty acid with 16 carbon atoms, is systematically named as hexadecanoic acid. The saturated fatty acids with more than 24 carbon atoms normally occur in foods and waxes. The fatty acids present in milk fats contain 4-10 carbon atoms while those of chain length of C12 to C24 occur in most animal and vegetable fats.

Some saturated fatty acids are butyric,lauric, myristic, palmitic.

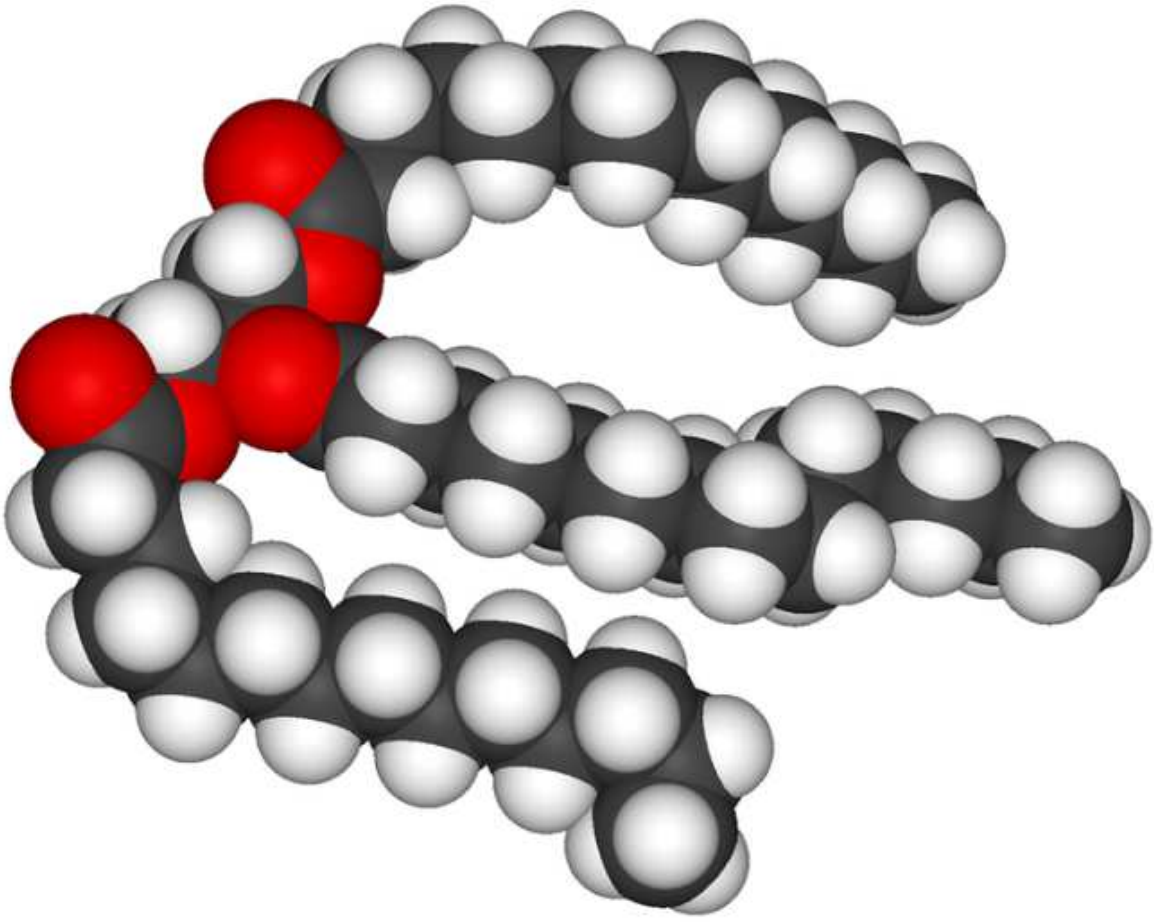


Fig 1.10: A fat, or triglyceride, molecule. Note the three fatty acid chains attached to the central glycerol portion of the molecule.(Wikipedia)

Stearic acid, also called octadecanoic acid is one of the many useful types of saturated fatty acids that come from many animal and vegetable fats and oils. It is a waxy solid. Arachidic acid also called eicosanoic acid is a saturated fatty acids found in peanut oil.

2. Unsaturated fatty acids

The unsaturated fatty acids contain double bonds between their carbon atoms. The number of double bonds may vary from 1 to 6. The hydrogen atom is removed where the double bond is formed. The

unsaturated fatty acids are more vulnerable to rancidity. The unsaturated fatty acids come in two forms- Mono-unsaturated fatty acids and Poly-unsaturated acids.

3. Monounsaturated fatty acids(MUFA)

The monounsaturated fatty acids contain only one double bond between the carbon atoms in a molecule of fatty acid. For example, oleic acid, palmitoleic acid. The mono-unsaturated fatty acids have a higher melting temperature that polyunsaturated fatty acids but lower than the saturated fatty acids. They are liquid in room temperature and may become semi-solid or solid when refrigerated.

4. Polyunsaturated fatty acids (PUFA) or Essential fatty acids (EFA).

Fatty acids contain more than one double bond and are derived from those containing one double bond. Example Linolenic acid, decosahaexoic acid.

5. Some examples of n-3 fatty acids are:

a-Linolenic acid (ALA), Stearidonic acid (STD), Eicosatrienoic acid (ETE)

Functions of Fats

- Fat supplies heat. One gram of fat gives about nine calories. Tissues except those of the central nervous system, can utilize fat as a source of energy in the presence of oxygen.
- Subcutaneous fat acts as insulation and helps in retaining body heat.
- Fat provides padding around the vital organs. It holds them in place and helps them to absorb the shock of physical blows.
- Fat is the carrier of the fat soluble vitamins A, D, E & K.
- The essential fatty acids are needed for the maintenance of body functions. Their main function includes:

  i) Maintenance of the functioning and integrity of cellular and sub cellular membranes.

  ii) Regulation of cholesterol metabolism by transporting it be-tween the blood and body tissue.

  iii) Act as precursors of an important group of hormone like compounds prostaglandins.

  iv) Delay blood clotting time.

Excess consumption of fats leads to obesity (over weight) & cardiovascular disorder whereas deficiency of fats causes dryness of the skin, it may also slow down the process of digestion and absorption of the food products.

Properties of Fats & Oils

Lipids are usually defined as those components that are soluble in organic solvents (such as ether, hexane or chloroform), but are insoluble in water. This group of substances includes triacylglycerol, diacylglycerols, monoacylglycerols, free fatty acids, phospholipids, sterols, carotenoids vitamin A and Vitamin D. The lipid fraction of a fatty food therefore contains a complex mixture of different types of molecules.

The fatty acids normally found in foods vary in chain length, degree of unsaturation and position on the glycerol molecule. Consequently, the triacylglycerol fraction itself consists of a complex mixture of different types of molecules. Each type of fat has a different profile of lipids present which determines the precise nature of its nutritional and physiochemical properties. The terms fat, oil and lipid are often used interchangeably by food scientists. Although sometimes the term fat is used to describe those lipids that are solid at the specified temperature, whereas the term oil is used to describe those lipids that are liquid at the specified temperature.

Rancidity

The change that a lipid undergoes leading to an undesirable flavor and odor is known as rancidity. This is brought in two ways:

1. Hydrolysis
2. Oxidation

Three types of rancidity is observed in fats and fatty foods:

i) Hydrolytic rancidity

ii) Ketonic rancidity

iii) Oxidative rancidity

Hydrolytic rancidity

In this case, the ester linkages of fats are hydrolyzed to yield free fatty acids. It is catalyzed by acids, enzymes and heat. It occurs because of the hydrolysis or lipolysis of fats. Raw milk undergoes rancidity and develops off flavor due to the even numbered fatty acids (C4 to C 12). Butyric acid in butter is responsible for its rancidity.

Lipolysis causes the following:

- It degrades the quality of the oil.
- The smoke point decreases.
- Foods fried in such type of oil have cracked surfaces, in-creased tendency for browning & increased fat absorption.

Ketonic Rancidity

When fats and oils are attacked by micro-organisms (AspergillusNiger, Penicilliumglaucum) then development of off flavors is observed due to aldehydes and ketones. This mechanism is known as Ketonic rancidity.

Oxidative Rancidity

It is most frequently observed in unsaturated fatty acids. When fats react with oxygen present in the air then undesirable changes are observed due to the formation of short chain fatty acids. This is known as oxidation rancidity.

The Mechanism

First the unsaturated hydrocarbon loses a hydrogen atom leading to formation of a free radical. After addition of oxygen to the free radical formation of hydro peroxides, peroxyradicals and new hydrocarbon radicals takes place. The entire reaction terminates when two free radicals react together. Antioxidants are the substances that are added to fats and oils to retard their oxidation and prevent rancidity. They react with free radicals and inhibit chain reaction. Some examples of antioxidants are: Tocopherol, Butylated hydroxyl anisole, Butylated hydroxyl toluene.

Reversion

Refined oil especially containing linolenic acid undergo oxidation (before rancidity) and develop off flavor. This process is known as reversion.

Hydrogenation

The conversion of oil into fat is brought about by a process called as 'hydrogenation'. This involves in treating the oil under pressure under a suitable temperature with hydrogen in the presence of a catalyst, usually nickel. The unsaturated fatty acids present in the oil gets in contact with the hydrogen. Due to the chemical process some physical changes are seen, thus the liquid oil turns into a solid fat. The unsaturated fatty acids are chiefly those of the oleic type but when they are hydrogenated, they get converted into stearic acid which is 'solid; in nature. We can get various consistencies of these solids due to the process of hydrogenation being stopped at the different stages of this process.

Cholesterol

The characteristic of cholesterol is:

- It occurs in all animal and human tissues.
- The white matter of the brain contains about 14% and the grey matter contains 6% of cholesterol.
- The sebum from sebaceous glands also contains cholesterol.

Functions of the Cholesterol.

- It serves as precursor in the formation of bile acids.
- It is present in the cell membranes.
- It is the precursor of steroid hormones.
- It is present in large amounts in nervous tissue and responsible for its function.
- It is the precursor of dehydrocholesterol(skin and other tissues), which is converted to Vitamin D, by the action of the UV rays (sunlight).

CHECK YOUR PROGRESS

1. What do you understand by rancidity?
2. What is hydrogenation?
3. What are the functions of lipids?

4.	Explain what you understand by cholesterol & explain its functions.

1.13 MINERALS

Minerals are inorganic components of food that leave ash as residue when burnt. Like vitamins they do not supply heat and energy to the body. They help in the growth and maintenance of the body. They appear in food in three states: As inorganic salts, in combination with organic compounds & in ionic form.

The inorganic salts can be sodium chloride, calcium phosphate etc. Hemoglobin and phospholipids are the examples of minerals in combination with organic compounds. The minerals are also found in their ionic form like Na, K etc.

- Macro minerals and Micro minerals

The minerals are classified as macro minerals and micro minerals. Macro minerals are present in amounts greater than 0.005 % of the body weight whereas micro minerals are present in less than 0.0005% of the body weight. The macro minerals are required in greater quantity by the body, as compared to the micro minerals. The macro minerals are as follows:

a) Calcium

b) Phosphorus

c) Potassium

d) Chlorine

e) Sodium

f) Magnesium

The micro minerals (trace elements) are as follows:

a) Iron

b) Fluorine

c) Zinc

d) Copper

e) Iodine

f) Chromium

g) Cobalt

h) Sulphur

About 4-6 % of body weight is made up of mineral elements. Their largest concentration is found in bones and teeth. They are also found in soft tissues such as nerves and muscles and in blood and other body fluids.

They help in regulating various body functions such as:

- Maintenance of acid-base balance.
- Control of water balance
- Muscle contraction
- Stimulation of nervous system
- Blood coagulation.

Macro Minerals

Calcium

Calcium occurs in the highest amounts in the body. The human skeleton contains about 99% while the remaining 1% is found in soft tissues. An infant at the time of birth contains about 27.5 g calcium and an adult contains 1000 to 1200g of calcium. The calcium found in soft tissues occurs in the ionic form. Our body absorbs 20-30% of the ingested calcium. This absorption is affected by the ratio of calcium and phosphorus present in the diet. Apart from this the presence of Vitamin D facilitates the absorption of calcium. The pH of the intestine affects the absorption of calcium. An alkaline pH lowers its absorption. The calcium ingested by the body is excreted in urine and faeces. It is also lost in sweat (15mg per day).

Functions-

- Formation of bones & teeth
- Coagulation of blood
- Muscle contraction
- Regulation of excitability of nerve fires and nerve centers.
- Regulation of enzymatic reactions along with calmodulin (intracellular receptor protein).
- Regulation of permeability of walls of the capillaries.
- Heart & muscle contraction

Deficiency

Calcium deficiency in children leads to rickets in children and osteomalacia in adults. During ageing of an individual the absorption of calcium decreases, which results in demineralization of the bones. This is followed by porosity, thinness and fragility of bones known as osteoporosis.

Hypocalcaemia- It is the lowering of the blood calcium levels below normal levels. This is caused by hyperparathyroidism. The symptoms are visible on face, hands and feet.

Sources

Milk and milk products, sesame seeds, dried fish, pulses, leafy vegetables.

Phosphorus

Phosphorus is found second in abundance to calcium. An adult human body contains about 400 to 700 g of phosphorus. About 80% of phosphorus is present as calcium phosphate in the bones. Blood and other cells contain the remaining 20% phosphorus in its ionic form and in combined state with the other organic compounds. Phosphorus is a soft, non-metallic element found in the body only in combination with other substances. Phosphorus is absorbed in the small intestine as inorganic phosphates.

Functions

- In combination with calcium, it feeds the nerves.
- It aids the growth of hair and helps counteract fatigue.
- It helps in the functioning of the heart and kidneys,
- It helps in regulating the acid-alkaline balance of the blood.
- It is necessary for the formation of phospholipids which helps in building the cell structure.
- It also helps in the transportation of fats & in metabolism.

Sources

Wholegrain cereals, milk and fish are most important food sources. Vegetables like carrots, leafy vegetables, fruits like black currants, raspberries, raisins and apricots are fairly good sources. Other sources are soya beans, lentils and other pulses and legumes.

Deficiency symptoms

- Loss of weight
- Retarded growth
- Reduces sexual power & general weakness.
- Poor mineralization of bones, deficient nerve and brain functions.

Magnesium

All human tissues contain small quantities of magnesium. The adult human body contains about 25g of this mineral, the greater part of which is present in bones in combination with phosphate and carbonate. Bone ashes contain less than 1% magnesium. About one-fifth of the total magnesium in the body is present in the soft tissues inside the cells, where it is mainly bound to protein.

Functions

- It keeps helps to keep the nerves relaxed. It is necessary for all muscular activity.
- It activates most of the enzymes involved in the metabolism.
- It helps in the utilization of vitamins B and E.
- It also helps in maintaining fluid and electrolyte balance.

- It prevents the building up of cholesterol and consequent artherosclerosis.
- It promotes a healthier cardiovascular system and thus helps prevent heart attacks.
- It helps in fighting depression
- It also provides relief from indigestion.

Sources

It is present in the green vegetables, nuts, soya beans, apples, figs, lemons, peaches, almonds, wholegrains, brown rice, sunflower seeds and sesame seeds.

Deficiency symptoms

In cases where magnesium intake or absorption has been decreased and magnesium excretion is increased, magnesium deficiency is observed. These conditions include chronic alcoholism, diabetes, malabsorption syndrome, renal disease, disorders of the parathyroid gland and postsurgical stress. Kidney damage or kidney stones, muscle cramps, atherosclerosis, heart attack, nervous irritability, premature wrinkles are observed.

Sodium

Man has been consuming sodium chloride (chemical name for common salt) from as far back as history has been recorded. The body of a healthy person weighing about 65kg contains 256g of sodium chloride. Of this, just over half is found in extracellular fluid. Bout 96g is found in the bones and less than 32g in the cells.

Functions

- Regulations of Acid-Base balance.
- Regulation of osmotic pressure of plasma and tissue fluids.
- Absorption of monosaccharides and amino acids.
- Initiation and maintenance of heart beat.

Deficiency symptoms

Deficiency of sodium is caused by excessive sweating, prolonged use of diuretics, or chronic diarrhea. Deficiency may lead to nausea, muscular weakness, heat exhaustion and mental apathy.

Sources

Vegetables like dry lotus stems and leafy vegetables are rich in sodium, as are a variety of pulses and legumes. Fruits, fish and meat also contain substantial amount of sodium.

Potassium

It is one of the most important minerals, is essential for the very life of every cell. It is also among the most generously and widely distributed of all the tissue minerals. Potassium is found principally in the intracellular fluid. A small amount of potassium in the extracellular fluid is necessary for normal muscular activity. The average adult human body contains 120g of potassium

and 245 g of potassium chloride. Potassium absorption occurs mainly in the small intestine. In healthy people on a normal diet, about 90% of potassium is excreted in the urine. Increased amounts of potassium are found in the urine whenever the tissues are losing potassium.

Functions of Potassium

- It maintains a proper acid-alkaline balance in the blood and tissues.
- It regulates the activities of muscle and heart.
- As it is a component of lean tissue, it is responsible for the growth and maintenance of the lean tissues of the body.
- It is important for the synthesis of glycogen.
- It promotes the secretion of hormones and helps the kidneys in detoxification of blood.
- It is involved in the proper functioning of the nervous system and helps to overcome fatigue. It also assists in reducing blood pressure.

Sources

Pulses like green gram, cow peas, red gram and black gram and vegetables like lotus stems and sword beans are rich in potassium. Other good sources are legumes, leafy vegetables, and fruits such as bael, sweet limes, peaches and apricots. Meat & milk also contains potassium.

Deficiency Symptoms

- Mental & physical stress.
- Potassium deficiency occurs during gastrointestinal disturbances.
- Body tiredness, palpitations of the heart, nervous shaking, excessive perspiration of the hands and feet. Slow healing of ulcers and fractures.

Iron

An adult human contains about 4-6 g of iron. About 70% of the total iron is found in the haemoglobin, myoglobin and enzymes. The remaining 30% is found in stored form in liver, bone marrow and spleen.Upto 60-70% of the haem iron in meat and other non-vegetarian food is absorbed. This absorption is facilitated by ascorbic acid, calcium and acidic pH in the intestines.

Functions

Iron is present in haemoglobin, myoglobin, cytochromes and other enzymes that bring about oxidation. Haemoglobin contains ferrous iron and is responsible for carrying oxygen to different tissues. It carried oxygen from the lungs to the different cells of the body & also carried carbon dioxide from the different cells back to the lungs to exhale out.

Deficiency-

People lacking in iron suffer from disease called as Anemia. It is commonly found in infants, preschool children, adolescent girls and pregnant women. Symptoms are low haemoglobincount, low red cell volume.

Sources- liver, lean meat, fish & poultry, legumes, dry fruits, whole grain cereals.

Fluorine

In 1805, J.L.Gay-Lussac first detected fluorine in the bodies of animals. There is a strong affinity between calcium and fluorine. These two elements work together, particularly in the outer parts of bones. They are found in the enamel of the teeth and the shiny and highly polished bone surface. Fluorine is pungent and corrosive. They are found in Bengal gram, cereals-especially rice, some leafy vegetables and most of all in dry tea leaves. Deficiency symptoms occurs in the form of dental caries. Deficiency of fluorine can be prevented by sufficient intake of fresh vegetables, fish, fruits, tea and dried meat.

Copper

Copper is present in liver, brain, heart and kidney of human beings. The total copper content of the body is 100-150 mg. it is present in a combined state in plasma and erythrocytes. In human body copper is a constituent of several enzymes and is found in combination with several proteins in the blood.

Functions-

- it helps in conversion of iron into hemoglobin. It stimulates the growth of red blood cells.
- It is essential for the utilization of vitamin C.
- It is an important constituent of several enzymes that catalyze metabolic reactions.

Deficiency- Anemia, digestive disturbances, impaired respiration, .

Sources-Mollusks and shellfish are rich sources of Copper, as are betel leaves, arecanuts and other nuts. Soft water contains more copper than hard water and water from the tap contains more copper than reservoir water. Liver, cereals, millets, pulses, oilseeds, meat, eggs and fish also contain copper.

Iodine

Iodine is an important constituent of thyroxine (thyroid hormones). Thyroxine plays a very important role in various metabolic activities. It prevents Goiter.

Functions- The chief storehouse of iodine in the body is the thyroid gland. Thyroxine which is secreted by this gland, contains iodine. This thyroid hormone controls the basic metabolisms and oxygen consumption of tissues. It controls the utilization of sugars. It regulates the rate of energy production and body weight and promotes proper growth. It improves mental alacrity and promotes healthy hair, nails, skin and teeth.

Deficiency- Goiter is the disease caused by the deficiency of iodine. The symptoms include the enlargement of the thyroid gland. In children, iodine deficiency results in growth retardation. This is known as cretinism. Dietary lack of iodine may lead to anaemia, fatigue, lethargy, slow pulse, low blood pressure & a tendency towards obesity. A Serious deficiency may result in high blood cholesterol and heart disease.

Sources

The best dietary source of iodine is iodized salt. Sea foods and spinach also contain reasonable quantities of iodine.

Chromium

Chromium is found in traces in animal and plants. Chromium levels are higher in infants than in adults. The total body content in adults is 5-10mg.

Functions- it plays an important role in metabolism of carbohydrates and fats. It works with the insulin in the metabolism of sugar. It seems to increase the effectiveness of insulin, thereby facilitating the transport of glucose into the cells and not allowing the blood glucose levels to rise. It helps to take protein where it is needed and also aids in growth.

Deficiency symptoms- Impairment of glucose tolerance. Protein energy malnutrition.

Sources- Brewer's yeast, meat, betel leaves, nuts, cheese, whole grains and spices are good sources of chromium.

Cobalt- Cobalt is found n small amounts in all the tissues. Its larger concentration is found in liver and kidneys. Cobalt deficiency has never been reported in human beings. It serves as a part of vitamin B-12.

Sulphur- Sulphur is an important constituent of Sulphur containing amino acids(cysteine, cysteine and methionine). It is found in keratin of skin and hair. It is also a component of glutathione, thiamine and biotin.

CHECK YOUR PROGRESS

1. What are Minerals?
2. What are sources of Calcium?
3. What are the functions of Sodium?
4. List down the sources of Iron and Iodine.

1.14 VITAMINS

Vitamins are organic compounds that occur in small quantities in natural foods that help in the growth and maintenance of the human body. Insufficient consumption of the vitamins may lead to several deficiency diseases. They are divided into two groups:

1. Fat Soluble Vitamins
    a) Vitamin A
    b) Vitamin D
    c) Vitamin E

d) Vitamin K

2. Water Soluble Vitamins

a) Vitamin B-Complex

i. Thiamine

ii. Riboflavin

iii. Niacin

iv. Pyridoxine

v. Pantothenic acid

vi. Folic acid

vii. Vitamin B12

viii. Biotin

ix. Choline

x. Inositol

b) Vitamin C

Fat soluble vitamins can only be absorbed in the presence of fats. Therefore, presence of fat in the diet is essential for their absorption. They can be stored in the body. Water soluble vitamins consists of a large number of substances. They are absorbed quickly in the body. They are particularly lost during cooking. They are not stored in the body. That is why, their regular supply in the diet is essential.

Vitamin	Year Isolated[43]
Thiamin	1926
Vitamin C	1926
Vitamin A	1939
Vitamin D	1931
Vitamin E	1936
Niacin	1937
Biotin	1939
Vitamin K	1939
Pantothenic acid	1939
Folate	1939
Riboflavin	1933
Vitamin B6	1936

Fig 1.11: Progress of isolation of vitamins

Water Soluble Vitamins

Vitamin B Complex

Thiamine or Vitamin B1 was discovered by Eijkman, a Dutch physician in 1897. He noticed that the poultry at the prison hospital showed symptoms similar to those of his patients suffering from beriberi, a debilitating condition. Thiamine is a white crystalline powder with yeast like odor and a saltish taste. It is readily soluble in water and slightly soluble in alcohol. Heat applied in cooking destroys this vitamin. Thiamine is absorbed from the small intestine. Large numbers of thiamine are present in the skeletal muscles, heart, liver, kidneys and brain.

Fig 1.12: Sustained Release High Potency B "50" Dietary Supplement, B vitamin dietary supplement tablets (Wikipedia)

It promotes growth, protects the heart muscles and stimulates brain action. It also aids digestion especially of carbohydrates. It helps to prevent constipation. It also helps to maintain the normal red blood count, improves circulation, and promotes healthy skin. It reduces fatigue, increases stamina and prevents premature ageing.

Deficiency causes loss of appetite, poor digestion, chronic constipation, loss of weight, mental depression, nervous exhaustion and insomnia. It leads to muscular weakness, leg cramps, slow heartbeat, irritability & consequent digestive disorders.

Wholegrain cereals, especially wheat, rice and oats are considered the best sources of thiamine. Other sources are dry lotus stems, capsicum, turnip greens, beet greens, apricots, nuts, mustard seeds, pork, sheep liver and mutton.

Riboflavin (Vitamin B2) The beauty vitamin.

This vitamin was recognized in the 1920s. It is a crystalline compound with a beautiful yellow orange hue. It is soluble in water. Though readily decomposed by heat in an alkaline solution, it is not destroyed by boiling in an acid solution. Riboflavin is absorbed into the bloodstream through the walls of the small intestine. It is carried to the tissues of the body and incorporated into the cell enzymes. The liver is the major site of storage.

Riboflavin is essential for growth and general health. It functions as a part of a group of enzymes which are involved in the metabolism of carbohydrates, fats and proteins. It aids digestion & helps in the functioning of the nervous system. It prevents constipation, promotes healthy skin, nails and hair & strengthens the mucous lining of mouth; it helps in the health of eyes. It helps in counteracting the tendency towards glaucoma.

A Deficiency of riboflavin causes bloodshot eyes, abnormal sensitivity of eyes, inflammation in mouth, cracks in lips & corners of mouth; it also leads to the malfunctioning of the adrenal glands.

Sources- It is found in green vegetables such as lotus stems, turnip greens, beets, radish leaves, colocasia and carrot leaves, papaya, raisins, custard apples, apricots, sheep liver, eggs, skimmed and whole milk powder.

Pantothenic Acid (Vitamin B5)

This is again a water soluble vitamin. It was discovered in 1933 by Roger Williams. Tissue extracts from a variety of biological materials provided a growth factor for yeast. This growth factor was identified as pantothenic acid, derived from the Greek word pantos, meaning ‘everywhere’. Pantothenic acid is absorbed from the alimentary tract, and excreted in urine and mother’s milk.

Pantothenic acid is a part of the enzyme system which plays a vital role in the metabolism of carbohydrates, fats and proteins and in the synthesis of amino acids and fatty acids. It also helps in the formation of the red blood cells. It also increases the production of certain hormones. It is primarily used as an anti-stress factor and protects against most physical and mental stresses and toxins.

Its deficiency causes chronic fatigue, increased tendency towards infections, greying & loss of hair, mental depression, irttitability, dizziness and muscular weakness, skin disorders, muscle cramps, low blood pressure, low blood sugar, duodenal ulcers.
Sources- Best sources are yeast, liver and eggs. Other sources are peanuts, mushrooms, split peas, soya beans, and soya bean flour.

Pyridoxine (Vitamin B6)

This is called as ‘Versatile vitamin’. In 1926 J.Goldberger and R.D.Lillie fed rats on a diet deficient in what was considered to be the pellagra preventive factor. P.Gyorgy later observed that the same factor prevented the development of skin lesion in rats. He proposed that this factor be called vitamin B6. Vitamin B6 was isolated in 1938 by three research groups working independently and was synthesized by S.A.Harris and K.Folkers in 1939.

Vitamin B6 is absorbed mainly in the jejunum, however it is also absorbed in the ileum of the small intestine.

Pyridoxine aids in food assimilation and protein & fat metabolism. It activates many enzymes; it is involved in the production of antibodies which protect against bacterial diseases. It helps in the healthy functioning of the nervous system and brain, protects against a high cholesterol level, certain types of heart diseases and diabetes. It regulates the balance between the potassium and sodium.

Deficiency of pyridoxine may cause anaemia, Oedema, mental depression and skin disorders, damage to pancreas, inflammation of the colon, tooth decay, loss of muscular control, migraine.

Yeast, sunflower seeds, wheat germ, soya beans, and walnuts are the richest sources of pyridoxine. Whereas lentils, lima beans, and other vegetables provide fair amounts.

Biotin

It strengthens immunity. Biotin was discovered in 1927 by M.A.Boas& was again researched in 1939 by P.Gyorgy, R.Kuhn and Ledered and was called Biotin. It is one of the most active biological substances known. An extremely small amount of this vitamin has a marked effect on the growth of yeast and certain bacteria.

Biotin is vital for a healthy immune system. It is involved in the metabolism of carbohydrates, proteins and fats. It is essential for the growth of hair. This vitamin helps to maintain the skin and the nervous system in a sound condition. It controls proper distribution of color pigments.

Deficiency of Biotin causes muscular weakness, pains, pins and needles (pricking of the skin), lassitude and lack of appetite, other common problems may be eczema, hair loss, skin disorders, lung infections, heart abnormalities, extreme fatigue, depression.

The rich sources of Biotin are brewer’s yeast, beef liver, rice bran, rice germ, rice polishing& peanut butter.

Folic Acid (Vitamin B-9)

It is also known as folacin and folate and was first recognized as dietary essential for chicks in 1938. It was used clinically in 1945 by T.D.Spies who found it to be effective in the treatment of anaemias relating to pregnancy and tropical sprue (an intestinal malabsorption). About half of the folic acid is stored in the body in liver.

It is necessary for the growth and division of all body cells. It also produces nucleic acids, RNA and DNA, that carry hereditary patterns. It aids in protein metabolism & normal growth. Folic acid is the singlemost important nutrient for a pregnant woman and her developing foetus. Folic acid also improves lactation.

Deficiency of Folic acid causes anaemia, serious skin disorders, loss of hari, fatigue and mental depression. The deficiency may also lead to loss of libido in males. It may also lead to dementia.

Sources may include, pulses and legumes such as Bengal gram and green gram. Green vegetables such as amaranth, cluster beans, spinach, mint are valuable sources of folic acid. It is also found in gingelly seeds and meat.

Cyanocobalamin (Vitamin B-12)

It stimulates growth of red blood cells. E.L.Smith, L.F.Parker, Hodgkin isolated vitamin B-12. It is freely soluble in water but is liable to destruction in the presence of alkalis and acids.

Vitamin B-12 is essential for the production and regeneration of red blood cells & proper functioning of the nervous system. This vitamins is necessary for the proper utilization of fats, carbohydrates and proteins for body building.

Its deficiency may cause pernicious (destructive). Poor appetite and retardation of growth in children, chronic fatigue, sore mouth, feeling of numbness or stiffness, loss of mental energy and difficulty in concentration is seen.

This vitamin is mostly found in foods of animal origin. Meat, liver, eggs, shrimps and dairy products - are valuable sources of this vitamin.

Choline

This is good for a healthy liver. Its importance in nutrition was established by C.H.Best and M.E.Huntsman in 1934. They discovered that choline deficiency produced fatty liver.

Choline helps in transportation of fats in the body and prevents accumulation of fat in the liver. In combination with fatty acids and phosphorus, it stimulates the formation of lecithin, an important constituent of nerve cells in the body. It aids memory.

A prolonged deficiency of choline may cause cirrhosis and the fatty degeneration of the liver, high blood pressure and atherosclerosis (hardening of the arteries).

Choline is available in liberal quantities in fish and sea foods, vegetables like beetroot, lettuce, carrots, ground nut, apples, Indian gooseberries,

Inositol

It is useful in prevention of hair loss. It is highly soluble in water and is not destroyed by heat in neutral, acid and alkaline mediums. It is however destroyed by Sulphur drugs, food processing techniques, alcohol and coffee. It is catabolized in the kidneys where it is converted to glucose.

It is essential for the transportation of fat in the body. It is found useful in the nourishment to the brain cells. It helps lower cholesterol levels; it helps in preventing of falling of hair & also useful in prevention of eczema.

The deficiency of inositol, causes patchy baldness, gastritis, hypertension, hardening of liver.

The important sources of inositol are liver, brewer's yeast, dried lima beans, grapefruit, raisins, wheat germ, unrefined molasses, peanuts and cabbage.

Vitamin C (Ascorbic Acid)

This is a water soluble vitamin. This was isolated in 1928 by SzentGyrogyi, while working in Hopkins laboratory. Glen King, W.N. Haworth, E.L.Hirst, Reichstein further synthesized and in 1938 'ascorbic acid' was officially accepted as the chemical name for Vitamin C.

One of the most significant functions of vitamin C is the formation of collagen, a protein substance that cements the cells together. Ascorbic acid enhances the absorption of iron. It is needed for buoyant health, vitality and endurance. This vitamin is also necessary for maintenance of bones and proper

functioning of the adrenal and thyroid glands. It promotes healing and protects all forms of stress-physical and mental.

A deficiency of vitamin C results in soft gums, skin hemorrhages, capillary weakness, deterioration in collagen, anaemia and slow healing of sores and wounds, lowers resistance to all infections. A prolonged deficiency may cause scurvy.

The main sources of vitamin C are citrus fruits and vegetables. Indian gooseberries, guavas contain larger amounts whereas Animal foods contain a very small amount of vitamin C. Soaked & germinated form of cereal & pulses may also develop small amounts of vitamin C.

Fat Soluble Vitamins

Vitamin A (Retinol) (For better eyesight)

Retinol is vitamin A that is found in man and liver oils of salt fish water. Carotene is the precursor of vitamin A. This is a fat soluble vitamin. It is also found in green pigment or pigmented plants. Vitamin A is essential for the maintenance of normal tissue structure & other important functions like vision and reproduction. It builds up resistance to respiratory and other infections and keeps the mucous linings and membranes of the body, especially those of the eyes, lungs, stomach and intestines in a healthy condition. It also helps in clearing up infections of the skin and in promoting healthy hair, teeth and gums. The sources of food include, sheep liver, egg yolk, whole milk, butter and ghee. Vegetables like colocasia, turnip greens, drumsticks, beet, carrots and spinach contain lot of carotene, fruits like mangoes, gooseberries, apricots, oranges, raspberries also are abundant in Vitamin A.

Prolonged deficiency may result in inflammation of eyes, poor vision and night blindness. It may also lead to lack of appetite, vigor, defective teeth and gums & skin disorders.

Vitamin D (The Sunshine Vitamin).

Fig 1.13: 500 mg calcium supplement tablets, with vitamin D, made from calcium carbonate, maltodextrin, mineral oil, hypromellose, glycerin, cholecalciferol, polyethylene glycol, and carnauba wax. (Wikipedia)

It is the most essential vitamin for preventing rickets, which is a known deficiency disease affecting children and is characterized by defective bone formation, disturbance of calcium utilization in the body and resulting weakness.

Research on the Chemical nature of vitamin D was initiated in 1924. By H.Steenbock and A.F.Hess. Vitamin D assists in the assimilation of calcium, phosphorus & other minerals in the digestive tract. It helps in the formation of teeth and bones. It helps to prevent dental caries. It protects children from rickets.

Vitamin D is produced from a substance present beneath the skin when sunlight falls upon the surface of the body. Its natural distribution in foods is limited to small amounts in fish oils, ghee, eggs and butter.

Vitamin E (Tocopherol)

This is an anti-ageing factor. This vitamin was named vitamin E by Dr.E.V.Shute in 1924. The main functions of vitamin E, are to help protect the functioning of cells and the intracellular processes. It is essential for normal reproductory functions, fertility and physical vigor. It dilates the capillaries and enables the blood to flow freely into the blood deficient muscle tissue, thus strengthening both the tissue and the nerves supplying them. The deficiency of vitamin E may lead to generative changes in the blood capillaries which in turn can lead to heart and lung disease, pulmonary embolism and brain stroke. It may lead to reproductive disorders, abortions, miscarriages. The richest sources include cold pressed crude vegetable oils, especially wheat germ, sunflower seeds, safflower and soya bean oils. Eggs, butter, raw and sprouted seeds & grains are also good sources. Meats, fruits and green leafy vegetables provide small quantities of this vitamin.

Vitamin K

Vitamin K is a fat soluble vitamin. It is essential for the production of a type of protein called prothrombin and other factors involved in the blood clotting mechanism. Hence it is also known as anit-haemorrhagic vitamin. This vitamin was discovered in 1935 by Dam. Vitamin K is not easily destroyed by light, heat or exposure to air. It is however destroyed by strong acids, alkalis, and oxidizing agents. X-rays and Radiation also can destroy vitamin K. Vitamin K is essential for the prevention of internal bleeding and haemorrhages. It aids in reducing excessive menstrual flow in women. It is also important in the normal functioning of the liver. Longer time taken for clotting of blood may cause severe haemorrhages anywhere in the body. Nose bleeds and bleeding can prove life threatening.

Vitamin K is widely distributed in foods. It appears abundantly in cauliflower, cabbage, spinach, yoghurt, soya beans, wheat and oats. Animal products contain little of vitamin K. Cow's milk is better source than human milk. Vitamin K is also manufactured by bacteria in healthy intestines.

CHECK YOUR PROGRESS

1. List down the water soluble and fat soluble vitamins.
2. Explain the importance of vitamins in human body.
3. List down at least two deficiency symptoms of the Water soluble vitamins.

1.15 SUMMARY

• In this chapter we have focused on the various Sectors of the Hospitality Industry. Catering is spread very wide in the form of various sectors like the five star hotels, resorts, motels and various other types of lodgings. We have seen various types of Caterings like: Transport Catering, Ship Catering, Railway Caterings, Rotels. The staff of the Company's or various Industries is also catered with nutritious food. Catering is found in Corporate sectors, in the form of Banquets, Welfare Catering is also an important aspect. Nowadays various International chains of Fast Food Restaurants have emerged. Hence we have learnt the various sectors of this industry where the Food is prepared & Served in a Hygienic way.

• We have learnt about the areaor premise utilized for the food preparation. The layout of the kitchen with all the sanitary requirements, the large & small equipments used for the cooking of food, various electrical equipments used. The basic requirement from the Floor to the ceiling is discussed. The gas ranges should be of high pressure & low pressure. The ventilation should be proper so that the smoke is ventilated out. The windows or other opening should be covered with wire mesh, the installation of the fire extinguisher is a must, water supply & the drainage system should be good enough, there should be a proper wash up area to clean the utensils, a storage room to keep all the raw materials, provision of the cold storage areas, working table etc.

• We have also learnt about the various reasons how a food can get spoilt or contaminated. Hence we have seen that food is contaminated through various sources. The main source of contamination could be through the soil, air, water, utensils & the food handler.

• We have seen how to take precautionary measures so as to keep the food safe. The food handler should go through various processes of hygienic practices to handle the food safely. He should follow the personal hygiene very strictly.

• Food should also be handled very carefully while storing at the correct temperatures. The knowledge of various methods of cooking hence plays a vital role in the same. The Danger zone where the bacteria are multiplied should be carefully observed and hence the food should be stored & cooked at the correct temperatures. Use of separate areas for veg & non veg raw materials, use of separate chopping boards, thawing practices etc. should be practiced so as to prepare a healthy food.

• Food is a prerequisite to nutrition. Nutrition is a branch of science that deals with the study of nutrients and the way these nutrients are ingested, digested, absorbed and utilized by the body and also the removal of the undigested or waste matter of the food that is consumed.

• Nutrient is organic and inorganic compounds that are required by the body in adequate amounts. These include, proteins, fats, carbohy-drates, Vitamins and minerals. Apart from these nutrients our body also requires fiber and water. They help in the digestion of food and various other activities of the body.

• The end product of carbohydrates digestion is glucose which is present in our blood. If excess carbohydrates are consumed, glucose is converted to glycogen and stored in liver and muscles.

• After the glycogen reaches its saturation point in liver and muscles, excess of carbohydrates is then converted to fats and stored in adipose tissue.

• Proteins help in building and repairing of body tissues. It also helps in regulating the various metabolic activities and regulates the immune system of the body.

- Diseases caused due to deficiency of proteins are Kwashiorkor and Marasmus.

- Fats are classified into simple lipids, compound lipids, derived lipids and unsaponifiable lipids.

- Fats provide heat, it provides padding around our vital organs, it is the carrier of the fat soluble vitamins A, D, E & K.

- Vitamins differ from each other in physiological function, in chemical structure and in distribution in food. They are broadly divided into fat soluble and water soluble.

- Used therapeutically, vitamins can be of immense help in treating disease and speeding recovery. They can be used in two ways: correcting deficiencies and treating diseases.

- Minerals are inorganic substances, like sodium, potassium, chlorine, calcium, phosphorus, magnesium, iodine, iron, cobalt and copper. They are classified into two categories Major & Minor, based on the intake level. If more than 100 mg of a mineral is required per day, the mineral is classified as a major mineral. Major minerals include, Calcium, Phosphorus, potassium, sodium, chlorine, magnesium and Sulphur. Minor or trace minerals include, boron, chromium, cobalt, fluorine, iodine, iron, manganese, molybdenum, selenium, silicon, vanadium and zinc.

- Minerals are vital for good health. Like vitamins they are essential for regulating and building the cells which make up the body.

1.16 KEY TERMS

- Catering Science: It is the Science of Preparing the food in a technical &safe method.

- Contamination: It is the Spoilage occurred in the food substance due to the foreign organisms.

- Contaminants: These are the constituents due to which the food gets spoilt, the contaminants like soil, air, water, plant, food handler.

- Food Spoilage: it is the decomposition of food where it gets deteriorated damaged making it unsuitable for consumption.

- Non-Perishable food: Foods such as oil, sugar, whole grains which has a higher shelf life.

- Perishable food: Food which have a shorter shelf life ranging from few hours to few days, eg. Milk, meat, eggs, fruits & vegetables.

- Semi-Perishable food: Food which has a little longer shelf life ranging from few weeks to few months, eg. Cereals, potatoes, onions, flours.

- Thawing: This is the process where a frozen product gets to its normal state or room temperature & in a state to be used for cooking.

- Danger Zone: This is a temperature ranging from 8 degrees to 63 degrees where the micro-organisms grow.

- Bain-marie- Open wells of water used for keeping food hot. Heat is by steam, gas or electricity and generally used as a serving counter in dining areas.

• Blast freezing- Freezing food rapidly in a blast of cold air blown by fan at -32 to -40 degrees C in 75 to 90 minutes depending upon how food is packed.

• First in First out- A rotation method in which items held in inventor the longest are the first to be issued and newly purchased items are stored behind or under items already in the store.

• Holding- Keeping items on the menu either hot or cold after cooking and before service.

• Rapid thawing cabinet- Used to defrost containers of frozen meals before they are reheated from -20 degrees C to 3 degree C. in approximately 4 hours.

• Non-perishable foods- Food products which have a long shelf life, such as flour, sugar, pulses, spices etc.

• Semi-perishable foods- Food products which have a shorter shelf life than non-perishable foods and should be used within few weeks to a few months such as potatoes, onions, apples etc.

- Acidosis: Excessive acid in the blood.
- Amine: A molecule having nitrogen element.
- Arteriosclerosis: Narrowing of the blood vessels
- Beriberi: Inflammation of the nerves due to Vitamin B shortage.
- Carcinogens: Any substances producing cancer.
- Collagen: A cementing substance in between the cells of the body; its derangement causes many bodily diseases.
- Hydrolyzed: The breaking down of fats into fatty acids.
- Hypercalcemia: An excess of calcium in the blood.
- Jejunum: the first part of the small intestine.
- Keratinize: Hardening of the skin.
- Metabolism: A chemical process in a living organism, resulting in energy production.
- Myoglobin: An oxygen carrying protein containing iron present in the muscles.
- Nephritis: Inflammation of the kidneys.
- Oedema: Swelling with fluid.
- Osteomalacia: A disorder in which bones become soft.

1.17 END QUESTIONS.

1. List the various sectors of the Hospitality Industry.
2. How is the Food preparation area divided?
3. Explain about the storage of the Food in the Kitchen.
4. Explain the importance of Catering Science in Hospitality industries.
5. What is the role of Food and Drug Administration?
6. Why is it important to know the rules of FDA?
7. Elaborate the definition of Colloid.
8. Describe with examples the features of food in solid state.
9. Describe with examples the features of food in solution form.
10. Describe with examples the features of food in colloid form.
11. Define crystalloid and colloid solutions.
12. Give characteristics of colloidal mixtures.
13. Elaborate on the classifications of colloids.

14. Explain the properties of colloids.
15. Discuss the features of emulsions as colloids.
16. Discuss the features of foam as colloids in terms of continuous and dispersed phases and examples.
17. Discuss the features of sol as colloids in terms of continuous and dispersed phases and examples.
18. Discuss the features of solid foam as colloids in terms of continuous and dispersed phases and examples.
19. Discuss the features of aerosol as colloids in terms of continuous and dispersed phases and examples.
20. Discuss the features of foam as colloids in terms of continuous and dispersed phases and examples.
21. Explain the function of food.
22. Elaborate on the importance of food.
23. Explain what is meant by Food Science as per definition given by Institute of Food Technologists.
24. Elaborate on the various branches of Food Science.
25. Explain the importance and role of Food Science in Food Processing industries.
26. Explain the concept of nutrition.
27. Elaborate on the consequences of consuming unhealthy diet and explain how study of nutrition can help us avoid preparation and consumption of such consequinces.
28. Discuss why nutrition must be concerned with social, economic, cultural and psychological implications of food and eating.
29. Discuss the concept of nutrients.
30. Explain the concept of essential and nonessential nutrients.
31. Elaborate what is meant by macronutrients and explain major macronutrients types.
32. Explain the difference between “Calorie” and “calorie” indicating which of these is used in context of food and nutrition.
33. Explain the nutritional classification of food.
34. Expalin the food groups with examples.
35. Explain the energy supplied by carbohydrates in Kcal/g and hence elaborate the role of carbohydrate in balanced diet.
36. Elaborate how carbohydrates are classified.
37. Discuss Monosaccharide with examples.
38. Discuss disaccharide with examples.
39. Discuss polysaccharide with examples.
40. Discuss complex polysaccharide with examples.
41. Explain the sources of carbohydrates.
42. What is the function of carbohydrates?
43. Explain the concept of dietary fiber with examples of their source.
44. Explain the importance of dietary fiber in maintaining good health.
45. Explain the significance of glycemic index or GI in body function and thereby for maintaining good health.
46. Explain the structure and composition of protein.
47. Elaborate on the importance of protein in the anatomy of animals and plants.
48. How do you classify proteins?
49. Explain the concept of amino acids.
50. What is meant by essential amino acid? Why are the called so?

51. Elaborate the concept of non-essential amino acid clearly indicating whether they are unwanted compounds or do not play any important roles in body function.
52. What are the sources of protein?
53. What is the function of protein in body?
54. Elaborate on Protein Energy Malnutrition with examples.
55. Explain Kwashiorkor clearly indicating its symptoms and causes.
56. Explain Nutritional Marasmus clearly indicating its symptoms and causes.
57. Explain the clothing of the Chef.
58. Give illustrations of the causes of food getting contaminated.
59. List down the Perishable, Semi-Perishable & Non-Perishable food products.
60. Explain what you understand by Contamination of food.
61. Explain the various sectors of the Hospitality Industry where catering is related.
62. Explain the various sources of Food contaminations.
63. Explain the other practices of safer food handling procedure followed in the kitchen.
64. Explain the importance of Catering Science in the Hospitality Industry.
65. Explain the Working area of the Food Production Department.
66. Explain the precautionary measures taken by the Food Handler.
67. Explain the concepts of Nutrients
68. Explain the concepts of Basic Food Groups
69. Explain the concepts of Functions of Proteins
70. Explain the concepts of Functions of Fats
71. Explain the concepts of Functions of Carbohydrates
72. Explain the concepts of Minerals
73. Explain the concepts of Vitamins
74. Explain the concepts of Goiter
75. Explain the concepts of Rickets
76. Explain the concepts of Osteoporosis
77. Explain the concepts of Osteoporosis
78. Explain the concepts of Kwashiorkor
79. What do you understand by Food Science & why is it important to have a knowledge in Food industry?
80. Write an Essay on Vitamins.
81. Write an Essay on Minerals.
82. Explain the various sources of Proteins
83. Describe the various sources of Fats
84. Discuss the various sources of Carbohydrates
85. Elaborate the various sources of Minerals
86. Explain the various sources of Vitamins
87. Explain the deficiency symptoms of Iron and Calcium.

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UNIT 2 : FOOD AND MICROORGANISMS

2.00 BEFORE WE BEGIN

Earlier human beings were unaware of the existence of microorganisms and their effect on food. There were only two tasks that were performed: Gathering and Producing of food. But due to extensive study in the field of microorganisms, people started getting aware & hence necessary precautionary measures were taken accordingly. The study of microbiology made it easier in the field of Food Industry. The study was applied to various areas like Food production outlets, breweries, dairy industries, pharmaceuticals etc. it was observed that microorganisms entered in the various stages of food cycle that is crop production, harvesting, storage, preparation, holding and serving. It was also observed that microorganisms were present in & on animals which affected the flesh and the person who consumed it.

People have been successful in utilizing microbes in fields like food, energy, industry and environment. For example, microorganisms degrade urban, municipal and industrial wastes into by products suitable for consumption as food (Conversion of Agricultural waste into single cell proteins) and production of energy during such conversions.

Yeasts grow on waste materials and recycle them into food. Crude petroleum products are converted to single cell protein by microorganisms. The fermentation of cattle dung by bacteria to biogas serves as an ideal bio fuel in rural areas.

In this unit, you will learn about the various types of microorganisms and the various factors that affect their growth. These growth factors are kept in mind while preserving food and preventing it from getting spoilt.

2.01 UNIT OBJECTIVES

After studying this unit you will be able to:

- Explain the concept of microbiology and microorganisms.
- Discuss the various types of microorganisms and their characteristics
- Describe the growth of bacteria and the various factors affecting the growth of other microorganisms.

2.02 CONCEPT OF MICROBIOLOGY AND MICROORGANISMS

Microbiology (from Greek μῑκρος, mīkros, "small"; βίος, bios, "life"; and -λογία, -logia) is the study of microorganisms, those being unicellular (single cell), multicellular (cell colony), or acellular (lacking cells). Microbiology encompasses numerous sub-disciplines including virology, parasitology, mycology and bacteriology.

Eukaryotic microorganisms possess membrane-bound cell organelles and include fungi and protists, whereas prokaryotic organisms—all of which are microorganisms—are conventionally classified as

lacking membrane-bound organelles and include eubacteria and archaebacteria. Microbiologists traditionally relied on culture, staining, and microscopy. However, less than 1% of the microorganisms present in common environments can be cultured in isolation using current means. Microbiologists often rely on molecular biology tools such as DNA sequence based identification, example 16s rRNA gene sequence used for bacteria identification.

Fig 2.01: An agar plate streaked with microorganisms (Wikipedia)

Viruses have been variably classified as organisms, as they have been considered either as very simple microorganisms or very complex molecules. Prions, never considered microorganisms, have been investigated by virologists, however, as the clinical effects traced to them were originally presumed due to chronic viral infections, and virologists took search—discovering "infectious proteins".

The existence of microorganisms was predicted many centuries before they were first observed, for example by the Jains in India and by Marcus Terentius Varro in ancient Rome. The first recorded microscope observation was of the fruiting bodies of moulds, by Robert Hooke in 1666, but the Jesuit priest Athanasius Kircher was likely the first to see microbes, which he mentioned observing in milk and putrid material in 1658. Antonie van Leeuwenhoek is considered a father of microbiology as he observed and experimented with microscopic organisms in 1676, using simple microscopes of his own design. Scientific microbiology developed in the 19th century through the work of Louis Pasteur and in medical microbiology Robert Koch. (Wikipedia)

Microbiology is study of microorganisms which are not seen by a normal human eye but can be seen under the Microscope.

History of Microbiology

The existence of microorganisms was hypothesized for many centuries before their actual discovery. The existence of unseen microbiological life was postulated by Jainism which is based on Mahavira's teachings as early as 6th century BCE. Paul Dundas notes that Mahavira asserted the existence of unseen microbiological creatures living in earth, water, air and fire. Jain scriptures describe nigodas which are sub-microscopic creatures living in large clusters and having a very short life, said to pervade every part of the universe, even in tissues of plants and flesh of animals. The Roman Marcus Terentius Varro made references to microbes when he warned against locating a homestead in the vicinity of swamps "because there are bred certain minute creatures which cannot be seen by the eyes, which float in the air and enter the body through the mouth and nose and thereby cause serious diseases."

In the golden age of Islamic civilization, some scientists hypothesized the existence of microorganisms, such as Avicenna in his book The Canon of Medicine, Ibn Zuhr (also known as Avenzoar) who discovered scabies mites, and Al-Razi who gave the earliest known description of smallpox in his book The Virtuous Life (al-Hawi).

In 1546, Girolamo Fracastoro proposed that epidemic diseases were caused by transferable seedlike entities that could transmit infection by direct or indirect contact, or vehicle transmission.

Fig 2.02: Van Leeuwenhoek is often cited as the first to observe, describe, and conduct scientific experiments with microorganisms.

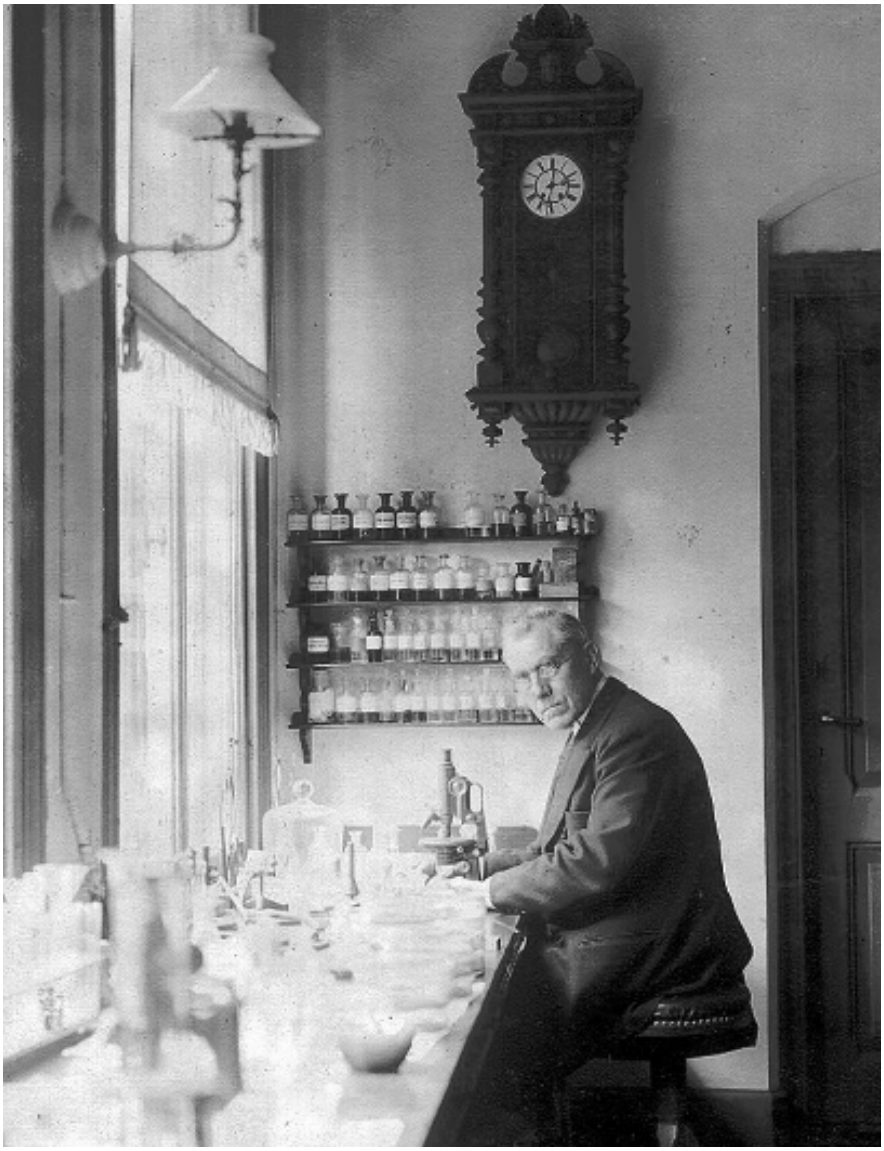

Fig 2.03: Martinus Beijerinck, the founding father of the Delft School of Microbiology, in his laboratory. Beijerinck is also often considered as one of the founders of virology, environmental microbiology, and industrial microbiology.

In 1676, Antonie van Leeuwenhoek , who lived most of his life in Delft, Holland, observed bacteria and other microorganisms using a single-lens microscope of his own design. He is considered a father of microbiology as he pioneered the use of simple single-lensed microscopes of his own design. While Van Leeuwenhoek is often cited as the first to observe microbes, Robert Hooke made his first recorded microscopic observation, of the fruiting bodies of moulds, in 1665. It has, however, been suggested that a Jesuit priest called Athanasius Kircher was the first to observe micro-organisms.

Kircher was among the first to design magic lanterns for projection purposes, so he must have been well acquainted with the properties of lenses. He wrote "Concerning the wonderful structure of things in nature, investigated by Microscope" in 1646, stating "who would believe that vinegar and milk abound with an innumerable multitude of worms." He also noted that putrid material is full of innumerable creeping animalcules. He published his Scrutinium Pestis (Examination of the Plague) in 1658, stating correctly that the disease was caused by microbes, though what he saw was most likely red or white blood cells rather than the plague agent itself.

Fig 2.04: An aerial view of Delft. Thanks to the pioneering contributions of Antonie van Leeuwenhoek and Martinus Beijerinck, Delft can be considered to be the true birthplace of microbiology, with its several sub-disciplines such as bacteriology, protozoology, and virology.

The birth of bacteriology

The field of bacteriology (later a subdiscipline of microbiology) was founded in the 19th century by Ferdinand Cohn, a botanist whose studies on algae and photosynthetic bacteria led him to describe several bacteria including Bacillus and Beggiatoa. Cohn was also the first to formulate a scheme for the taxonomic classification of bacteria, and to discover endospores. Louis Pasteur and Robert Koch were contemporaries of Cohn, and are often considered to be the father of microbiology and medical microbiology, respectively. Pasteur is most famous for his series of experiments designed to disprove the then widely held theory of spontaneous generation, thereby solidifying microbiology's identity as a biological science. One of his students, Adrien Certes, is considered the founder of marine microbiology. Pasteur also designed methods for food preservation (pasteurization) and vaccines against several diseases such as anthrax, fowl cholera and rabies. Koch is best known for his contributions to the germ theory of disease, proving that specific diseases were caused by specific pathogenic micro-organisms. He developed a series of criteria that have become known as the Koch's postulates. Koch was one of the first scientists to focus on the isolation of bacteria in pure culture resulting in his description of several novel bacteria including Mycobacterium tuberculosis, the causative agent of tuberculosis.

Fig 2.05: Innovative laboratory glassware and experimental methods developed by Louis Pasteur and other biologists contributed to the young field of bacteriology in the late 19th century.

While Pasteur and Koch are often considered the founders of microbiology, their work did not accurately reflect the true diversity of the microbial world because of their exclusive focus on micro-organisms having direct medical relevance. It was not until the late 19th century and the work of Martinus Beijerinck and Sergei Winogradsky that the true breadth of microbiology was revealed. Beijerinck made two major contributions to microbiology: the discovery of viruses and the development of enrichment culture techniques. While his work on the Tobacco Mosaic Virus established the basic principles of virology, it was his development of enrichment culturing that had the most immediate impact on microbiology by allowing for the cultivation of a wide range of microbes with wildly different physiologies. Winogradsky was the first to develop the concept of chemolithotrophy and to thereby reveal the essential role played by micro-organisms in geochemical processes. He was responsible for the first isolation and description of both nitrifying and nitrogen-fixing bacteria. French-Canadian microbiologist Felix d'Herelle co-discovered bacteriophages in 1917 and was one of the earliest applied microbiologists.

Joseph Lister was the first to use phenol disinfectant on the open wounds of patients

Branches of Microbiology

Fig 2.06: Food microbiology laboratory at the Faculty of Food Technology, Latvia University of Agriculture.(Wikipedia)

The branches of microbiology can be classified into pure and applied sciences. Microbiology can be also classified based on taxonomy, in the cases of bacteriology, mycology, protozoology, and phycology. There is considerable overlap between the specific branches of microbiology with each other and with other disciplines, and certain aspects of these branches can extend beyond the traditional scope of microbiology.

There are five major groups of microorganisms that are studied under microbiology. These are:

1. Viruses- The study of which is known as Virology.
2. Bacteria- The study of which is known as bacteriology.
3. Fungi- The study of which is known as mycology
4. Algae- The study of which is known as philology.
5. Protozoa – The study of which is known as Protozoology.

Microbes can be grouped under these kingdoms as follows:

- Bacteria, algae and fungi (in plant kingdom).
- Protozoa (in animal kingdom).

These criteria cannot be kept in mind while studying microbes, because the study of microbiology encompasses a variety of organisms that have various characteristics.

Applications of Microbiology

Fig 2.07: Fermenting tanks with yeast being used to brew beer (Wikipedia)

While some fear microbes due to the association of some microbes with various human diseases, many microbes are also responsible for numerous beneficial processes such as industrial fermentation (e.g. the production of alcohol, vinegar and dairy products), antibiotic production and act as molecular vehicles to transfer DNA to complex organisms such as plants and animals. Scientists have also exploited their knowledge of microbes to produce biotechnologically important enzymes such as Taq polymerase, reporter genes for use in other genetic systems and novel molecular biology techniques such as the yeast two-hybrid system.

Bacteria can be used for the industrial production of amino acids. *Corynebacterium glutamicum* is one of the most important bacterial species with an annual production of more than two million tons of

amino acids, mainly L-glutamate and L-lysine. Since some bacteria have the ability to synthesize antibiotics, they are used for medicinal purposes, such as Streptomyces to make aminoglycoside antibiotics.

A variety of biopolymers, such as polysaccharides, polyesters, and polyamides, are produced by microorganisms. Microorganisms are used for the biotechnological production of biopolymers with tailored properties suitable for high-value medical application such as tissue engineering and drug delivery. Microorganisms are used for the biosynthesis of xanthan, alginate, cellulose, cyanophycin, poly(gamma-glutamic acid), levan, hyaluronic acid, organic
acids, oligosaccharides and polysaccharide, and polyhydroxyalkanoates.

Microorganisms are beneficial for microbial biodegradation or bioremediation of domestic, agricultural and industrial wastes and subsurface pollution in soils, sediments and marine environments. The ability of each microorganism to degrade toxic waste depends on the nature of each contaminant. Since sites typically have multiple pollutant types, the most effective approach to microbial biodegradation is to use a mixture of bacterial and fungal species and strains, each specific to the biodegradation of one or more types of contaminants.

Symbiotic microbial communities confer benefits to their human and animal hosts health including aiding digestion, producing beneficial vitamins and amino acids, and suppressing pathogenic microbes. Some benefit may be conferred by eating fermented foods, probiotics(bacteria potentially beneficial to the digestive system) or prebiotics (substances consumed to promote the growth of probiotic microorganisms). The ways the microbiome influences human and animal health, as well as methods to influence the microbiome are active areas of research.

Research has suggested that microorganisms could be useful in the treatment of cancer. Various strains of non-pathogenic clostridia can infiltrate and replicate within solid tumors. Clostridial vectors can be safely administered and their potential to deliver therapeutic proteins has been demonstrated in a variety of preclinical models.

Food Microbiology

Food microbiology is the study of the microorganisms that inhabit, create, or contaminate food, including the study of microorganisms causing food spoilage, pathogens that may cause disease especially if food is improperly cooked or stored, those used to produce fermented foods such as cheese, yogurt, bread, beer, and wine, and those with other useful roles such as producing probiotics (Wikipedia).

Food microbiology deals with the relation of microorganisms with the food. The food shows some symptoms when they come across the microorganisms. The food sometimes deteriorates, swells, changes its structure and so on. The food gets spoilt when the microorganisms attack on them. The Pathogenic bacteria, viruses and toxins produced by microorganisms contaminate the food and cause food borne illness. However, some microorganisms and the microbial products ca also be used to act against these pathogenic microbes. For example, the use of antibiotics. The microorganisms can be destroyed by using the proper methods of cooking and following the right hygienic practices.

Apart from the negative effects of microorganisms, there are certain microorganisms which are useful. Due to the fermentation process the microorganisms thus change the properties of the food. Yeast is used in many ways for example in the making of the breads, brewing of beer, production of wine etc. Lactic acid producing bacteria are used in the production of cheese, yoghurt, pickles etc. This helps in improving the shelf life of the product.

There are various examples Indian foods like idli, dosas, dhoklas which are fermented by the acids produced due to the fermentation process.

Fig 2.08: A microbiologist working in a biosafety laboratory tests for high risk pathogens in food.(Wikipedia)

Thus we can say that the focus of food microbiology is on the detection and analysis of food-borne spoilage microorganisms. It includes the study of identification and culture of microorganisms, life cycle of microorganisms, infections and diseases caused by them and how we can make use of their activities.

Food safety is a major focus of food microbiology. Numerous agents of disease, pathogens, are readily transmitted via food, including bacteria, and viruses. Microbial toxins are also possible contaminants of food. However, microorganisms and their products can also be used to combat these pathogenic microbes. Probiotic bacteria, including those that produce bacteriocins, can kill and inhibit pathogens. Alternatively, purified bacteriocins such as nisin can be added directly to food products. Finally, bacteriophages, viruses that only infect bacteria, can be used to kill bacterial pathogens. Thorough preparation of food, including proper cooking, eliminates most bacteria and viruses. However, toxins produced by contaminants may not be liable to change to non-toxic forms by heating or cooking the contaminated food due to other safety conditions. (Wikipedia)

Fermentation is one of the methods to preserve food and alter its quality. Yeast, especially Saccharomyces cerevisiae, is used to leaven bread, brew beer and make wine. Certain bacteria,

including lactic acid bacteria, are used to make yogurt, cheese, hot sauce, pickles, fermented sausages and dishes such as kimchi. A common effect of these fermentations is that the food product is less hospitable to other microorganisms, including pathogens and spoilage-causing microorganisms, thus extending the food's shelf-life. Some cheese varieties also require molds to ripen and develop their characteristic flavors.

Microbiological Polymers

Several microbially produced biopolymers are used in the food industry.

Alginate

Alginates can be used as thickening agents. Although listed here under the category 'Microbial polysaccharides', commercial alginates are currently only produced by extraction from brown seaweeds such as Laminaria hyperborea or L. japonica.

Poly-γ-glutamic acid

Poly-γ-glutamic acid (γ-PGA) produced by various strains of Bacillus has potential applications as a thickener in the food industry.

Food testing

To ensure safety of food products, microbiological tests such as testing for pathogens and spoilage organisms are required. This way the risk of contamination under normal use conditions can be examined and food poisoning outbreaks can be prevented. Testing of food products and ingredients is important along the whole supply chain as possible flaws of products can occur at every stage of production. Apart from detecting spoilage, microbiological tests can also determine germ content, identify yeasts and molds, and salmonella. For salmonella, scientists are also developing rapid and portable technologies capable of identifying unique variants of Salmonella .

Polymerase Chain Reaction (PCR) is a quick and inexpensive method to generate numbers of copies of a DNA fragment at a specific band ("PCR (Polymerase Chain Reaction)," 2008). For that reason, scientists are using PCR to detect different kinds of viruses or bacteria, such as HIV and anthrax based on their unique DNA patterns. Various kits are commercially available to help in food pathogen nucleic acids extraction, PCR detection, and differentiation. The detection of bacterial strands in food products is very important to everyone in the world, for it helps prevent the occurrence of food borne illness. Therefore, PCR is recognized as a DNA detector in order to amplify and trace the presence of pathogenic strands in different processed food.

Microorganisms

There are two different words used for the microorganisms. One is called as the microbes and the other as microorganisms. The word microorganism is more commonly used. The microorganisms are very small in size and they may be 1000^{th} times smaller than a millimeter. Thus the microorganisms could not be seen with normal eyes. Major Applications of microbiology are in the following areas:

- In Food & Dairy industry.
- In production of industrial products.

- In genetic Engineering and Biotechnology
- In environmental microbiology
- In medical microbiology
- In agriculture.

Apart from the roles played by the microorganisms they also function in other fields also. They produce antibiotics and chemotherapeutic agents. The Streptomyces produces may antibiotics that are commercially available as streptomycin, tetracycline, erythromycin and chloramphenicol. Bacteria like bacillus can also produce antibiotics like polymyxin from bacillus polymyxa, Penicilliumchrysogenum (mold) was used to produce the first commercially available antibiotic penicillin. Penicillin is produced by saccharomyces cerevisiae (yeast). Bacteria are the most successful bio insecticide for the control of insects including mosquitoes, the carrier of malaria. They play an important role in biogeochemical cycling of nutrients, in maintenance of soil fertility and in crop protection.

CHECK YOUR PROGRESS

1. What do you understand by Food Microbiology?
2. Explain the various types of microorganisms & their uses.

2.03 MICROORGANISMS IN FOOD

List of microorganisms used in food and beverage preparation (Source: Wikipedia)

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Acetobacter aceti	bacterium	chocolate	
Acetobacter aceti	bacterium	vinegar	
Acetobacter cerevisiae	bacterium	Beer	
Acetobacter fabarum	bacterium	chocolate	
Acetobacter fabarum	bacterium	coffee	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Acetobacter lovaniensis	bacterium	vegetables	
Acetobacter malorum	bacterium	vinegar	
Acetobacter orientalis	bacterium	vegetables	
Acetobacter pasteurianus	bacterium	chocolate	
Acetobacter pasteurianus	bacterium	vinegar	
Acetobacter pomorum	bacterium	vinegar	
Acetobacter syzygii	bacterium	chocolate	
Acetobacter syzygii	bacterium	vinegar	
Acetobacter tropicalis	bacterium	chocolate	
Acetobacter tropicalis	bacterium	coffee	
Arthrobacter arilaitensis	bacterium	smear-ripened cheese	
Arthrobacter bergerei	bacterium	smear-ripened cheese	
Arthrobacter globiformis	bacterium	smear-ripened cheese	
Arthrobacter nicotianae	bacterium	surface-ripened cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Arthrobacter nicotianae	bacterium	Tilsit cheese	
Arthrobacter variabilis	bacterium	smear-ripened cheese	
Aspergillus acidus	fungus	tea	
Aspergillus niger	fungus	awamori	
Aspergillus fumigatus	fungus	chocolate	
Aspergillus oryzae	fungus	miso	
Aspergillus oryzae	fungus	sake	
Aspergillus oryzae	fungus	soy sauce	
Aspergillus sojae	fungus	miso	
Aspergillus sojae	fungus	soy sauce	
Bacillus cereus	bacterium	chocolate	
Bacillus coagulans	bacterium	chocolate	
Bacillus licheniformis	bacterium	chocolate	
Bacillus pumilus	bacterium	chocolate	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Bacillus sphaericus	bacterium	stinky tofu	
Bacillus stearothermophilus	bacterium	chocolate	
Bacillus subtilis	bacterium	chocolate	
Bacillus subtilis	bacterium	natto	
Bifidobacterium adolescentis	bacterium	yogurt	
Bifidobacterium animalis	bacterium	dairy	
Bifidobacterium bifidum	bacterium	dairy	
Bifidobacterium breve	bacterium	dairy	
Bifidobacterium breve	bacterium	soy	
Bifidobacterium infantis	bacterium	dairy	
Bifidobacterium lactis	bacterium	dairy	
Bifidobacterium longum	bacterium	dairy	
Bifidobacterium pseudolongum	bacterium	dairy	
Bifidobacterium thermophilum	bacterium	dairy	
Brachybacterium alimentarium	bacterium	Beaufort cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Brachybacterium alimentarium	bacterium	Gruyère cheese	
Brachybacterium tyrofermentans	bacterium	Beaufort cheese	
Brachybacterium tyrofermentans	bacterium	Gruyère cheese	
Brevibacterium aurantiacum	bacterium	cheese	
Brevibacterium casei	bacterium	smear-ripened cheese	
Brevibacterium linens	bacterium	smear-ripened cheese	
Candida colliculosa	fungus	cheese	
Candida colliculosa	fungus	kefir	
Candida exiguus	fungus	sourdough bread	
Candida humicola	fungus	chocolate	
Candida kefyr	fungus	surface-ripened cheese	
Candida krusei	fungus	surface-ripened cheese	
Candida milleri	fungus	sourdough bread	
Candida mycoderma	fungus	Limburger cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Candida pelliculosa	fungus	chocolate	
Candida rugosa	fungus	chocolate	
Candida tropicalis	fungus	chocolate	
Candida utilis	fungus	cheese	
Candida valida	fungus	sourdough	
Candida vini	fungus	Reblochon cheese, wine	
Candida zeylanoides	fungus	Reblochon cheese	
Carnobacterium divergens	bacterium	cheese	
Carnobacterium divergens	bacterium	fish	
Carnobacterium divergens	bacterium	meat	
Carnobacterium maltaromaticum	bacterium	dairy	
Carnobacterium piscicola	bacterium	meat	
Corynebacterium ammoniagenes	bacterium	cheese	
Corynebacterium casei	bacterium	smear-ripened cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Corynebacterium flavescens	bacterium	cheese	
Corynebacterium mooreparkense	bacterium	smear-ripened cheese	
Corynebacterium variabile	bacterium	cheese	
Cyberlindnera mrakii	fungus	wine	
Cystofilobasidium infirmominiatum	fungus	cheese	
Debaryomyces hansenii	fungus	smear-ripened cheese	
Debaryomyces hansenii	fungus	Reblochon cheese	
Debaryomyces kloeckeri	fungus	Limburger cheese	
Enterococcus faecalis	bacterium	cheese	
Enterococcus faecalis	bacterium	cream	
Enterococcus faecalis	bacterium	ham	
Enterococcus faecalis	bacterium	miso	
Enterococcus faecalis	bacterium	pickle	
Enterococcus faecalis	bacterium	sausage	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Enterococcus faecalis	bacterium	soy sauce	
Enterococcus faecium	bacterium	Manchego cheese	
Enterococcus faecium	bacterium	ham	
Enterococcus faecium	bacterium	miso	
Enterococcus faecium	bacterium	pickle	
Enterococcus faecium	bacterium	soy sauce	
Fusarium domesticum	fungus	cheese	
Geotrichum candidum	fungus	cheese	
Gluconacetobacter azotocaptans	bacterium	chocolate	
Gluconacetobacter azotocaptans	bacterium	coffee	
Gluconacetobacter diazotrophicus	bacterium	chocolate	
Gluconacetobacter diazotrophicus	bacterium	coffee	
Gluconacetobacter entanii	bacterium	vinegar	
Gluconacetobacter europaeus	bacterium	vinegar	
Gluconacetobacter hansenii	bacterium	vinegar	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Gluconacetobacter johannae	bacterium	chocolate	
Gluconacetobacter johannae	bacterium	coffee	
Gluconacetobacter oboediens	bacterium	vinegar	
Gluconacetobacter xylinus	bacterium	vinegar	
Gluconobacter oxydans	bacterium	chocolate	
Hafnia alvei	bacterium	cheese	
Halomonas elongata	bacterium	meat	
Issatchenkia orientalis	fungus	kefir	
Kazachstania exigua	fungus	kefir	
Kazachstania unispora	fungus	kefir	
Kloeckera africana	fungus	chocolate	
Kloeckera apis	fungus	chocolate	.
Kloeckera javanica	fungus	chocolate	
Kluyveromyces lactis	fungus	cheese	
Kluyveromyces marxianus	fungus	cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Kluyveromyces marxianus	fungus	chocolate	
Kocuria rhizophila	bacterium	cheese	
Kocuria rhizophila	bacterium	meat	
Kocuria varians	bacterium	dairy	
Kocuria varians	bacterium	sausage	
Lactobacillus acetotolerans	bacterium	fruit	
Lactobacillus acetotolerans	bacterium	sourdough bread	
Lactobacillus acetotolerans	bacterium	vegetables	
Lactobacillus acidifarinae	bacterium	sourdough bread	
Lactobacillus acidipiscis	bacterium	dairy	
Lactobacillus acidipiscis	bacterium	fish	
Lactobacillus acidophilus	bacterium	vegetables	
Lactobacillus acidophilus	bacterium	yogurt	
Lactobacillus alimentarius	bacterium	fish	
Lactobacillus alimentarius	bacterium	meat	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus brevis	bacterium	Canestrato Pugliese cheese	
Lactobacillus brevis	bacterium	vegetables	
Lactobacillus brevis ssp. *linens*	bacterium	kefir	
Lactobacillus bucheri	bacterium	bread	
Lactobacillus bucheri	bacterium	wine	
Lactobacillus cacaonum	bacterium	chocolate	
Lactobacillus casei	bacterium	Idiazabal cheese	
Lactobacillus casei	bacterium	Manchego cheese	
Lactobacillus casei	bacterium	Roncal cheese	
Lactobacillus casei	bacterium	yogurt	
Lactobacillus casei ssp. *pseudoplantarum*	bacterium	Grana Padano cheese	
Lactobacillus casei ssp. *pseudoplantarum*	bacterium	Parmigiano-Reggiano cheese	
Lactobacillus cellobiosus	bacterium	chocolate	
Lactobacillus collinoides	bacterium	cider	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus composti	bacterium	*shōchū*	
Lactobacillus coryniformis	bacterium	cheese	
Lactobacillus crispatus	bacterium	sourdough bread	
Lactobacillus curvatus	bacterium	Cacio di Fossa cheese	
Lactobacillus curvatus	bacterium	Canestrato Pugliese cheese	
Lactobacillus curvatus	bacterium	Pecorino Romano cheese	
Lactobacillus curvatus	bacterium	Pecorino Sardo cheese	
Lactobacillus curvatus	bacterium	sausage	
Lactobacillus delbrueckii	bacterium	vegetables	
Lactobacillus delbrueckii ssp. *bulgaricus*	bacterium	cheese	
Lactobacillus delbrueckii ssp. *bulgaricus*	bacterium	yogurt	
Lactobacillus delbrueckii ssp. *lactis*	bacterium	Pecorino Romano cheese	
Lactobacillus dextrinicus	bacterium	meat	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus diolivorans	bacterium	chicha	
Lactobacillus fabifermentans	bacterium	chocolate	
Lactobacillus farciminis	bacterium	fish	
Lactobacillus farciminis	bacterium	soy	
Lactobacillus fermentum	bacterium	chocolate	
Lactobacillus fermentum	bacterium	Pecorino Romano cheese	
Lactobacillus fermentum	bacterium	sourdough bread	
Lactobacillus gasseri	bacterium	dairy	
Lactobacillus gasseri	bacterium	sourdough bread	
Lactobacillus ghanensis	bacterium	chocolate	
Lactobacillus hammesii	bacterium	sourdough bread	
Lactobacillus harbinensis	bacterium	vegetables	
Lactobacillus helveticus	bacterium	cheese	
Lactobacillus helveticus	bacterium	vegetables	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus hilgardii	bacterium	chocolate	
Lactobacillus hilgardii	bacterium	wine	
Lactobacillus homohiochii	bacterium	sake	
Lactobacillus homohiochii	bacterium	sourdough bread	
Lactobacillus jensenii	bacterium	bread	
Lactobacillus johnsonii	bacterium	dairy	
Lactobacillus johnsonii	bacterium	sourdough bread	
Lactobacillus kefiranofaciens	bacterium	kefir	
Lactobacillus kefiri	bacterium	kefir	
Lactobacillus kimchii	bacterium	kimchi	
Lactobacillus kisonensis	bacterium	pickle	
Lactobacillus kunkeei	bacterium	wine	
Lactobacillus mali	bacterium	cider	
Lactobacillus mali	bacterium	rum	
Lactobacillus mali	bacterium	wine	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus manihotivorans	bacterium	cassava	
Lactobacillus mindensis	bacterium	sourdough bread	
Lactobacillus mucosae	bacterium	sourdough bread	
Lactobacillus nagelii	bacterium	wine	
Lactobacillus namuresis	bacterium	sourdough bread	
Lactobacillus nantesis	bacterium	sourdough bread	
Lactobacillus nodensis	bacterium	dairy	
Lactobacillus oeni	bacterium	wine	
Lactobacillus otakiensis	bacterium	pickle	
Lactobacillus panis	bacterium	sourdough bread	
Lactobacillus parabrevis	bacterium	cheese	
Lactobacillus parabrevis	bacterium	kefir	
Lactobacillus parabrevis	bacterium	vegetables	
Lactobacillus parabuchneri	bacterium	sourdough bread	
Lactobacillus paracasei	bacterium	dairy	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus paracasei	bacterium	meat	
Lactobacillus paracasei ssp. *paracasei*	bacterium	Cacio di Fossa cheese	
Lactobacillus paracasei ssp. *paracasei*	bacterium	Canestrato Pugliese cheese	
Lactobacillus paracasei ssp. *paracasei*	bacterium	Pecorino Sardo cheese	
Lactobacillus parakefiri	bacterium	kefir	
Lactobacillus paralimentarius	bacterium	sourdough bread	
Lactobacillus paraplantarum	bacterium	cheese	
Lactobacillus paraplantarum	bacterium	vegetables	
Lactobacillus pentosus	bacterium	Canestrato Pugliese cheese	
Lactobacillus pentosus	bacterium	fish	
Lactobacillus pentosus	bacterium	fruit	
Lactobacillus pentosus	bacterium	wine	
Lactobacillus perolens	bacterium	cheese	
Lactobacillus perolens	bacterium	vegetables	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus plantarum	bacterium	Cacio di Fossa cheese	
Lactobacillus plantarum	bacterium	Canestrato Pugliese cheese	
Lactobacillus plantarum	bacterium	chocolate	
Lactobacillus plantarum	bacterium	Idiazabal cheese	
Lactobacillus plantarum	bacterium	Manchego cheese	
Lactobacillus plantarum	bacterium	Pecorino Romano cheese	
Lactobacillus plantarum	bacterium	Roncal cheese	
Lactobacillus plantarum	bacterium	sausage	
Lactobacillus plantarum	bacterium	vegetables	
Lactobacillus pobuzihii	bacterium	fruit	
Lactobacillus pontis	bacterium	sourdough bread	
Lactobacillus rapi	bacterium	pickle	
Lactobacillus rapi	bacterium	vegetables	
Lactobacillus reuteri	bacterium	sourdough bread	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus rhamnosus	bacterium	Grana Padano cheese	
Lactobacillus rhamnosus	bacterium	Parmigiano-Reggiano cheese	
Lactobacillus rhamnosus	bacterium	meat	
Lactobacillus rhamnosus	bacterium	vegetables	
Lactobacillus rossiae	bacterium	sourdough bread	
Lactobacillus sakei	bacterium	sake	
Lactobacillus sakei	bacterium	sausage	
Lactobacillus salivarius	bacterium	dairy	
Lactobacillus sanfranciscensis	bacterium	sourdough bread	
Lactobacillus satsumensis	bacterium	*shōchū*	
Lactobacillus secaliphilus	bacterium	sourdough bread	
Lactobacillus senmaizukei	bacterium	pickles	
Lactobacillus siliginis	bacterium	sourdough bread	
Lactobacillus similis	bacterium	rum	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactobacillus spicheri	bacterium	sourdough bread	
Lactobacillus suebicus	bacterium	fruit	
Lactobacillus spp.	bacterium	butter	
Lactobacillus spp.	bacterium	olive	
Lactobacillus sunkii	bacterium	pickle	
Lactobacillus tucceti	bacterium	dairy	
Lactobacillus tucceti	bacterium	sausage	
Lactobacillus vaccinostercus	bacterium	fruit	
Lactobacillus vaccinostercus	bacterium	vegetables	
Lactobacillus versmoldesis	bacterium	sausage	
Lactobacillus yamanashiensis	bacterium	cider	
Lactobacillus yamanashiensis	bacterium	wine	
Lactococcus lactis	bacterium	buttermilk	
Lactococcus lactis	bacterium	chocolate	
Lactococcus lactis ssp. *cremoris*	bacterium	Cheddar cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Lactococcus lactis ssp. *lactis*	bacterium	cheese	
Lactococcus raffinolactis	bacterium	cheese	
Lactococcus spp.	bacterium	butter	
Lecanicillium lecanii	fungus	cheese	
Leuconostoc carnosum	bacterium	meat	
Leuconostoc citreum	bacterium	cheese	
Leuconostoc citreum	bacterium	fish	
Leuconostoc fallax	bacterium	sauerkraut	
Leuconostoc holzapfelii	bacterium	coffee	
Leuconostoc inhae	bacterium	kimchi	
Leuconostoc kimchii	bacterium	kimchi	
Leuconostoc lactis	bacterium	cheese	
Leuconostoc mesenteroides	bacterium	chocolate	
Leuconostoc mesenteroides	bacterium	vegetables	
Leuconostoc	bacterium	cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
mesenteroides ssp. *cremoris*			
Leuconostoc mesenteroides ssp. *cremoris*	bacterium	vegetables	
Leuconostoc mesenteroides ssp. *dextranicum*	bacterium	butter	
Leuconostoc mesenteroides ssp. *dextranicum*	bacterium	Idiazabal cheese	
Leuconostoc mesenteroides ssp. *dextranicum*	bacterium	pickle	
Leuconostoc mesenteroides ssp. *dextranicum*	bacterium	Roncal cheese	
Leuconostoc mesenteroides ssp. *mesenteroides*	bacterium	Idiazabal cheese	
Leuconostoc mesenteroides ssp. *mesenteroides*	bacterium	Roncal cheese	
Leuconostoc palmae	bacterium	palm wine	
Leuconostoc pseudomesenteroides	bacterium	butter	
Leuconostoc pseudomesenteroides	bacterium	buttermilk	
Leuconostoc pseudomesenteroides	bacterium	sour cream	
Leuconostoc spp.	bacterium	butter	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Leuconostoc spp.	bacterium	olive	
Leuconostoc spp.	bacterium	wine	
Macrococcus caseolyticus	bacterium	cheese	
Macrococcus caseolyticus	bacterium	sausage	
Microbacterium foliorum	bacterium	surface-ripened cheese	
Microbacterium gubbeenense	bacterium	Limburger cheese	
Microbacterium gubbeenense	bacterium	smear-ripened cheese	
Microbacterium gubbeenense	bacterium	Tilsit cheese	
Micrococcus luteus	bacterium	cheese	
Micrococcus lylae	bacterium	sausage	
Mucor hiemalis	fungus	soy bean curd	
Mucor plumbeus	fungus	cheese	
Mucor racemosus	fungus	cheese	
Mucor racemosus	fungus	chocolate	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Neurospora intermedia	fungus	oncom	
Oenococcus oeni	bacterium	wine	
Pediococcus acidilactici	bacterium	sausage	
Pediococcus acidilactici	bacterium	vegetables	
Pediococcus pentosaceus	bacterium	sausage	
Penicillium album	fungus	farmhouse cheeses	
Penicillium camemberti	fungus	cheese	v
Penicillium caseifulvum	fungus	cheese	
Penicillium chrysogenum	fungus	cheese	
Penicillium chrysogenum	fungus	sausage	
Penicillium commune	fungus	surface-ripened cheese	
Penicillium nalgiovense	fungus	cheese	
Penicillium nalgiovense	fungus	ham	
Penicillium nalgiovense	fungus	sausage	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Penicillium roqueforti	fungus	cheese	
Penicillium solitum	fungus	meat	
Pichia fermentans	fungus	dairy	
Pichia fermentans	fungus	kefir	
Pichia fermentans	fungus	wine	
Propionibacterium acidipropionici	bacterium	cheese	
Propionibacterium freudenreichii ssp. *freudenreichii*	bacterium	dairy	
Propionibacterium freudenreichii ssp. *shermanii*	bacterium	Emmental cheese	
Propionibacterium jensenii	bacterium	cheese	
Propionibacterium thoenii	bacterium	cheese	
Proteus vulgaris	bacterium	surface-ripened cheese	
Pseudomonas fluorescens	bacterium	yogurt	
Psychrobacter celer	bacterium	cheese	
Rhizopus microsporus ssp. *oligosporus*	fungus	oncom	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Rhizopus microsporus ssp. *oligosporus*	fungus	tempeh	
Rhodosporidium infirmominiatum	fungus	cheese	
Rhodotorula glutinis	fungus	chocolate	
Rhodotorula minuta	fungus	smear-ripened cheese	
Rhodotorula rubra	fungus	chocolate	
Saccharomyces bayanus	fungus	beer	
Saccharomyces bayanus	fungus	cider	
Saccharomyces bayanus	fungus	wine	
Saccharomyces carlsbergensis	fungus	lager beer	
Saccharomyces cerevisiae	fungus	ale beer	
Saccharomyces cerevisiae	fungus	bread	
Saccharomyces cerevisiae	fungus	cider	
Saccharomyces cerevisiae	fungus	cheese	
Saccharomyces cerevisiae	fungus	chocolate	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Saccharomyces cerevisiae	fungus	wine	
Saccharomyces pastorianus	fungus	lager beer	
Saccharomyces rouzii	fungus	miso	
Saccharomyces uvarum	fungus	lager beer	
Staphylococcus carnosus	bacterium	cheese	
Staphylococcus carnosus ssp. *carnosus*	bacterium	sausage	
Staphylococcus condimenti	bacterium	soy	
Staphylococcus equorum	bacterium	meat	
Staphylococcus equorum ssp. *linens*	bacterium	cheese	
Staphylococcus fleurettii	bacterium	cheese	
Staphylococcus piscifermentans	bacterium	fish	
Staphylococcus saphrophyticus	bacterium	Harzer cheese	
Staphylococcus sciuri ssp. *carnaticus*	bacterium	cheese	
Staphylococcus simulans	bacterium	sausage	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Staphylococcus succinus	bacterium	dairy	
Staphylococcus succinus	bacterium	meat	
Staphylococcus vitulinus	bacterium	cheese	
Staphylococcus vitulinus	bacterium	meat	
Staphylococcus warneri	bacterium	meat	
Staphylococcus xylosus	bacterium	cheese	
Staphylococcus xylosus	bacterium	sausage	
Streptococcus gallolyticus	bacterium	dairy	
Streptococcus salivarius	bacterium	yogurt	
Streptococcus thermophilus	bacterium	cheese	
Streptococcus thermophilus	bacterium	yogurt	
Streptomyces griseus	bacterium	meat	
Streptomyces mobaraensis	bacterium	meat, fish	
Tetragenococcus halophilus	bacterium	miso	
Tetragenococcus halophilus	bacterium	soy sauce	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Tetragenococcus koreensis	bacterium	kimchi	
Torulaspora delbrueckii	fungus	smear-ripened cheese	
Torulopsis versatilis	fungus	miso	
Thrichosporon beigelii	fungus	smear-ripened cheese	
Verticillium lecanii	fungus	Tomme cheese	
Weissella beninensis	bacterium	cassava	
Weissella cibaria	bacterium	kimchi	
Weissella fabaria	bacterium	chocolate	
Weissella ghanesis	bacterium	chocolate	
Weissella koreensis	bacterium	kimchi	
Weissella paramesenteroides	bacterium	sausage	
Weissella thailandensis	bacterium	fish	
Yarrowia lipolytica	fungus	Raclette cheese	
Yarrowia lipolytica	fungus	smear-ripened cheese	

Microorganism	Type Of Microorganism	Food or Beverage	Reference(s)
Yarrowia lipolytica	fungus	dairy	
Zygotorulaspora florentina	fungus	kefir	
Zymomonas mobilis	bacterium	palm wine	
Zymomonas mobilis	bacterium	pulque	

Microorganisms enter the food since harvesting, further they are transferred during the processing of the food and handling them. The microorganisms also enter the food during the handling process by the food handler.

Generally, foods carry a variety of saprophytic microorganisms. They enter the food from the surrounding area, during preparation and processing, their compete elimination is quite difficult but not impossible. Their number can be decreased by reducing or altering the environmental conditions, storage practices, correct processing & handling methods etc. These factors and the response of microbes against them help in preventing food spoilage and facilitates in practicing newer methods of food preservation.

Classification of Food based on shelf life.

According to the shelf life, food can be classified as following:

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

Spoilage Causing Microorganisms in Food

The most common types of food stuffs that are subject to spoilage by microbes are fruits, vegetables, meats, poultry, seafood, milk and dairy products. They have different biochemical compositions and thus different microbes show different reactions on their spoilage. The Breakdown of food by microbes thus result in production of acid which makes the food sour and the release of

gaseous substance when the food is contaminated by the microbes. The digestion of the fats, as in spoiled butter, yields fatty acids giving a rancid odor or taste to food. Some food stuffs become slimy due to the production of some capsules in bacteria along with pigment development that gives some color to foods.

Some common examples of food spoilage are as under:

1. **Meat & Fish**: The spoilage causing microorganisms are introduced during handling, processing, packaging and storage. The microorganisms get transferred when the food handler does not follow the hygienic practices. The bacteria can get transferred when the food handler is not well & he sneezes or coughs on the food. Sometimes, green coloration of meat surface is observed that is due to gram-positive rods, like lactobacillus, or gram positive coccus leuconostoc.

2. **Poultry and Eggs**- The chicken carries some bacteria in their wings and also in its internal organs. They carry species of microorganisms like the salmonella. Proteus causing black rot where hydrogen sulphide accumulates due to digestion of Sulphur-containing amino acids that may contaminate the eggs. The egg yolk gets readily contaminated as compared to the egg white because egg white is resistant to gram-positive bacteria due to the presence of lysozyme.

3. **Breads and Bakery products**- Spoilage causing microbes require food for their growth supplied by the ingredients of bread, flour, egg, sugar and salt. Heat resistant bacteria & molds survive even at the baking temperatures. Bacteria like Bacillus produce a soft and cheesy texture with long, stringy threads in the bread. This is known as the 'ropiness of bread'. Bacteria like Salmonella, Streptococcus and Lactobacillus grow well on cream rolls and whipped cream. They produce acids in the food.

4. **Other Foods**- Molds and Bacteria grow well on fruits and vegetable. Molds like aspergillus spoil cereal grains and peanuts. Claviceps grow in wheat, rye and barley. The disease is known as ***'ergot disease'***. The toxin produced by molds is known as aflatoxin.

Food Product	**Nutrients**	**Microorganisms Causing Spoilage**
Cereal Grains	Carbohydrates	Aspergillus, Fusarium, Penicillium, Rhizopus
Bread	Carbohydrates	Bacillus, Aspergillus, Penicillium, Rhizopus
Vegetables	Carbohydrates	Achromobacter, Pseudomonas, Lactobacillus, Bacillus

Fruits and Juices	Carbohydrates	Acetobacter, Lactobacillus, Saccharomyces.
Fresh Meat	Proteins & Lipids	Micrococcus, Pseudomonas.
Sausages, Bacon, Ham	Proteins & Lipids	Micrococcus, Lactobacillus, Streptococcus, Penicillium.
Poultry	Proteins & Lipids	Achromobacter, Pseudomonas, Micrococcus, Salmonella
Fish, Shrimp	Proteins	Achmobacter, Pseudomonas, Micrococcus.
Milk & Milk Products	Carbohydrates, Proteins & Lipids	Streptococcus, Lactobacillus, Pseudomonas, Bacillus
Eggs	Proteins & Lipids	Pseudomonas

Table 2.1 Micro-organisms causing food spoilages

Microorganisms in Food Service.

The Various microorganisms found in food service are as follows:

1. **Escherichia Coli**

These are found in Intestines of animals and humans.

- The pathogenic form is E. coli; this is found in raw or undercooked beef or meat.
- It also contaminates vegetables, unpasteurized apple cider, raw milk, salami, alfalfa sprouts and drinking water.
- The pathogenic form may also cause hemorrhagic colitis. The symptoms are initial abdominal pain and cramping & bloody diarrhea.
- The elderly and young children are most susceptible to the disease.
- Quats, iodophors and hypochlorite act as disinfectant against the bacteria.

2. **Listeria Monocytogenes.**

This is the most pathogenic form of all monocytes.

- It is found in soil ditches and surface water of canals.

- It grows well in highly humid areas that are equally rich in nutrients, such as food processing equipment.
- It contaminates high moisture foods like milk, cheese, potatoes, cucumber, ham, seafood, sausages and fish products.
- It also grows on animal carcasses.
- Microbes can survive in refrigerated temperatures also.
- The disease caused by Listeria is Listerosis.
- Quats, iodophors and hypochlorite act as disinfectant against the microbe.

3. Salmonella

Salmonella is found in the intestinal tracts of human, animals and birds.

- It goes well on egg and egg products, mayonnaise, fruits and vegetables, meat and meat products.
- It can grow at room temperature and also at the freezer temperature.
- Infections could occur from fever to arthritis.
- It also occurs dehydration.

4. Staphylococcus Aureus

Among all the species of staphylococcus, S.Aureus is associated with food borne illness.

- Humans are a primary source of staphylococcus contamination of food during preparation.
- It can contaminate food through knives, chopping boards, grinding instruments, saws etc.
- Inadequate handling of food, unhygienic food preparation, and inadequate storage practices etc. can lead to food poisoning.
- It develops toxins like enterotoxins which causes gastroenteritis.
- The vegetative body gets destroyed on cooking whereas the toxin is resistant to refrigeration and freezing.
- Vomiting, diarrhea, headache and abdominal cramping are the common symptoms.
- Quats, iodophors and hypo chloride disinfectants and sanitizers have been shown to be effective against the microbe.

Uses of Microorganisms in Food.

1. Lactic Acid Fermentation

The group of bacteria referred to as lactic acid fermenters, usually brings about fermentations in dairy industry. Bacteria have been used in the preparation of yoghurt and cheeses for centuries. The following are some of the preparations which employ lactic acid fermenters:

- **Acidophilus milk** is made with lactobacillus acidophilus.
- **Butter** is prepared by the addition of lactic acid starter to pasteurized cream. This gives a typical characteristic flavor & odor to the butter.
- In dairy products the microbes that can produce acid from lactose, breakdown the milk proteins and the flavor to the compounds are used to prepare cheese, yoghurt and fermented milk.
- **Yoghur**t is thickened fermented milk made using a mixture of bacteria that work together to produce the desired acid and flavors. Many people believe that eating live yoghurt bacteria is good for their health.
- **Cheese** manufacturing depends on microbial activities at several stages to produce the required flavor, texture and appearance. There are many different types of cheeses. Blue cheese is made by inoculating whole cheeses with a fungus which gives the typical taste and appearance. Cheese is often made with Streptococcus and Lactobacillus bacteria.
- Fermented meat products like **salami** are prepared by a combination of lactic acid fermentation with curing salts and drying for keeping quality, safety and color. Yeasts and molds may also contribute to the flavor of these products.
- **Fermented Vegetables**- Like Sauerkraut, olives and gherkins are made by lactic fermentation of the brine-soaked food. Sauerkraut making requires Leuconostocmesenteroides and Lactobacillus brevis to ferment sugars that provide a variety of such organic product as lactic acid, acetic acid, ethanol and mannitol.
- Lactic acid bacteria work alongside baker's yeast in some dough to improve the structure, flavor and storage life of French bread and fermented dough. Sourdough bread requires the help of yeast, Saccharomyces, along with lactobacilli, to provide its characteristic texture and flavor.
- Some of the flavors in wine are partly due to fermentations by bacteria which break down malic acid in the fruit juice to lactic acid and carbon dioxide gas.
- Kefir includes many different microbes, including yeasts, lactobacilli, lactococci and leuconostoes. Depending on geographical locations, the precise types of microbes will vary.
- Vitamins are economically made synthetically, but some are produced biosynthetically, that is partly from synthetics and party from bacteria. Yeast extracts such as vegemite and marmite are rich in B vitamins.

- **Citric acid** used to be extracted primarily from lemons, but worldwide demand for it forced the commercial industry to seek other sources. The fungus, aspergillus Niger, when grown on sugar beet molasses, produces huge quantities of citric acid.

- Olives are edible only after fermentation with Lactobacillus plant arum and Lactobacillus mesenteroides.

- Coffee and Chocolate require Erwiana, Leuconostoc and lactobacillus species plus the yeasts of the genus Saccharomyces to remove the tough outer coats. The microbes do not affect the taste of coffee but are necessary to confer the characteristic taste to cocoa and chocolate.

2. Yeast Fermentation

Yeasts are simple, single-celled fungi widely found in the environment. They can break down sugars into ethanol (alcohol) and carbon dioxide. This ability is harnessed to make bread, beer, wine and many other alcoholic drinks. Yeasts also contribute to the development and flavor of some fermented milk, vegetable and meat products.

- **Bread**: Yeast contributes to the texture and taste of bread. Dough is made by mixing yeast with flour, salt and water. The yeast ferments sugars in the mixture to make alcohol and bubbles of carbon dioxide. The gas gets trapped in the sticky proteins of the dough and causes it to rise. The alcohol in converted to compounds which give the bread flavor as it is cooked.

- **Alcohol Drinks**: Any fruit or vegetable containing fermentable carbohydrates can be used to produce alcoholic drinks. Beer is made by brewing the cereals like barley. Wine is prepared by fermenting the crushed grapes. Cider is made from apples and Perry from pears. Spirits like Whisky and brandy are made by distilling the alcoholic liquors.

3. Other Fermented Food.

- **Vinegar**- Vinegar contains acetic acid. It is an excellent food preservative and flavoring although it was originally discovered as a spoilage product of wine. It is made by two stage fermentation. First, yeast turns sugars into alcohol and then the alcohol is converted into acetic acid by bacteria. Malt vinegar is made from cereal based liquor while wine vinegar is made from fruit juice. The Japanese make rice vinegar.

- **Tempeh, Soy Sauce, Tofu**: Far East and Asia, fermented products like tempeh, soy sauce and tofu are all made by the action of molds on soya beans. Sake (rice wine) is aactually a Japanese Beer which is made by growing a mold on cooked rice. This mold breaks down the starches into sugars. Yeast is then added which converts the sugars into alcohol.

- **Chocolate and Coffee**: These beans which are used to make coffee have an inside pod on their parent trees. Both types of beans are coated in a slimy layer of plant tissue when they are harvested. Microbes are used to break down this material and prepare the beans for roasting. Bacteria that break down pectin carry out the digestion

in coffee, but the fermentation of cocoa beans is more complex and involves acetic acid bacteria and yeasts as well.

4. **Fungal foods**

- **Cultivated Mushrooms**

These fruiting bodies of certain filamentous fungi are microbes that we eat whole. They are produced in mushroom farms by a carefully controlled process. The familiar field mushroom is now being joined on the supermarket shelves by more exotic types like shitake and oyster caps. It is made by growing the filamentous fungus fusarium venenatum in a fermenter and harvesting the threads (hyphae) is a healthy high protein, low-fat alternative to meat.

5. **Microbial Food Ingredients**.

Many food ingredients are made by large-scale fermentations of microbes. These includeflavorings, thickeners, stabilizers and enzymes.

6. **Food for the Future.**

In the future, microbes will be needed even more to help feed the increasing population of the world. They could be used to develop DNA technology that can do the following:

- Protect food crops; biological pesticides can be used to protect vegetables and fruits when chemical measures no longer work.
- Improve the nutritional quality of foods in developing countries.
- Genetically modified foods have a controversial issue at present and public concerns have halted many research programmes in this area.

2.04 BRIEF HISTORY OF MICROORGANISMS

Although microorganisms have existed for a long time, their existence was unknown until the invention of the microscope in the 17th century. In 1674 **AntonivanLeeuwenhock**, a Dutch cloth merchant, observed microorganisms through his glass lens in a drop of lake water. He described bacteria, yeasts, algae and protozoan. He had little formal education but because of his special interest in microscopic world he made great contributions to microbiology. He had special interest in glass grinding and preparation of lens. The microscope invented by him consisted of spherical mirrors.

The discovery of the microbial world immediately raised questions regarding the origin of microorganisms. One of the first to provide evidence that microorganisms do not arise spontaneously in organic infusions was ***LazzaroSpallanzani,*** who in the middle of the 18th century conducted a number of experiments on this problem. He was successful in showing the effect of heat on the growth of microorganisms. He concluded that air-borne microorganisms spoil food which is exposed to air after heating.

Around the middle of the 19th Century **Louis Pasteur**, the French Organic chemist showed that growth did not occur in infusions that had been heated but exposed to air provided the incoming air was treated to remove the microorganisms. Support to Pasteur's conclusions that air contained microorganisms also came from **John Tyndall** the English physicist (1820-1893), who showed that

sterile infusions placed in a dust-free chamber could remain sterile indefinitely even if kept exposed to air.

Tyndall concluded that microorganisms exist in two forms- a heat-labile form (vegetative) and a heat-resistant form (endospore), and that endospores developed into vegetative cells during cooling and caused spoilage by the support of his series of experiments known as ' **tyndallization".**

CHECK YOUR PROGRESS

Who is called the 'Father of Microbiology'?
What are endospores?

2.05 COMMON CHARACTERISTICS OF MICRO-ORGANISMS

Microorganisms are of different types with several distinguishing characteristics. However, the most common characteristics that are observed in all the microorganisms are **nutrition and respiration**.

- **Nutrition**

Microorganisms acquire food in the following three ways:

1. By manufacturing their own food.
2. By depending on some living host cells.
3. By depending on some dead host cells.

Microorganisms containing chlorophyll can prepare their own food. They manufacture food in the presence of sunlight. This process is known as *photosynthesis.* Such microorganisms are called *autotrophs*. For example, green algae contain chlorophyll and can synthesize its own food.

Apart from the discussed relationships, microorganisms also show symbiotic relationship with other living organisms. In such relationships, there is a mutual relationship between the microorganisms and the host. The host provided food and shelter to the microorganisms and in turn the microorganisms perform various functions that are useful to it. For example, bacteria living inside the root nodules of pulses get food and shelter from the plant and in turn make available atmospheric nitrogen to the plant.

- **Respiration**

Microorganisms exist in a wide range of habitats. Their oxygen requirement varies with the change in their habitat and the ability to derive oxygen from their surroundings. On the basis of oxygen requirements, microorganisms are classified into three broad categories:

1. **Aerobes:** These microorganisms use oxygen to release energy from food, example- algae, protozoa and some bacteria like salmonella which causes typhoid.

2. **Anaerobes**: These microorganisms do not use oxygen to release energy from food, example-viruses, some fungi and bacteria like clostridium which causes food poisoning.

3. **Facultative organisms**: they can respire either aerobically or anaerobically like Shigella that causes dysentery r Staphylococcus that causes food poisoning.

GENERAL CHARACTERISTICS OF MICRO-ORGANISMS

Each type of microorganisms has its own characteristics.

- Each type has characteristic cellular composition
- They have their own morphology
- They have their own means of locomotion
- They have their own means of reproduction
- They can be seen only under microscope.
- They get affected by various factors like heat, water, food & grow rapidly with time.
- They have the capacity to contaminate food.
- Many of them are useful in the preparation of certain food products.

Bacteria

Cell has four components:

i) Slime layer

ii) Cell Wall

iii) Cytoplasmic membrane and

iv) Cytoplasm and Cytoplasmic inclusions.

Structure of a Bacterial Cell.

- Prokaryotic structure.
- Microscopic and Unicellular
- Length varies from 2-5 µ (1µ = 0.001 mm is called micron or micrometer. One million micron equals 1 meter), some are 60 µ.
- The slime layer is composed of polysaccharides (dextran and dextrin). The Cell wall is granular, tough, rigid, fibrillary structure. It is 50-60 Angstrom in thickness. The Cytoplasmic membrane is made of double layer of phospholipids molecules.

- Proteins are embedded in the lipid bilayer. The cytoplasm includes carbohydrates,proteins, lipids, minerals, nucleic acids and water. Bacteria are spherical or cocci, rod shaped, spiral or helical in shape.

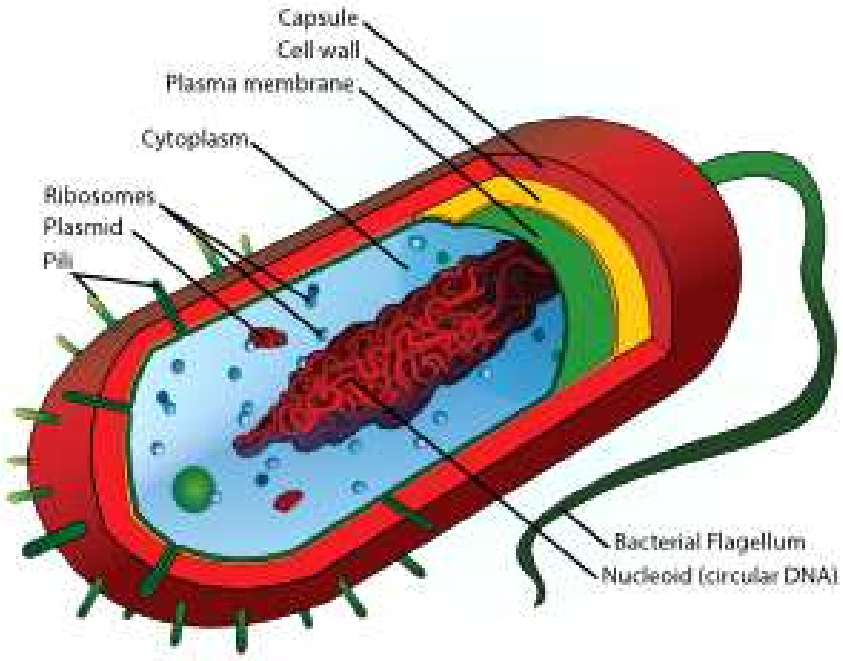

Fig 2.09: Structure of a bacterial cell

Bacteria generally reproduce by vegetative and asexual methods. Vegetative reproduction takes place by budding and by binary fission. Asexual reproduction takes place by endospores, conidia and zoospores. Sexual reproduction takes place by transformation, transduction and conjugation.

Uses of Bacteria:

- Lactic acid bacteria produce lactic acid as an end product and are found in our digestive systems. They are useful in the preparation of fermented dairy products, pickling of vegetables, baking, and wine making, curing of fish, meats and sausages.
- Bacteria break down the organic fertilizer into material that can be used by plants.
- Some species of soil bacteria convert nitrogen into nitrites, compounds that are readily absorbed by plants.
- Some bacteria are used in the production of vinegar and some drugs.
- They are used in the ageing process of cheese.
- Bacteria are also grown commercially and are added to certain foods like yogurt and drinks.
- Bacteria are also used in modern sewage disposal known as bio-remediation.

- Gram positive bacteria are usually more sensitive to antibiotics than gram negative bacteria, although conversely, some antibiotics act only on gram-negative cells.

Fungi

The study of fungi is called mycology or mycetology. Fungi can be of two types:

1. Molds.
2. Yeasts.

Occurrence (Habitat and Nutrition).

Fungi are heterotrophic in nature and their bodies consist of rhizoids (that penetrate into the food), sporangiophore(vertical hypha) and sporangium (contains spores). Parasites can be ectoparasites/ ectophytic parasites (grow on the surface of the host) and endoparasites/ endophytic parasites (enter and live inside the body of the host). Fungi which grow on cow dung are known as *coprophilous*fungi. Yeast is found on surfaces of fruits, sap of trees and plants such as corn, nectar of flowers and the leaves of the plants. It also exists in soil in vineyards and orchards and in digestive tracts of animals especially insects. Yeast grows in cream, butter and certain types of fermented milks.

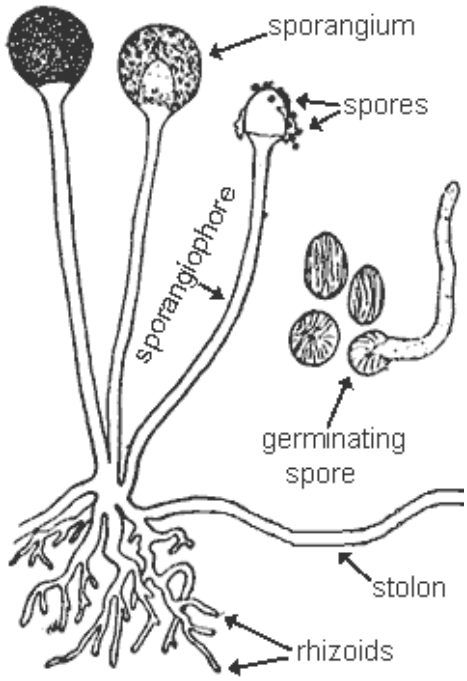

Fig 2.10:Fungi

The general characteristics of molds are as follows:

- The molds are multicellular in nature.
- They are filamentous.
- They grow on the food.

- They are recognized by their cottony or fuzzy appearance.
- The color of the molds may be white, dark or even smoky.
- The thallus or vegetative body is the characteristic of thallophytes which lack true roots, stems and leaves.

The hypha can be:

a) **Aseptate-** Multinucleate vegetative body: coenocytes; septa formed during formation of reproductive structures.

b) **Septate:** Septa can be perforated/ porous (porous septa) or without pores (Non porous septa).

Reproduction may be vegetative fragmentation (accidental fragmentation), fission (splitting of vegetative cells by constriction), budding (results in formation of pseudo mycelium as in case of yeasts), conidian formation (hypha breaking into conidia), chlamydospores (thick walled resistant spores), asexual { zoospores (thin walled, uni-nucleate, uni-/bi-flagellate formed inside zoosporangia)}, aplanospores (thin walled, non-motile spores, arising from sporangiophores), conidia (thin walled, non-motile, exogenous spores, found in chains/ singly, arising from conidiophores) or sexual (plasmogamy: union between two protoplasm or karyogamy: union between two nuclei; both of them leading further to meiosis resulting in haploid cells).

Molds are of great economic importance. However, hazardous molds produce toxins known as ***mycotoxins.***

The General Characteristic of yeast is listed as follows:

1. Yeasts are unicellular and are found naturally in soil and dust.

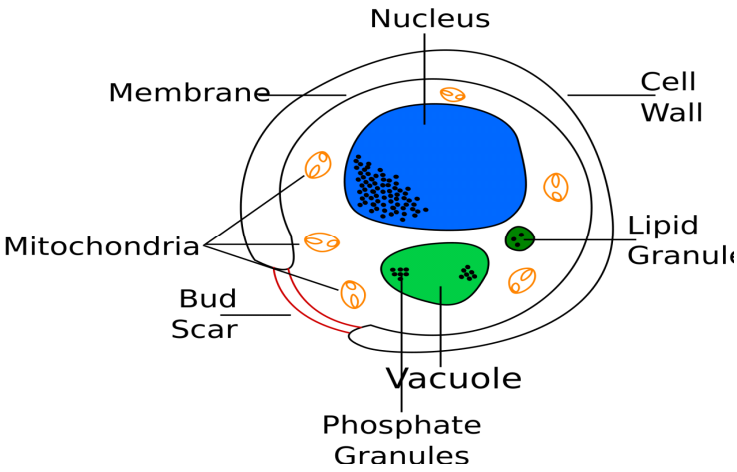

Fig 2.11 Yeast

- Yeasts are larger in size than bacteria.
- The form of yeast may be spherical to ovoid, lemon, pear, cylindrical or even elongated into a false or true mycelium.

- Yeasts reproduce either asexually by polar budding or sexually by forming ascopores.
- Yeast cells are capable of fermenting sugars to alcohol and carbon dioxide.
- Yeast is used to manufacture breads and alcoholic beverages.
- Certain yeast rich in proteins can be cultivated on industrial wastes as a source of food.
- Yeast can grow on the surface of high acid and salt containing pickles and chutneys.
- Yeast spoils dry fruits, fruit juices, squashes, honey and soy sauce by forming alcohol and carbon dioxide.
- Most yeasts grow best with a plentiful supply of moisture.
- The growth of most yeasts is favored by an acid reaction in the vicinity of pH 4 to 4.5, and they will not grow well in an alkaline medium unless adapted to it.

Virus

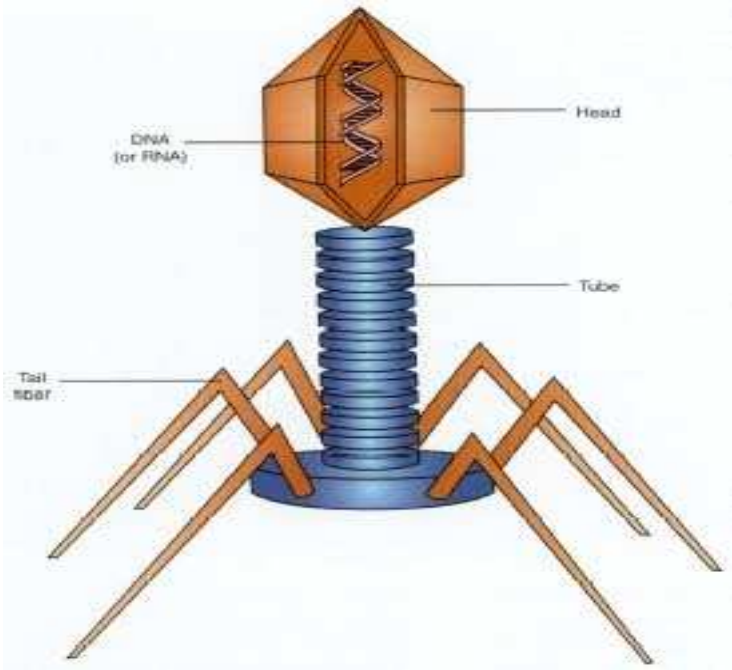

Fig.2.12 Virus

Virus means 'poison'. These are 'genes enclosed in protein sheath'. Virology is the study of viruses. Ivanowsky first demonstrated their occurrence in tobacco leaves suffering from mosaic disease. **Beijerinck, Loeffler and Frosch** established the occurrence of viruses by discovering diseases in plants and animals. Beijerinck name the infective fluids containing viruses, as Contagium (living fluid infectant). The yellow fever was the first viral disease that was discovered in human beings. The other viral diseases are common cold, influenza, poliomyelitis, small pox, chicken pox, measles, mumps and rabies. Many Scientists discovered bacteriophage virus, E.Coli, Tobacco mosaic virus etc. the size of the virus ranges from 0.015 to 0.2 micrometers. Their shape is much variable. The tobacco mosaic virus is rod shaped, polio and influenza viruses are spherical and some bacteriophages look like tiny tadpoles.

Protozoa

Protozoa are a diverse group of unicellular eukaryotic organisms. They do not possess cell walls. Their size varies between 5 and 50 micrometers in diameter. Some are significantly larger. Among the largest are the deep-sea dwelling xenophyophores, single celled foraminifera whose shells can reach 20cm in diameter. Many protozoan species are symbionts, some are parasites and some are predators of bacteria, algae and other protists.They are motile and their locomotion is facilitated with the help of flagella, cilia or fibrils. Parasitic protozoa cause various food safety problems.

Some protozoa have life phases alternating between proliferative stages and dormant cysts. As cysts, protozoa can survive harsh conditions, such as exposure to extreme temperatures or harmful chemicals, or long periods without access to nutrients, water, or oxygen for a period of time. Being a cyst enables parasitic species to survive outside of a host, and allows their transmission from one host to another. Many protozoan species exchange genetic material by sexual means (through conjugation); however, sexuality is generally decoupled from the process of reproduction, and does not immediately result in increased population.

A number of protozoan pathogens are human parasites, causing diseases such as malaria, sleeping sickness, amoebic dysentery, keratitis etc.

CHECK YOUR PROGRESS

Mention any two characteristic of bacteria.
What are the various types of Fungi?

Explain about viruses & protozoa.

2.06 CONCEPT OF GROWTH OF MICROORGANISMS

Growth is defined as an orderly increase of the cellular components. Microorganisms grow in a variety of environments. 'Balanced Growth' as defined by **Campbell** is, "doubling of every biochemical unit of the cell within the time duration of a single division without change in the rate of growth".

Growth Measurement

A number of methods are available for measuring microbial growth. The choice depends upon the measurement, objectives and on the available techniques' usefulness. In some cases of industrial fermentation which contain complex media, indirect methods for estimation need to be applied. No matter what method is used, considerable care is required in interpreting the results.

Growth commonly refers to the magnitude of the total population. Growth in this sense can be determined by numerous techniques based on one or more of the following types of measurement:

1. **Cell count**: Directly by microscopy or by using an electronic particle counter or in directly by a colony count.

2. **Cell mass**: Directly by weighing or by measurement of cell N2 or indirectly by turbidity.

3. **Cell activity**: Indirectly by relating the degree of biochemical activity to the size of population.

The most common means of bacterial reproduction is binary fission; one cell divides producing two cells. If the conditions are favorable, cell division is normally followed by a period of enlargement or growth. This is due to the absorption of food and water that leads to formation of cytoplasm resulting in enlargement. In highly favorable conditions, cells are unusually large. Under unfavorable conditions, the length of rod-shaped cells is shorter than that in favorable conditions.

Under favorable conditions, some kinds of bacteria, e.g. E.coli may double in number about every 20 minutes. This is known as the generation time.

During the initial hours of growth, there may be lag phase in which there is little or no increase in cell numbers. During the first part of the lag phase, the cells are adapting to the new environment. Now the growing cells begin to divide and continue to do so at regular intervals until the maximum growth that can be supported by their environment is approached. This period of rapid cell division is known as the logarithmic phase of growth. The stationary phase occurs when rapid growth is halted by the depletion of nutrients, accumulation of waste products, or other factors. The stationary phase remains for a considerable time by maintaining a balance between the death of some cells and the continued division of others. With the depletion of the nutrients and other unfavorable conditions, the bacterial cells eventually start dying, unless the cells are transferred into a new environment capable of supporting continued growth. This is the death phase of phase of decline. The bacterial cells form spores during the phase of the decline, these are highly resistant to unfavorable climatic conditions and only the vegetative body dies. These resistant spores again proliferate into new vegetative body whenever suitable conditions are provided to them.

CHECK YOUR PROGRESS

What do you understand by the bacterial growth?

List the various phases of bacterial growth.

Thermal Death Time (TDT).

An interesting aspect of the thermal death of microorganisms is that, at given lethal temperature, the death rate is proportional to the number of microorganisms still living. This is referred to as the log order of death, which means that under constant thermal conditions the same percentage of microbial population, will be destroyed in a given time interval, regardless of the size of the surviving population. Thus, if 90%of an original microbial population is killed in the first minute, 90 % of the remaining will be killed in the second minute and so on.

The food high in acid (having a pH of 4.6 or less), such as tomatoes or orange juice, need not be heated severely because the acid increases the killing power of heat. With acid foods, in many cases, temperature at or below 100 degrees for a few minutes constitutes adequate heat treatment. Certain spices and food chemicals act synergistically with heat in killing microorganisms and so reduce the heat treatment that must be used. To provide a substantial margin of safety it is better to

work out the heat treatment by assuming that the food contains a heat-resistant spores and its population is large.

2.07 FACTORS AFFECTING THE GROWTH OF MICROORGANISMS

Microorganisms can grow in various conditions & multiply. They require the following things to grow:

- Food
- Temperature
- Moisture and drying
- Osmotic pressure (OP).
- Light and other radiations
- Mechanical injury
- Supply of free oxygen
- Injury of chemicals
- Hydrogen ion concentration (pH)
- Interaction between microbes.

Food

Food is required to carry out synthetic activities and respiratory activities of the cell. The microbes act on the carbohydrates, proteins and fats present in the food. The nutrients needed by microorganisms as an energy source is glucose, nitrogen,

Sulphur, phosphorus, vitamins and some trace elements like copper, iron, zinc, sodium, chloride, potassium, calcium.

Temperature

1. **Optimum Temperature:**

The temperature which is best for the growth of microorganisms is called optimum temperature.

2. **Maximum Temperature:**

The highest temperature at which growth occurs is known as the maximum temperature; the temperature is slightly above the optimum temperature.

3. **Minimum Temperature**: It I the lowest temperature at which growth occurs; it is lower than optimum temperature.

Microorganisms have been divided into three groups on the basis of their optimum growth temperatures.

1. **Thermophiles**- The microorganisms whose optimum temperature is above 45 degrees are called thermophiles. The optimum temperature for bacteria is 40 degrees.
2. **Mesophiles**: The microorganisms growing between temperatures 15 ^{o}C and 45 degrees are called mesophiles.
3. **Psychrophiles:** These are capable of growing well at temperatures 15 degrees entigrade.

Mesophiles are killed if heated in a medium 50-65 degrees for a few minutes.

Bacillus and Clostridium form heat resistant spores when boiled for several hours.

Heat kills bacteria by precipitation of proteins.

Non-sporulating, mesophilic bacteria can withstand up to a temperature of 60-70 ^{o}C or the time interval used in milk pasteurization. These are called thermoduric and cause considerable trouble in milk processing.

Thermophiles create problems in the dairy industry and cause spoilage in canned foods. Psychrophilesdevelop in soils and most natural wastes and cause spoilage of refrigerated foods that are kept for long periods.

In natural substances such as raw milk, which contains a mixed flora of

microorganisms, there will be various species capable of growing at temperatures ranging from 0-65 ^{o} C.

The danger zone

Bacteria grow most rapidly in the range of temperatures between 40 degree F and 140 ^{o}F.They quite often double in every 20 minutes in this temperature range. This temperature is called as the 'Danger Zone'. Food should never be left out of the refrigerator when room temperature is around 36-37^{o} C as the microorganisms develop rapidly during this temperature. If the food has been left out for less than 2 hours, it should be either refrigerated or used immediately. If the food is left out for 2-4 hours, it should not be refrigerated but used immediately, and if for more than 4 hours then it has to be checked thoroughly about its status & it may be discarded.

Precautions to be taken while cooking of food, storing leftovers, reheating and freezing or refrigerating the food.

- Raw meat and poultry should always be cooked to a safe minimum internal temperature.
- The oven temperature should be not less than 325 ^{o}Fahrenheit for roasting meat and poultry.

- A safe minimum internal temperature should be kept to prevent spoilage like:

    1. Beef, veal and lamb steaks, roasts and chops 145 ^{o} F,
    2. Pork- 160 ^{o} F.
    3. Cook ground beef, veal and lamb at 160 ^{o}F.
    4. Poultry should be kept at a safe minimum internal temperature of 165 ^{o}F. However, for poultry the minimum internal temperature of 165 ^{o} F for safety may not achieve the desired doneness for quality purposes.

- Use of a food thermometer to ensure that meat and poultry have reached a safe minimum internal temperature.
- If raw meat and poultry should be handled safely so that they do not produce toxins to produce any food borne diseases. Cooking does not destroy those toxins that are heat resistant.
- The leftovers should be refrigerated within 2 hours.
- A temperature of 40 degrees Fahrenheit should be maintained in the refrigerator

Moisture

Microorganisms need moisture to grow, without moisture they remain dormant or still. When moisture, water or any liquid comes in their contact they become active.

Dehydration restricts the metabolic activities of bacteria and may lead to death, especially at room temperature or above in the presence of oxygen. Bacterial spores are resistant to moisture and remain viable for years, unlike the vegetative cells which are killed rapidly by drying.

The concept of lowering water activity in order to prevent bacterial growth is the basis for preservation of foods by drying (in sunlight or by evaporation) or by addition of high concentrations of salt or sugar.

Osmotic Pressure

Osmosis is the process whereby solvent and small solute molecules such as those of salt pass through a semi-permeable membrane to equalize their concentration. If the osmotic pressure OP of a medium surrounding the cell is similar to that of liquid within the cell, the solution is said to be isotonic. A hypertonic solution has a greater OP than the liquid within the cell, whereas a hypotonic solution has a lower OP than that of the liquid in the cell.

Light and Other Radiations

Visible light is useful to bacteria having photosynthetic pigments, in that it allows them to convert the light energy in to chemical energy. Such light is generally useless to other bacteria. Radiations of shorter wavelengths may be harmful to the growth of microorganisms and may lead to their photochemical denaturation. This may cause death of the cell, or the modification of gene resulting in mutation. The rate of killing of cells by radiation depends upon the intensity of the source, the time of exposure and the amount of shielding material. Some viruses, spores of bacteria and molds are more

resistant to the Ultra violet rays. X rays and ionizing atomic radiations such as alpha particles are also harmful to the microorganisms.

Mechanical Injury

Bacteria are so minute that they escape the mechanical injury but they can get affected due to the internal pressure of the ice crystals from the deep freezer.

Supply of Free Oxygen

The supply of free oxygen is important to the growth of microorganisms. The growth rate of the microorganisms depends on the optimum aeration conditions. An increase in the supply of oxygen increases the growth only up to a certain level. That is why an optimum supply of oxygen is required for the maximum rate of growth. When bacteria grow in milk, they use all dissolved oxygen that may be present in the milk.

Injury by chemicals

Bacteria survive in natural environment and grow rapidly. Materials that are used to inhibit the growth of bacteria without necessarily killing them are called antiseptics or bacteriostatic agents. Compounds used to kill bacteria are called disinfectants, germicides or bactericidal agents.

Hydrogen Ion concentration (or acidity or pH value)

Generally, the pH value of the fruits is less than 4.5, whereby the pH. value found in vegetables, fish, meats and milk products are non-acidic that is their pH value is greater than 4.5. the pH of acidic food is significantly low; they do not allow the bacterial growth and subsequent spoilage. Mainly yeasts and molds spoil them. Non-acidic foods having sufficiently high pH, are spoiled mainly by bacteria. Most molds can grow over a wide range of hydrogen ion concentration (pH= 2-8.5) but the majority is favored by an acid pH

On the basis of their pH, bacteria are classified as per following:

1. **Acidophiles** grow best at a pH of 1 to 5.4; e.g. Lactobacillus (it ferments milk).
2. **Neutrophiles** exist from pH 5.4 to 8.5; most bacteria that cause human disease falls under this category.
3. **Alkaliphiles** exist from pH 7.0 to 11.5, e.g. Vibrio cholera which causes disease called **cholera.**

The bacteria that require high concentration of sodium for their growth are termed as halophiles. They are basically of marine origin. There are some yeasts and molds that can grow in high sugar concentrations of up to 40-70 %. They are called as osmophiles.

CHECK YOUR PROGRESS

1. What is the effect of pH on the growth of microorganisms?
2. What do you understand by danger zone?
3. What are the various factors affecting the growth of microorganisms?

2.09 METHODS OF CONTROLLING MICROBIAL GROWTH

Controlling of microbial growth is very essential. This is normally required while preparing of medicines, in agriculture sector, food industry etc. Microbial growth can be controlled by the following ways:

- By killing the microbes
- By inhibiting the growth of microbes.

The killing of the microbes can be done by using the heat media, by the radiation method and by the use of chemicals.

The method of inhibiting the growth of microbes can be done by the use of the Drying method, by lowering the temperatures and by the use of chemicals.

The substance or a chemical that kills or inhibits the growth of microorganisms is known as an anti-microbial agent. Such a substance may be a synthetic chemical or a natural product. Agents that kill organisms are called cidal agents, with a prefix indicating the kind of organisms killed bactericidal and fungicidal agents. Cidal agents are antiseptic and disinfectant in nature.

Substances that do not kill but only inhibit growth are called static agents and may be bacteriostatic or fungi static agents. The principal agents used to control are physical agents that are used on objects outside the body, chemical agents which are used on inanimate objects as well as on the body surface and the chemotherapeutic agents which are most often used inside the living body.

Physical Control of Microorganisms

The main agent to control the microbes is heat, other than it; there are other methods such as boiling water, autoclave, fractional sterilization, pasteurization, hot oil etc. Controlling can be done using ultra violet rays which destroys the bacteria, which reduces the air contamination. Microbes are also controlled by using chemical methods to remove the pathogenic organisms from a body; this is also called as disinfection. Antiseptics and disinfectants may be either bactericidal or bacteriostatic. The former agents kill the microbes whereas the latter temporarily prevents their further multiplication.

Controlling can be also done by the various preservation methods like Salting using the salts e.g. preservation of syrups, jams, jellies. By Drying method in which the product is dried & all the moisture content is taken out e.g. fish, cereals, meat etc. Preserving can also be done by lowering down the temperature e.g. by refrigerating the products so that the microorganisms remain dormant and do not grow.

2.10 RECENT CONCERNS

One of the most common infectious diseases of birds is the avian influenza that occurs worldwide. It is caused by type A strains of the influenza virus. They are also the carrier of the virus.

In Poultry two distinctly different forms of the disease are observed:

1. **Mild form**: This is a common type of disease wherein the signs of illness may be ruffled feathers, reduced egg production or mild effects on the respiratory system in birds.

2. **Lethal form**: It is a rare type of avian influenza. There are various sub types of viruses which infect the wild birds. These birds act as an extensive reservoir of influenza viruses. The vast majority of these viruses are harmless. Moreover, all virus strains of the H5 and H7 subtypes are not highly pathogenic. They become pathogenic after going through mutations in the body of the birds. These viruses are highly contagious among the poultry and are transmitted by the movement of live birds from one farm to another, by the contaminated shoes of the people, vehicles, equipments, feed and cages.

The most important control measures are:

- Rapid removing/disposing of all infected birds
- Proper disposal of the carcass
- Disinfecting the farms regularly
- Implementing strict sanitary measures
- Restrictions on the movement of the live poultry from one region to another.

Influenza viruses only infect humans, certain species of birds, horses, pigs and seals. There are only four viruses that cause human infections: H7N3, H7N7, H9N2, & H5N1. Of these H5N1 virus cause severe illness while others cause only mild symptoms. The incubation period of the H5N1 avian influenza ranges from two to eight days and possibly as long as 17 days.

Symptoms found are high fever, diarrhea, vomiting, abdominal pain, bleeding from nose and gums, chest pain and lowering down on respiratory tract.

Swine Influenza: Also called swine flu, hog flu and pig flu is an infection by any one of several types of swine influenza virus. It is common in pigs. The subtypes of the virus include:

- H1N!
- H1N2
- H3N1
- H2N3

The swine influenza virus is common in porcine populations worldwide. The H1N1 viral strain implicated in 2009, among humans often is called ‘swine flu’. Further research showed that the outbreak is due to a new strain of H1N1 not previously reported in pigs. People who work with poultry and swine, especially people with intense exposures are at increased risk of infection with influenza virus. According to the Centre for disease control and prevention (CDC), in humans the symptoms of the seine flu virus are similar to those of influenza. The symptoms are fever, cough, sore throat, body aches, headache, fatigue, diarrhea, vomiting, respiratory failure, Pneumonia, dehydration & electrolyte imbalance. Treatment given is Tamiflu(oseltamivir) and Relenza (zanamivir).

2.11 SUMMARY

- The discipline of science dealing with the laws of life and development of organisms particularly microscopic or sub-microscopic forms of life is called ‘microbiology”.
- There are some positive roles played by microorganisms in the food industry.
- There are two different words for the microscopic forms- ‘microbes’ and microorganisms’.
- Microorganisms are found in soil, mud, water, air, in animals, plants, food products, nails, skin and space.
- Microorganisms are of different types with several distinguishing characteristics. However, the most common characteristics that are observed in all the microorganisms are nutrition and respiration.
- Microorganisms grow in a variety of environments. ‘balanced growth’ as defined by Campbell is, ‘doubling of every biochemical unit of the cell within the time duration of a single division without change in the rate of growth.
- Microorganisms occur nearly everywhere on the surface of the earth and therefore they are capable to grow and survive under a wide range of environmental conditions.
- Bacteria grow between 8 degrees to 68 degrees’ temperature; this is called as the ‘danger zone’.
- They multiply by the method ‘binary fission’ along with time.
- Bacteria require food, temperature, moisture and time to multiply.
- An antiseptic is a harmless substance and can be applied externally to the body such as skin. It should not be consumed orally. A disinfectant is an agent that kills microorganisms. It does not kill the spores.
- Microorganisms have both positive and negative impact on human life. They are useful in the production of butter, cheese, curd, wine and other alcoholic beverages.
- Controlling of microbial growth is very essential. This is normally required while preparing of medicines, in agriculture sector, food industry etc. Microbial growth can be controlled by the following ways: By killing the microbes & by inhibiting the growth of microbes.
- An interesting aspect of the thermal death of microorganisms is that, at given lethal temperature, the death rate is proportional to the number of microorganisms still living. This is the thermal death time.

2.12 KEY TERMS

- **Shelf Life**: Length of time that food, drinks and other perishable items are given before they are considered unsuitable for sale or consumption.

- **Cosmopolitan bacteria**: Ubiquitous nature of bacteria that can live soil, acidic hot springs, radioactive waste, water, earth's crust, organic matter and the live bodies of plants and animals.
- **Phagocytosis**: The cellular process of engulfing or eating up of solid particles by the cell membrane of any cell.
- **Unicellular organisms**: organisms that have only one cell.
- **Motility**: Ability of an organism to move spontaneously and actively.
- **Flagellum**: A tail-like structure that projects from the body of prokaryotic and eukaryotic cells that helps in locomotion.
- **Autotrophic organisms**: Produces complex organic compounds from simple inorganic molecules using solar energy from sunlight (by photosynthesis). These organisms can synthesize their own food.
- **Vegetative reproduction**: A process by which new offspring of plants are produced from the parent body without production of seeds or spores.
- **Asexual reproduction**: A reproduction method which does not involve reduction cell division (meiosis) followed by fertilization.
- **Sexual reproduction**: Involves reduction cell division, followed by fusion of gametes as a result of fertilization in order to restore the original number of chromosomes.
- **Chlorophyll**: A green pigment found in most plants and microorganisms.
- **Colitis**: A chronic digestive disease characterized by inflammation of the colon.
- **Cytoplasm**: Part of a cell that is enclosed within the plasma membrane or cell membrane.
- **Osmotic pressure**: The pressure that must be applied to a solution to prevent the inward flow of water across a semi permeable membrane.
- **pH (potanz hydrogen):** A measure of the acidity or basicity of a solution. Pure water is neutral. The pH for pure water at 25°C is 7.0. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline.
- **Osmolarity:** Determined by solute concentration in the environment. Osmolarity is inversely related to water activity (Aw), which is more like a measure of the concentration of water in a solution.

2.13 END QUESTIONS

1. What do you understand by Danger Zone?

2. What is the role of microorganisms in the food?
3. What are the factors that affect the growth of microorganisms?
4. What are the various methods of controlling bacterial growth?
5. Explain the brief history of microorganisms.

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UNIT 3 : HYGIENE IN FOOD PRODUCTION AND SERVICE AREAS

3.00 BEFORE WE BEGIN

In this unit we will study Indian cooking. As you are going to be a professional in hospitality studies and will be seen as a brand ambassador for Indian cuisine, it will be one of the fundamental part of your study. We have studies various ingredients used in a kitchen during our study at the first semester under HTS 101 course. We will study the Indian cuisine in depth in this unit. India has been known for its signature spices which used to account for a great volume of the world trade during seventeenth to around nineteenth century. The trade of the British East India Company alone stood at around half the total world trade at one point of time. We will study the regional cuisines of the North, West, South, East and Central India and the various popular Food Items. The importance of the study of Indian Cuisine thus needs to be duly appreciated for being a professional Indian hospitality expert.

3.01 UNIT OBJECTIVES

After studying this unit you will be able to

- Explain the various sources by which contamination may occur.
- Describe the importance of Hygiene
- Discuss the importance of safe food handling.
- Elaborate the importance of HACCP, Good Manufacturing practices.

3.02 FOOD CONTAMINATION

Fig 3.01: Food contamination is a concern for food industry

(Pic https://en.wikipedia.org/wiki/2008_Chinese_milk_scandal)

Food contamination refers to the presence in food of harmful chemicals and microorganisms which can cause consumer illness. This article addresses the chemical contamination of foods, as opposed to microbiological contamination, which can be found under food borne illness.

The impact of chemical contaminants on consumer health and well-being is often apparent only after many years of processing. Prolonged exposure at low levels (e.g., cancer). Chemical contaminants present in foods are often unaffected by thermal processing (unlike most microbiological agents). Chemical contaminants can be classified according to the source of contamination and the mechanism by which they enter the food product. (Wikipedia)

Food can be spoiled or contaminated due to various reasons. The food can be contaminated due to unhygienic practices followed in the preparation areas. It can also be contaminated by using the dirty equipment or even due to wrong storage practices in the refrigerator or the cold rooms. Hence it is very important for us to have a keen eye & observe how the food can remain fresh and free from the microorganisms. If the contaminated food is consumed, then there are chances of food poisoning & even developing food borne diseases. A good sanitation practice can keep away such hazards. Waste disposal/ garbage disposal methods can help reduce pollution & even improve the ecological balance.

Sources of Food Contamination

Food material during the raw stage undergoes various processes. From the time the seeds are sown in the soil the contamination process starts followed by the harvesting, farm storage, transportation to the warehousing, its processing, packaging or till its last stage of presentation. Hence various types of foreign organisms in the form of microorganisms get in contact with the food eventually spoiling the same.

There are various ways by which contamination could occur:

- Through the soil
- Through air
- Through metals or packaging material
- Due to cleaning agents
- Due to sewage
- By the food handlers.

The soil is one of the important sources of contamination. They have heat resistant spore forming bacteria. There are various reasons by which the soil could get contaminated & hence the vegetables growing on or within the soil gets contaminated due to the same. The soil thus gets contaminated due to the sewage water. The animals roaming over the land also contaminates the soil. Hence the vegetables should be washed thoroughly before cooking & it should be made dust/soil free.

Some organisms which can spoil the food can get through the air into the product; this could happen during the fermentation process of the particular food. Mold spores from air could spoil the cheese, meat, sweetened condensed milk, bacon & sliced bread. The microorganisms are found in the air especially on dust particles or in moisture droplets, mostly in the undisturbed air.

Various metals are contaminated due to the rust or the chemical changes occurred due to the contact of the metal with air (oxidation) hence such metals if used accidentally could cause hazards. This could lead to the cross contamination as well.

Sometimes the vessels used in the kitchen are not cleaned properly leaving the residues of the cleaning agent hence such cleaning agents can lead to food poisoning.

The sewage water can get interfered with the plants or crops. Hence care should be taken that such sewage water should not interfere with the crops or plants. Sometimes natural waters are also contaminated due to the sewage water thus contributing the microorganisms to the shell fish, fish & seafood. These pathogens contributing in the food leads to gastrointestinal diseases.

Food handlers should take utmost care while handling food. They should follow the rules adhered to the personal hygiene. They should wear proper uniform, should not sneeze or cough on food, should cover their wounds if any & should not report on duty if having viral infection.

Cases of Pesticides and carcinogens in Food

There are many cases of banned pesticides or carcinogens found in foods.

- Greenpeace exposed in 2006 in China that 25% of surveyed supermarkets agricultural products contained banned pesticides. Over 70% of tomatoes that tested were found to have the banned pesticide Lindane, and almost 40% of the samples had a mix of three or more types of pesticides. Fruits were also tested in this investigation. Tangerines, strawberries, and Kyofung grapes samples were found contaminated by banned pesticides, including the highly toxic Methamidophos. These fruits can also be found in Hong Kong market. Greenpeace says there exists no comprehensive monitoring on fruit produce in the Hong Kong as of 2006.
- In India, soft drinks were found contaminated with high levels of pesticides and insecticides, including lindane, DDT, malathion and chlorpyrifos.
- News of Formaldehyde, a carcinogen was found in Vietnamese national dish, Pho, broke in 2007 Vietnam food scare. Vegetables and fruits were also found to have banned pesticides. "Health agencies have known that Vietnamese soy sauce, the country's second most popular sauce after fish sauce, has been chock full of cancer agents since at least 2001", thundered the Thanh Nien daily. "Why didn't anyone tell us?" The carcinogen in Asian sauces is 3-MCPD and its metabolite 1,3-DCP, which has been an ongoing problem before 2000 affecting multiple continents.

2005 Indonesia food scares.

- Carcinogenic formaldehyde was added as a preservative to noodles, tofu, salted fish, and meatballs. The 2005 Indonesia food scare was a food scare in 2005 in Jakarta, Indonesia, when the government found that 60% of noodle shops in the capital had been serving noodles laced with formaldehyde, a known carcinogen. Noodles in the 2007 Vietnam food scare also had the same contaminant, and the chemical preservative had also definitely been found on tofu, noodles, and salted fish. Thailand has similar formaldehyde problems. Rumors spread that it was used on chicken as well. This was particularly bad in a nation like Indonesia where chicken is widely consumed because of the Islamic stance on pork.
- Other food contaminants found by Depok Health agency in elementary schools in 2006 were sodium benzoate, cyclamate and borax exceeding the permissible levels. Benzoate and cyclamate were commonly used as food additives in Indonesia. Other substances found in the samples, such as borax, rhodamine, formaldehyde and yellow methanil—used as a dye—are not fit for consumption.

2008 Chinese milk scandal

- The **2008 Chinese milk scandal** was a widespread food safety incident in China. The scandal involved milk and infant formula along with other food materials and components being adulterated with melamine. A Fonterra director had given San Lu management a document

detailing the European Union's permitted levels of melamine, but Fonterra chief executive Andrew Ferrier has stated that at no time did Fonterra say small amounts of melamine were acceptable.

- Of an estimated 300,000 victims in China, six babies died from kidney stones and other kidney damage and an estimated 54,000 babies were hospitalized. The chemical gives the appearance of higher protein content when added to milk, leading to protein deficiency in the formula. In a separate incident four years prior, watered-down milk had resulted in 12 infant deaths from malnutrition.
- The scandal broke on 16 July 2008, after sixteen babies in Gansu Province were diagnosed with kidney stones. The babies were fed infant formula produced by Shijiazhuang-based Sanlu Group. After the initial focus on Sanlu—market leader in the budget segment—government inspections revealed the problem existed to a lesser degree in products from 21 other companies, including an Arla Foods-Mengniu joint venture company known as Arla Mengniu, Yili, and Yashili.
- The issue raised concerns about food safety and political corruption in China, and damaged the reputation of China's food exports. At least 11 countries stopped all imports of Chinese dairy products.
- A number of criminal prosecutions were conducted by the Chinese government. Two people were executed, one given a suspended death penalty, three people receiving life imprisonment, two receiving 15-year jail terms, and seven local government officials, as well as the Director of the Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), being fired or forced to resign.
- The World Health Organization referred to the incident as one of the largest food safety events it has had to deal with in recent years, and that the crisis of confidence among Chinese consumers would be hard to overcome. A spokesman said the scale of the problem proved it was "clearly not an isolated accident, [but] a large-scale intentional activity to deceive consumers for simple, basic, short-term profits."
- In late October 2008, similar adulteration with melamine was discovered in eggs and possibly other food. The source was traced to melamine being added to animal feed, despite a ban imposed in June 2007 following the scandal over pet food ingredients exported to the United States.
- In 2012, Jiang Weisuo, a 44-year-old general manager of a dairy products plant in Shanxi province, was rumoured to have been murdered in Xi'an city. It was Weisuo who had first alerted authorities to the scandal. According to the Xi'an Evening News, Jiang died in hospital on 12 November from knife wounds inflicted by his wife, Yang Ping, but the purported murder by his wife was subsequently reported to be incorrect

Processing Contaminants

Processing contaminants are generated during the processing of foods (e.g., heating, fermentation). They are absent in the raw materials, and are formed by chemical reactions between natural and/or added food constituents during processing. The presence of these contaminants in processed foods cannot be entirely avoided. Technological processes can be adjusted and/or optimized, however, in order to reduce the levels of formation of processing contaminants. Examples are: nitrosamines, polycyclic aromatic hydrocarbons (PAH), heterocyclic amines, histamine, acrylamide, furan, benzene, trans fat, 3-MCPD, semicarbazide, 4-hydroxynonenal (4-HNE), and ethyl carbamate. There is also the possibility of metal chips from the processing equipment contaminating food. These can be identified using metal detection equipment. In many conveyor lines, the line will be stopped, or when weighing the product with a Check weigher, the item can be rejected for being over- or underweight or because small pieces of metal are detected within it.

In the food preparation areas, food can also get contaminated due to the following reasons:

- Due to improper storage and handling (If the raw meat & poultry are not handled carefully or if they are not stored properly. They can contaminate the other food products.)
- Due to the food handlers.
- Due to the animals, rodents, birds or insects in the food preparation area. These could get in connection with the food hence transferring the microorganisms on the food.
- Due to the dust & improper handling of the garbage.

Hair in food

There is a heavy stigma attached to the presence of hair in food in most societies. There is a risk that it may induce choking and vomiting, and also that it may be contaminated by toxic substances. Views differ as to the level of risk it poses to the inadvertent consumer.

In most countries, people working in the food industry are required to cover their hair because it will contaminate the food. When people are served food which contains hair in restaurants or cafés, it is usual for them to complain to the staff.

Fig 3.02: Hair in Food (Pic: https://www.popsci.com/science/article/2010-09/hair-food-health-risk)

There are a range of possible reasons for the objection to hair in food, ranging from cultural taboos to the simple fact that it is difficult to digest and unpleasant to eat. It may also be interpreted as a sign of more widespread problems with hygiene. The introduction of complete-capture hairnets is believed to have resulted in a decrease in incidents of contamination of this type.

Sometimes protein from human hair is used as a food ingredient, in bread and other such similar products. Such use of human hair in food is forbidden in Islam. Historically, in Judaism, finding hair in food was a sign of bad luck

Emerging food contaminants

While many food contaminants have been known for decades, the formation and presence of certain chemicals in foods has been discovered relatively recently. These are the so-called emerging food contaminants like acrylamide, furan, benzene, perchlorate, perfluorooctanoic acid (PFOA), 3-monochloropropane-1,3-diol (3-MCPD), 4-hydroxynonenal, and (4-HNE).

Safety and regulation

Acceptable Daily Intake (ADI) levels and tolerable concentrations of contaminants in individual foods are determined on the basis of the "No Observed Adverse Effect Level" (NOAEL) in animal

experiments, by using a safety factor (usually 100). The maximum concentrations of contaminants allowed by legislation are often well below toxicological tolerance levels, because such levels can often be reasonably achieved by using good agricultural and manufacturing practices.

Regulatory officials, in order to combat the dangers associated with foodborne viruses, are pursuing various possible measures.

The EFSA published a report in 2011 on "scientific opinion regarding an update of the present knowledge on the occurrence and control of foodborne viruses".

This year, an expert working group created by the European Committee for Standardization (CEN), is expected to publish a standard method for the detection of norovirus and hepatitis A virus in food.

The CODEX Committee on Food Hygiene (CCFH) is also working on a guideline which is now ready for final adoption.

European Commission Regulation (EC) No 2073/2005 of 15 November 2005 indicates that "foodstuffs should not contain micro-organisms or their toxins or metabolites in quantities that present an unacceptable risk for human health", underlining that methods are required for foodborne virus detection.

Food contaminant testing

To maintain high quality of food and comply with health, safety and environmental regulatory standards it is best to rely on food contaminant testing through an independent third party such as laboratories, certification companies or similar. For manufacturers the testing for food contaminants can minimize the risk of noncompliance in relation to raw ingredients, semi-manufactured foods and final products. Also, food contaminant testing assures consumers safety and quality of purchased food products and can prevent foodborne diseases, and chemical, microbiological, or physical food hazards.

The establishment of ADIs for certain emerging food contaminants is currently an active area of research and regulatory debate.

Mechanism of Pollution and ways to contain it

Food pollution is the alteration or damage that a substance –or its effects- produces in the pureness or the state of the food without being its own, and that supposes a risk to the people consuming it. In this second and final part of this document, we will focus in getting to know a little more about the sources of pollution, as well as the measures to be adopted to avoid food pollution.

Food is polluted by different ways, due to the large variety of sources of pollution; the constant interchange of pollutants is very easy. This way, bacteria can go from, e.g. fecal matter of people and animals to the ground, of to the hands of handlers, or the water and from there to the food, just to name a few examples.

The most relevant problem with pollution, especially the one produced by bacteria, is the fact that it is almost impossible to detect it through the senses. This way, it is impossible to "See" the bacteria or their reproduction. Only in some cases there may have been evidences, such as the smell, that could indicate a potential pollution for pesticides, for example, or the presence of strange objects, such as a piece of glass or a screw.

Basically we can notice three types of pollution:

• Primary pollution or source pollution: It occurs during the process of food production. Currently, it is very difficult to produce vegetables totally free from pollutants, chicken or livestock without bacteria in their intestines, with which it is almost always inevitable to achieve that some food come with a certain degree of pollution from the place of production.
• Direct pollution: This is possibly the simplest way how food gets polluted, and these way pollutants get to the food through the handler. Examples of this type of pollutants could be the ones that occur when the handler eliminates drops of saliva when sneezing, coughing in process areas, when the handler with infected wounds touches the food, when raw materials or food get in touch with a chemical product such as a pesticide, when flies or other pests are over the food, or when a strange body incorporates to the food during the process.

• Crossed pollution: This type of pollution is understood as the entrance of any pollutant (bacteria, chemical product, and physical element), from a polluted food or raw material to a food that is not, to surfaces in touch with this that are clean (tables, equipment, tools).

This mechanism almost always occurs in an unpredictable manners and occurs, e.g. when in the fridge, drops of the meat fall on the food ready to be consumed. The most frequent ways of crossed pollution occur when the handler allows the contact of a raw food with a cooked one, ready to be consumed. For example, if a raw chicken or meat is cut with a knife, and with the same knife a food ready to be consumed is cut, or if raw food is placed on a cutting board and then in the same cutting board without washing or disinfecting, a cooked food is placed, ready to be consumed.

CHECK YOUR PROGRESS

Explain the concept of food contamination.
What are the sources of food contamination?
Discuss the various cases of food contamination which lead to widespread public debates.
Explain how food contamination is processed.
Explain the importance of not letting hair in food.
Discuss safety and regulations regarding food contamination.
Discuss the process of food contamination testing.
Explain ways in which food get contaminated.

3.03 HYGIENE IN FOOD SERVICE ESTABLISHMENT

Thus we have seen that the microorganisms contaminate the food in various ways. The microorganisms enter the food through air, water, soil, equipments, chemicals etc. They enter food during the receiving, storing, preparing, holding, serving, garbage disposal etc. They may enter the food also through the food handler if the hygienic practices are not followed properly. Hence the hygiene & sanitation process should be carried out very carefully. The hygiene therefore should be focused on the three important aspects:

- Hygiene related to the environment in the food preparation area.
- Personal hygiene.

- Safe Food Handling procedure.

To carry out the tasks related to the hygiene process it is quite important for us to also know the various types of food which could be spoilt easily. These food products can get easily spoilt & hence pathogenic bacteria can easily multiply on such products. These products could be milk & milk products, eggs, meat, poultry, fish, shellfish, starchy food etc.

Environmental Hygiene.

Environmental contaminants are chemicals that are present in the environment in which the food is grown, harvested, transported, stored, packaged, processed, and consumed. The physical contact of the food with its environment results in its contamination. Possible sources of contamination include:

- Air: radioactive nuclides (137Caesium, 90Strontium), polycyclic aromatic hydrocarbons (PAH)
- Water: arsenic, mercury
- Soil: cadmium, nitrates, perchlorates
- Polychlorinated biphenyls (PCB), dioxins, and polybrominated diphenyl ethers (PBDE) are ubiquitous chemicals
- Packaging materials: antimony, tin, lead, perfluorooctanoic acid (PFOA), semicarbazide, benzophenone, isopropyl thioxanthone (ITX), bisphenol A
- Processing/cooking equipment: copper, or other metal chips, lubricants, cleaning, and sanitizing agents
- Naturally occurring toxins: mycotoxins, phytohaemagglutinin, pyrrolizidine alkaloids, grayanotoxin, mushroom toxins, scombrotoxin (histamine), ciguatera, shellfish toxins (see shellfish poisoning), tetrodotoxin, among many others. (Wikipedia)

Environmental hygiene leads to the safety of food and hence safety of the consumers. Environmental hygiene is related to the following aspects:

- Site
- Structure of the establishment
- Equipment, furniture & fittings used.
- Ventilation
- Lighting
- Water supply & waste disposal.

Site

The site where food preparation is done or served should be:

- Insect free
- Floorings should be sturdy & washable. There should be no cracks.
- Drainage facility should be perfect.
- The windows should be covered with nets to avoid rodents & insects to enter the kitchen or the food service area. Insect killing machines could be installed for the same.
- There should be exhaust facility in the kitchen.
- Receiving area, store rooms should be kept clean.
- Separate arrangements should be made for handling vegetarian & non vegetarian foods.
- Sanitary rooms should be provided to the staff.

- The room should be well lit & well ventilated.

Structure of the premise/establishment

- The walls should be easy to clean.
- The floors should be easy to wipe.
- Proper sewage facility should be present.
- Plumbing, wiring should be safe.
- Hand washing facility should be present.
- Easy moving should be facilitated for the food handlers to carry out smooth operations.
- Easy exit & entry in the food service area in terms of emergency.
- Proper are to be designed for the storage of gas cylinders.
- Special areas to be designed for the installation of the firefighting equipment.

Equipment, Furniture & Fittings.
The equipments should be easy to clean. The equipment should be sturdy and should not be broken or damaged. Such damaged equipment should be quickly discarded & should not be used.

Ventilation.
Kitchen should always be installed with exhaust fans and chimneys to extract the smoke out of the kitchen. Proper ventilation should be maintained in the kitchen. The ducts should be cleaned from time to time.

Lighting- Proper lighting is important in the kitchen as various activities are carried out in the kitchen such as cutting, slicing, chopping etc. Adequate lighting helps the kitchen staff to be away from eye strain, hence proper lighting helps to avoid accidents. Only white lights which can give a normal effect should be used, coloured lights should not be used in the food preparation areas, whereas certain lights like orange , yellow could be used in the food service areas which can match with the color of the food served.

Water supply- The quality of water should be very clean. The water supply in the kitchen should be used for washing the utensils and for using in cooking. The water should be free from impurities. If the water has contaminants, then any one could develop water borne disease. Hence water has to be purified by physical, chemical and biological methods. The purification of water thus reduces the concentration of pathogenic microorganisms.

Waste disposal- The garbage is a very important aspect which has to be disposed. Hotel develops lot of garbage from cooking and other activities. Garbage bins have to be used, their lids should be tight enough. No flies should be seen on such bins, as they have to be lined with garbage plastic bags. Dry and wet garbage should be separated out and they have to be deposited in different garbage bins. There are various ways to dispose garbage: they can be treated with the vermiculture method where the earthworms are inserted in the garbage and thus the compost is prepared. Thus the hotel garbage can be converted to vermin composting. Garbage can also be disposed of by the incineration method. Biogas can also be produced by the reduction of organic waste in the absence of oxygen. Bio mass is a renewable energy source. It consists of both living and dead materials. It consists of organic material. It can be converted to other usable forms of energy.

CHECK YOUR PROGRESS

Explain the concept of hygiene.
Discuss environment hygiene.
Elaborate possible sources of environment contaminations.
What precautions are to be taken for avoiding contaminations at the site of food preparation?
What precautions are to be taken for avoiding contaminations at the structure of premises of food preparation?
What precautions are to be taken for avoiding contaminations regarding the furniture and equipments of food preparation?
Explain the importance of water disposal in respect of avoiding food contamination.
Explain about the lighting and ventilation found in the catering establishment
What do you understand by garbage disposal?

3.04 KITCHEN HYGIENE

Hygiene in the kitchen is very important to keep germs away and to keep you and your family healthy. This is also extremely important if you own a restaurant, to keep kitchens clean and in great hygiene, to keep germs away and to keep customers healthy and happy. Bad hygiene can lead to food poisoning and disease outbreaks in the family and customers.

Fig 3.03: It is important to keep kitchen counter tops clean and tidy

Many people are not aware of that you can NOT use the same cloth in the bathroom that you use for kitchen counters. So we will now explain the cloth colors and also where they are used. There are many types of germs and some places more than other...

Kitchen Cloths

Blue and Green should be used to clean the kitchen counters, stove, kitchen machines as well as kitchen tables and chairs, including other furniture. Do NOT under any circumstances use this cloths

in bathroom or kitchen floor drains, or the toilet. Floor drains and toilets contain a lot of bacteria and germs, way more than what is in the kitchen.

Yellow is used to clean bathroom sinks, taps and showers and toilet seat and the toilet cover. Do not under any circumstances use this cloth to floor drains or inside toilet and it's corners.

Red is used for cleaning floor drains and inside the toilet and it's corners. This cloth should NOT! I repeat NOT be used in kitchen or to clean the shower, sink and taps with, or on any other furniture for that matter.

All the kitchen equipments should be kept clean & tidy. There are small and large equipments used in the kitchen. Hence a lot of hygienic practices are to be followed for the same. For example, the chopping boards are to be kept clean. There should be different kinds of chopping boards for vegetarian and non-vegetarian raw materials. The working tables should always be kept clean. The gas ranges too have to be kept spotlessly clean. The dusters should be always replenished from time to time and discarded when they are not in a good position as this would lead to the cross contamination & could spread bacteria like E. coli, salmonella, staphylococcus etc. These cloths, dusters provide food particles, moisture and a good platform for such microorganisms.

Steps to be taken to prevent infection in the kitchen:

- The non-vegetarian raw material such as chicken, mutton etc. should be washed carefully and refrigerated in the deep storage refrigerator.
- Wash hands after the handling of the raw material.
- Always wash the cutting or chopping boards thoroughly after use.
- Wash all the vegetables before use.
- Use of garbage bins is must.
- All the working tables should be cleaned regularly with the proper cleaning agents.
- Perishable food products should be stored at proper temperatures.
- Select the fish properly before buying them, as they should be fresh.
- Food cans should be checked before purchasing. They should be leak proof.
- Food handlers should take utmost care regarding cleanliness. They should wash their hands after using the wash rooms, handling raw material etc.
- They should not sneeze or cough on the food, rather they should cover their mouth accordingly.
- They should cover the wounds if any with a proper water proof bandage.
- Food items should never be left open.
- Always store the raw food like chicken or fish at the lower shelf as their drippings could fall on the other food items.
- Food stored in the deep freezer should be thawed to a normal temperature before use.

Cleaning and Disinfection.

For a successful catering business, it is very necessary to keep the cleanliness up to the proper standard. The utensils and other equipments along with the floors should be thoroughly cleaned using the various disinfectants. The cleaning organization includes the manual cleaning method and the machine method (dish washing machine).

The steps involved in the cleaning and disinfecting method are:

- The pre-cleaning activity which removes the excess food waste by sweeping, wiping or pre-rinsing.
- The main cleaning method where a proper detergent is used to loosen the surface waste and greasy substances.
- The rinsing method- Here the detergent, food wastes and the grease is removed.
- Disinfection- This process kills the bacteria.
- Final rinse- This process removes the entire bacteria and thus disinfects the surface, making it risk free.

Cleaning Compounds

The cleaning compounds are used for washing the floors, walls or used in the high pressure dishwashers. Good cleaning compounds are economical, easy to measure and dissolve well.

Types of Cleaning Compounds

Most of the cleaning compounds are a combination of two or more compounds. This combination of ingredients is done to prepare a specific product for a particular type of surface or dirt. For example:

Alkaline cleaning agents- They act at a pH between 7 (neutral) and 14 (most alkaline). There are several types of alkaline cleaners like the strong alkaline cleaners like the sodium hydroxide which has strong dissolving powers, but could cause damage to skin as well hence they have to be used with utmost care. The heavy duty alkaline cleaners have moderate dissolving powers and may be slightly corrosive, these are good at removing fats but do not remove mineral deposits. Example is sodium carbonate. There are other alkaline cleaning agents which are mild in nature like sodium bicarbonate and are good in softening water.

Acid cleaning compounds- These are strong acid cleaners and mild acid cleaners. The strong acid cleaners can remove the mineral deposits from steam equipments, boilers and some food processing equipments. Example phosphoric acid, hydrofluoric acid etc. The mild acid cleaners are slightly corrosive & may cause reactions on skin and eyes. Examples are hydroxyl acetic acid, gluconic acid etc.

Sanitizing

This cleaning process removes the solid deposits. Sanitizing thus destroys the microorganisms that are left on the clean surface. If the surface is still dirty, the soil protects the microbes from sanitizing agents. Therefore, the equipment and surfaces must be thoroughly clean for sanitizers to work properly. The major types of sanitizers are: Heat, Radiation and Chemicals.

Many equipments are sanitized using hot water or steam. Radiation destroys the microorganisms with their ultra violet light, cathode and gamma rays. There are various chemicals as well which are used as sanitizers to work upon the microorganisms. For example, chorine sanitizers which have antimicrobial activities.

Quaternary ammonium compounds- They are often called as Quats and are good for cleaning and sanitizing floors, walls, furnishings &equipments. They also work as detergents. Quats work better than chlorine and iodine sanitizers, these do not irritate the skin and have no taste or odor when diluted properly. They work at a high pH. They are more effective against molds as compared to bacteria.
The cleaning and sanitizing is essential to reduce the risk of food poisoning and food spoilage by bacteria, to disinfect the equipments, to control pests, to reduce the risk of contamination, to keep the atmosphere clean & to increase the rate of customer turnover.

Machine Drainage

Machine drainage system involves the blockages of the drain pipes of machines such as washing machine or dishwasher. Usually, vacuum pumps are used to clean the debris in the pipes. The drain is cleaned for sanitary reasons. The drain hose is attached to the rear of the machine by support clips. It may be routed either to the left or the right as required. The drain hose is place on a stand pipe. The diameter of the stand pipe is usually 35mm. It can also be placed over a sink. The height of the sink is kept in between 60-100 cm. Apart from connecting it to the sink it can also be permanently connected either to the existing waste pipe or to a dedicated waste outlet. If the machine is close to a sink, then it is possible to alter the current waste trap to accept waste water from the machine. When the waste from the machine cannot be connected to the trap, then the next option is the dedicated waste outlet. The waste outlet has a vertical pipe with water trap at the lower end. This waste pipe is connected to the foul water sewer. The foul water sewers collect the waste from the kitchen sink, toilets etc. Care should be taken while installing. The hose should not be obstructed, twisted or bent. The end of the hose should not submerge in water. Syphonage should be prevented if the hose is connected to any airtight joint.

10 rules for kitchen hygiene

Fig 3.04: Clean hands is the first rule of a clean kitchen

(Pic http://www.besthomekitchenstuff.co.uk/top-10-rules-for-good-kitchen-hygiene/)

The kitchen is a hotspot for bacteria and parasites. This is why good kitchen hygiene during both food preparation and cooking are extremely critical in terms of preventing food borne illnesses.

Bacteria may sit on kitchen counters, stick to your raw meats, and end up contaminating all those delicious foods. These being germs, they are for the most part completely invisible. Here are 10 must-follow kitchen hygiene rules:

1. Wash Your Hands!

Many people tend to assume that diarrhea and other forms of sickness only come due to food poisoning from outside our homes. While you may never guarantee 100% protection against a diversity of food borne illnesses, there are several simple good kitchen hygiene precautions which you can implement towards reducing the risk.

Germs can very quickly and easily spread between our hands into the food, so keeping clean hands before initiating in any food handling process is essential. Washing hands properly when you are going to touch raw meat, especially after visiting the toilet or using the kitchen bin significantly helps in reducing the spread of several types of harmful bacteria like salmonella and E. coli.

Out there, you can pick up lots of bacteria, so it's vital to always thoroughly wash your hands prior to preparing or eating food. Using good anti-bacterial hand washes plus wipes can make all the difference in terms of kitchen hygiene. As part of your kitchen hygiene rules, use warm water and soap at all times, washing your hands thoroughly—at least for about 20 seconds.

If you only have to remember one critical thing about hygiene in the kitchen, remember this rule!

2. Proper Food Storage

Correct food storage is as critical as correct cooking. When storing cooked food in your fridge or cooler ensure it is at room temperature or even lower. Placing warm food inside a fridge implies it has not cooled evenly and could as such, cause food poisoning.

Fig 2.12: Importance of proper storage of consumables can hardly be overstated

All your food should always be covered, as left in the open it becomes vulnerable to bacteria. All raw animal foods should be stored in the fridge bottom. This is because raw fish, meat, and poultry can easily drip onto other ready-to-eat foods in the fridge causing potentially fatal illness.

Make it a habit to always check the instructions on food storage and the 'use by' date on all packaging. Any leftovers should be covered and stored in the fridge or freezer inside 2 hours of the cooking. First, ensure they have cooled completely before storing them.

3. Cook Food Thoroughly

You are perhaps thinking this is obvious stuff! But you will be surprised by the number of people who actually under cook their food. With undercooked food, there is a higher risk of harmful bacteria getting ingested which may trigger food poisoning. All animal foods ought to be cooked to a minimum of 170 ° F, if you want to get rid of viruses, bacteria, and parasites which bring food borne illnesses.

If unsure, cut into foods like meat, sausages, chicken, and burgers to check if they have been fully cooked all through. When you are reheating food, ensure it steams hot all through, and never have any food reheated more than once.

Hygiene in the kitchen includes washing vegetables and fruits to remove harmful bacteria and germs from the surface of the foods. If you usually obtain bargain food from the "a truck back" or regularly eat at establishments that are not licensed, you could be courting trouble.

4. Never Defrost Food On The Counter

Defrost the food to be cooked in the refrigerator, in cold water, or in the microwave, never on the counter. All perishable foods must never be thawed on the counter for periods lasting more than 2 hours because while at the centre, the food may still be frozen but the outer food surface could enter into what is referred to as the Danger Zone.

This is a zone whose temperature range lies between 40° and 140°F, in which lethal bacteria tend to multiply rapidly. It is best to thaw all frozen foods by placing them in the fridge bottom shelf or under cold running water for less than an hour.

Poultry and meat can be thawed in airtight packaging placed in cold water, but ensure the water is changed every half hour and the thawed food must be used immediately. If time is a factor, you may use the microwave.

5. Clean Up and Down

After cooking, keeping a clean kitchen is very important. It is estimated that the average kitchen chopping board carries more faecal bacteria compared to the average toilet seat.

Damp kitchen sponges and washing brushes are known bacteria havens. Washing your kitchen and wiping down your equipment with the good hygiene products greatly reduces cross-contamination risk dramatically.

Also, bacterial growth is prevalent where water lingers for a while, so it's important to frequently wipe down the underside of your dish drainer. Better yet, get a dish drainer that has a spout that leads water into the sink.

Also, it's a good idea to invest in a steam mop as they're able to eliminate 99% of bacteria by using the extremely hot temperatures of steam. They're pretty versatile as they can clean different types of floors and surfaces too.

Fig 3.05: Clean the kitchen properly

6. Either Keep It Hot Or Cold

If you cannot keep it hot or cold, then it's best not to keep it at all. There are some particular foods that are extremely vulnerable to rapid bacterial growth prior to cooking and after. This group of food includes poultry, eggs, fish, sliced melons, tofu, beans, rice, and sprouts. Such foods ought to always be kept above 140°F or below 40°F.

Never keep cooked food in your refrigerator for more than 7 days. If leftovers are to be safe, make sure you heat them to a minimum of 170° F! If you suspect that a food could be spoilt—uncharacteristic colour or odour or damaged packaging—it's best to throw it out.

7. Clean the Kitchen Sink and Oven

At least once each day, wipe down the sink as part of your kitchen hygiene rules. Every week, disinfect it by filling it up with either hot or warm water plus a small quantity of bleach. Remember to scrub around the entire sink with a good scourer, not forgetting the inside of the plus and plug chain.

After every use, wipe out your oven using a cloth and warm water. This may appear a tedious task, but if you really don't want to have an oven that looks horrible, it's vital that you regularly attack it using appropriate chemicals.

If your oven happens to be particularly dirty, perhaps after a heavy session of cooking and baking, prepare a thick bicarbonate of soda paste, smear this all over the oven, leaving it to do its part overnight. Come morning, grab a solid scourer, some warm water and then scrub away all the grime dirt using some elbow grease!

8. Avoid Cross Contamination

Always use individual or separate cutting boards for different food ingredients like fish/raw meat/poultry, farm produce, and cooked foods. Using a common chopping/cutting board poses a health risk, but these can be prevented easily through maintaining a clean kitchen at all times. You may, for example, opt to have a distinct red cutting board to be used specifically only for raw animal foods so as to avert any cross contamination.

The fact is that the majority of food poisoning cases actually happen within the home. It is usually a direct consequence of poor kitchen hygiene, where germs coming from raw foods get transferred to the kitchen surfaces and other foods as we prepare meals.

Fig 3.06: Always use individual or separate cutting boards for different food ingredients like fish/raw meat/poultry

Poor personal cleansing can greatly reduce chances of cross contamination. Your personal health standards could have a significant effect on the spread of germs, bacteria, and illnesses through the way you come into contact with nutritional consumables.

9. Maintain Your Kitchen Fridge And Freezer

At least once a month, take out the fridge shelves and compartments and have them washed with warm water and soap. As part of your hygiene rules, always rinse and dry the shelves before putting back. You can wipe the fridge inside with a mixture of water and bicarbonate of soda. Remember to wipe down the fridge outside too, particularly the handle!

For the freezer, when ice starts building up, it needs defrosting. After the ice has melted, take out all the compartments and shelves, washing them in soapy warm water, rinse them before placing them back. At least once a year, pull out the freezer and vacuum the unit's cooling elements to make it more efficient.

10. Use A Good Kitchen Bin

Without a mechanical garbage disposal unit in your kitchen, you will need to have a good kitchen bin or trash bag. What is most important is that you need to regularly empty your bin, preferably on a daily basis. If that does not happen, the food leftovers may start to decompose and bacteria will grow very fast in your kitchen.

Fig 3.07: A good dust bin is essential for sanitized kitchen

Sooner or later, you may also begin to have unwanted "visitors" and a smelly odour. Besides regular trash removal and bin cleaning, your kitchen bin must have a tight lid and a bonus if it's touchless sensored or pedal opened.

Final Word on Good Kitchen Hygiene Rules

Personal hygiene is in general extremely important in terms of preventing food poisoning and sickness coming from the kitchen. Proper hand washing, upholding general cleanliness and being alert to the dangers associated with cross contamination are some of the most important factors to keep in mind as you prepare food.

Keeping good kitchen hygiene standards helps in preventing the growth and spread of bacteria, infections, bad odours, and illnesses. Maintaining hygiene in the kitchen and a clean kitchen becomes necessary for a variety of reasons – personal, psychological, health, social, or simply as a normal way of life.

CHECK YOUR PROGRESS

Explain the importance of maintain kitchen hygiene.
What points should be kept in mind regarding the use of kitchen cloth.
Discuss the steps to be taken to prevent infection in the kitchen.
Elaborate on the various types of cleaning compound used in kitchen.
Explain the concept of sanitization.
Discuss machine drainage.
Elaborate on the ten rules of kitchen hygiene.
Explain the importance of cleaning hands in kitchen hygiene.
Why is it important to cook food thoroughly?
Why should one never defrost food on the counter?
How can you avoid cross contamination?
Explain why you should have a good kitchen bin.

3.05 PEST CONTROL

Pest controlling has to be done regularly in the kitchen. Pests contaminate the food due to their droppings, hair, feathers etc. They carry microorganisms on them. There are various pests which are

hazardous in the food preparation areas such as Insects, Birds and rodents. Food preparation areas should be kept clean. Insect killing machines, traps should be installed at specific places. This prevents the spread of the diseases, wastage of food & damages to the equipments. The most common pests which cause nuisance are houseflies, fruit flies, cockroaches, ants, rats, mice and lizards.

Fig 3.08: Pest control is a must in a professional kitchen (Pic Pinterest)

Following controlling measures should be taken into account for the same:

- The food premises should be designed and constructed in such a way to minimize the contamination by the pests.
- Insect proof screens should be installed to the windows from where the flies and other pests could enter.
- The cupboards where the raw ingredients are stored should be few inches above the surface of the floor.
- Insect killing machines should be installed.
- Food should be stored properly so that they do not attract the pests.
- Environment sanitation can be achieved by proper disposal of garbage, decaying food and animal carcasses & other wastes.
- All food wastes should be held in tightly covered bins.
- Various insecticide sprays, aerosols and pellets are effective in controlling fly populations in the kitchen and food service areas.
- A clean environment without fly attracting odors or damp dirty places is the most important preventive measure.
- Check regularly the food stuffs for their decay & discard the spoilt ones immediarely.
- All the cracks and crevices should be properly sealed to avoid cockroaches.
- Permitted insecticides should be applied to cracks and crevices, undersides of tables, cupboards, equipments, behind and under the sinks and other areas likely to harbor pests.

Good Housekeeping

Good Housekeeping helps to reduce the pest infestation to the minimum. There are various methods to keep the surface areas cleaned. Most of the surfaces from floors to the ceilings are kept clean by the Housekeeping department. Many cleaning agents are used to clean the surface areas. The cleaning agents could be various polishes, sprays etc which are applied on the surfaces so that the surfaces are disinfected increasing the life of the product and keeping the pests away. There are various applications for example which are treated on woods or furniture which keeps the termites away & from decaying. Vacuum cleaning the entire rooms are public areas makes the room dust free. Use of disinfectants at public areas, toilets &bathrooms disinfect the surfaces.

The most effective method of control is of course the employement of well qualified professional exterminators on a contract basis. However, these exterminators cannot be expected to maintain the premises absolutely insect free without the supplemental support and assistance of the hotel staff. For this reason it is recommended that all maids carry insecticide sprays on their carts and use them routinely when cleaning guest room and terraces. Cleanliness and constant vigilance, particularly in handling food, refuse and garbage is the best defense against rodents. All containers of these items should be clean and tightly covered and should preferably be in metal. Wire enclosures should be used for dry food stuffs in cartons or bags. This procedure plus periodic campaigns by the contract exterminators should keep the hotel free of rats and mice.

CHECK YOUR PROGRESS

Explain the concept of pest control.
What measures should be taken while implementing pest control?
Elaborate the importance of good housekeeping in maintaining kitchen hygiene.
What do you understand by cleaning & sanitizing?
Which are the various cleaning compounds used in hotels?
Explain the significance of Cleaning.
What are sanitizers and how do they work?

3.06 PEST CONTROL IN HOMES AND CITIES

Many unwelcome animals visit or make their home in residential buildings, industrial sites and urban areas. Some contaminate foodstuffs, damage structural timbers, chew through fabrics or infest stored dry goods. Some inflict great economic loss, others carry diseases or cause fire hazards, and some are just a nuisance. Control of these pests has been attempted by improving sanitation and garbage control, modifying the habitat, and using repellents, growth regulators, traps, baits and pesticides.

General methods

Physical pest control

Fig 3.09: Dog control van, Rekong Peo, Himachal Pradesh, India

Physical pest control involves trapping or killing pests such as insects and rodents. Historically, local people or paid rat-catchers caught and killed rodents using dogs and traps. On a domestic scale, sticky flypapers are used to trap flies. In larger buildings, insects may be trapped using such means as pheromones, synthetic volatile chemicals or ultraviolet light to attract the insects; some have a sticky base or an electrically charged grid to kill them. Glueboards are sometimes used for monitoring cockroaches and to catch rodents. Rodents can be killed by suitably baited spring traps and can be caught in cage traps for relocation. Talcum powder or "tracking powder" can be used to establish routes used by rodents inside buildings and acoustic devices can be used for detecting beetles in structural timbers.

Poisoned bait

Fig 3.10: Rodent bait station, Chennai, India

Poisoned bait is a common method for controlling rats, mice, birds, slugs, snails, ants, cockroaches and other pests. The basic granules, or other formulation, contains a food attractant for the target species and a suitable poison. For ants, a slow-acting toxin is needed so that the workers have time to carry the substance back to the colony, and for flies, a quick-acting substance to prevent further egg-laying and nuisance. Baits for slugs and snails often contain the molluscide metaldehyde, dangerous to children and household pets.

Warfarin has traditionally been used to kill rodents, but many populations have developed resistance to this anticoagulant, and difenacoum is often substituted. These are cumulative poisons, requiring bait stations to be topped up regularly. Poisoned meat has been used for centuries to kill animals such as wolves and birds of prey. Poisoned carcasses however kill a wide range of carrion feeders, not only the targeted species. Raptors in Israel were nearly wiped out following a period of intense poisoning of rats and other crop pests.

Fumigation

Fig 3.11: Tent fumigation of a house in America

Fumigation is the treatment of a structure to kill pests such as wood-boring beetles by sealing it or surrounding it with an airtight cover such as a tent, and fogging with liquid insecticide for an extended period, typically of 24–72 hours. This is costly and inconvenient as the structure cannot be used during the treatment, but it targets all life stages of pests.

An alternative, space treatment, is fogging or misting to disperse a liquid insecticide in the atmosphere within a building without evacuation or airtight sealing, allowing most work within the building to continue, at the cost of reduced penetration. Contact insecticides are generally used to minimise long lasting residual effects.

Sterilization

Populations of pest insects can sometimes be dramatically reduced by the release of sterile individuals. This involves the mass rearing of a pest, sterilising it by means of X-rays or some other means, and releasing it into a wild population. It is particularly useful where a female only mates once and where the insect does not disperse widely. This technique has been successfully used against the New World screw-worm fly, some species of tsetse fly, tropical fruit flies, the pink bollworm and the codling moth, among others.

Laboratory studies conducted with U-5897 (3-chloro-1,2-propanediol) were attempted in the early 1970s for rat control, although these proved unsuccessful. In 2013, New York City tested sterilization traps, demonstrating a 43% reduction in rat populations. The product ContraPest was approved for the sterilization of rodents by the United States Environmental Protection Agency in August 2016.

Methods for specific pests

Natural rodent control

Fig 3.12: Brown rat infestation

Several wildlife rehabilitation organizations encourage natural form of rodent control through exclusion and predator support and preventing secondary poisoning altogether. The United States Environmental Protection Agency notes in its Proposed Risk Mitigation Decision for Nine Rodenticides that "without habitat modification to make areas less attractive to commensal rodents, even eradication will not prevent new populations from recolonizing the habitat." The United States Environmental Protection Agency has prescribed guidelines for natural rodent control and for safe trapping in residential areas with subsequent release to the wild. People sometimes attempt to limit rodent damage using repellents. Balsam fir oil from the tree *Abies balsamea* is an EPA approved non-toxic rodent repellent. *Acacia polyacantha* subsp. *campylacantha* root emits chemical compounds that repel animals including rats.

Pantry pests

Fig 3.13: The red flour beetle, Tribolium castaneum*, attacks stored grain products worldwide.*

Insect pests including the Mediterranean flour moth, the Indian mealmoth, the cigarette beetle, the drugstore beetle, the confused flour beetle, the red flour beetle, the merchant grain beetle, the sawtoothed grain beetle, the wheat weevil, the maize weevil and the rice weevil infest stored dry foods such as flour, cereals and pasta.

In the home, foodstuffs found to be infested are usually discarded, and storing such products in sealed containers should prevent the problem from reoccurring. The eggs of these insects are likely to go unnoticed, with the larvae being the destructive life stage, and the adult the most noticeable stage. Since pesticides are not safe to use near food, alternative treatments such as freezing for four days at 0 °F (−18 °C) or baking for half an hour at 130 °F (54 °C) should kill any insects present.

Clothes moths

Fig 3.14: Larva, pupa and adult clothes moth Tineola bisselliella *with characteristic damage to fabric*

The larvae of clothes moths (mainly *Tineola bisselliella* and *Tinea pellionella*) feed on fabrics and carpets, particularly those that are stored or soiled. The adult females lay batches of eggs on natural fibres, including wool, silk and fur, as well as cotton and linen in blends. The developing larvae spin protective webbing and chew into the fabric, creating holes and specks of excrement. Damage is often concentrated in concealed locations, under collars and near seams of clothing, in folds and crevices in upholstery and round the edges of carpets as well as under furniture. Methods of control include using airtight containers for storage, periodic laundering of garments, trapping, freezing, heating and the use of chemicals; mothballs contain volatile insect repellents such as 1,4-Dichlorobenzene which deter adults, but to kill the larvae, permethrin, pyrethroids or other insecticides may need to be used.

Carpet beetles

Carpet beetles are members of the family Dermestidae, and while the adult beetles feed on nectar and pollen, the larvae are destructive pests in homes, warehouses and museums. They feed on animal products including wool, silk, leather, fur, the bristles of hair brushes, pet hair, feathers and museum specimens. They tend to infest hidden locations and may feed on larger areas of fabrics than do clothes moths, leaving behind specks of excrement and brown, hollow, bristly-looking cast skins. Management of infestations is difficult and is based on exclusion and sanitation where possible, resorting to pesticides when necessary. The beetles can fly in from outdoors and the larvae can survive on lint fragments, dust and inside the bags of vacuum cleaners. In warehouses and museums, sticky traps baited with suitable pheromones can be used to identify problems, and heating, freezing, spraying the surface with insecticide and fumigation will kill the insects when suitably applied. Susceptible items can be protected from attack by keeping them in clean airtight containers.

Bookworms

Books are sometimes attacked by cockroaches, silverfish, book mites, booklice, and various beetles which feed on the covers, paper, bindings and glue. They leave behind physical damage in the form of tiny holes as well as staining from their faeces. Book pests include the larder beetle, and the larvae of the black carpet beetle and the drugstore beetle which attack leather-bound books, while the common clothes moth and the brown house moth attack cloth bindings. These attacks are largely a problem with historic books, because modern bookbinding materials are less susceptible to this type of damage.

Evidence of attack may be found in the form of tiny piles of book-dust and specks of frass. Damage may be concentrated in the spine, the projecting edges of pages and the cover. Prevention of attack relies on keeping books in cool, clean, dry positions with low humidity, and occasional inspections should be made. Treatment can be by freezing for lengthy periods, but some insect eggs are very resistant and can survive for long periods at low temperatures.

Beetles

Fig 3.15: House timber split open to reveal larvae of the house longhorn beetle, Hylotrupes bajulus, in their burrows, which are partially filled with frass

Various beetles in the Bostrichoidea superfamily attack the dry, seasoned wood used as structural timber in houses and to make furniture. In most cases, it is the larvae that do the damage; these are invisible from the outside of the timber, but are chewing away at the wood in the interior of the item. Examples of these are the powderpost beetles, which attack the sapwood of hardwoods, and the furniture beetles, which attacks softwoods, including plywood. The damage has already been done by the time the adult beetles bore their way out, leaving neat round holes behind them. The first that a householder knows about the beetle damage is often when a chair leg breaks off or a piece of structural timber caves in. Prevention is through chemical treatment of the timber prior to its use in construction or in furniture manufacture.

Termites

Termites with colonies in close proximity to houses can extend their galleries underground and make mud tubes to enter homes. The insects keep out of sight and chew their way through structural and decorative timbers, leaving the surface layers intact, as well as through cardboard, plastic and insulation materials. Their presence may become apparent when winged insects appear and swarm in the home in spring. Control and extermination is a professional job involving trying to exclude the

insects from the building and trying to kill those already present. Soil-applied liquid termiticides provide a chemical barrier that prevents termites from entering buildings, and lethal baits can be used; these are eaten by foraging insects, and carried back to the nest and shared with other members of the colony, which goes into slow decline.

CHECK YOUR PROGRESS

How is the pest control implemented in houses and cities?
Explain the various methods of pest control.
Elaborate on the methods of physical pest control as used in cities and houses.
Discuss the poison bait method of pest control.
Discuss the Fumigation method of pest control.
Discuss the Sterilization method of pest control.
Discuss the Natural rodent control method of pest control.
Explain the various pests in the pantry and how they may be controlled.
Explain how Clothes moths are controlled.
Explain how carpet beetle are controlled.
Explain how bookworms are controlled.
Explain how beetles are controlled.
Explain how termites are controlled.

3.07 SAFE FOOD HANDLING

As we all know that the food can get contaminated through various sources. Hence it is the prime duty of the Food handler to take precautionary measures for the same. Despite careful selection and storage of food and good personal hygiene on the part of the food handler, outbreaks of food-borne illnesses can occur if unsafe procedures are followed in preparing and mixing food and if temperature is not controlled during preparing and holding food.

Sanitary procedures are very important during preparation, cooking and holding of food. Even a number of diseases can be spread due to unsanitary practices while serving food. These diseases can be avoided by following certain rules about sanitation.

Personal Hygiene:

The Food Handler should take the following precautions:

1. Always wash hands before touching food & after going to the toilet.

2. Always wash hands after touching the garbage bin.

3. Always wash hands after sneezing or coughing.

4. After smoking, eating, combing hair or after carrying out any cleaning work, one should always wash hands.

5. Hence Personal hygiene is of utmost importance. The nails should be trimmed, hair should be short, the uniform should be clean, girls should not apply nail paints, no rings should be worn as it could fall while preparing food, any cuts or boils should be covered properly with a water proof

dressing, the food handler is not well should immediately report to the supervisor as he may be cause contamination.

Fig 3.16 The Food Handler

6. Handle dishes and utensils in a sanitary manner. Plates should be held by the bottom or edge, cups by handles or bottoms, silverware by handles. Avoid touching the eating surface of crockery and cutlery.

7. Single service items should be dispensed in such a way that customers re-move one item at a time without touching other items.

8. All the service personnel should check serving dishes for any signs of soil or improper cleaning.

9. Do not serve food in chipped or cracked dishes.

10. Foods held on buffet tables must be kept at proper hot or cold holding temperatures. Check the temperature of all foods with a probe thermometer.

11. After a buffet closes, ensure that the food displayed should be discarded or cleared immediately.

12. Never handle the food with your bare hands, bread rolls, chappatis, apad, sugar cubes, salads, cold cuts, cheese, ice and even garnishes should not be touched. Always use pair of tongs, serving spoons & use plastic gloves to handle the food,

Other practices for the safe food handling

- Always store the cooked meat above raw meat.

- There should be separate areas for handling the vegetarian & non vegetarian food products.
- Use different chopping boards for fish, chicken, meat & vegetables.
- Use of probe thermometer should be used to check for the correct temperatures for the large volume of food.
- Food should be always kept hot above 63 ^{o}C ^{o}& if it has to be stored safely then it should be stored under 8 degrees centigrade. This is called as the Danger Zone.
- Food should always be thawed properly before use.
- Correct ways of cooking methods should be applied.
- The correct clothing is very important while working in the kitchen as it protects the chef from fire as well as it also absorbs the sweat; the chef cap helps against hair fall.
- The dusters used to clean the work area should always be clean.

Storage of Specific Foods

Meat & Meat products should be refrigerated soon after delivery at 0 to 2 ^{o}C. This temperature minimizes and controls bacterial growth if meat is contaminated. Raw meat should be wrapped loosely for better circulation. Cooked meat should be wrapped tightly. Frozen meats should be wrapped and sealed in moisture-proof paper or containers to prevent freezer burn. Cooked and raw meat should be stored separately. Larger cuts of meat should be hung in the cold room and nothing should be stored below. Trays should be kept below to collect the blood drippings & should be washed regularly.

Poultry is more perishable than meat and should be stored between 0 to 2 ^{o}C. Whole dressed birds may be loosely wrapped in wax paper or aluminum foil and refrigerated for three days. Frozen poultry should be stored at -18^{o}C and should be cooked soon after thawing. It should be used within 06 months

There are various stages at which the food is handled in the food outlet:

- During purchasing & receiving of the food.
- Storage of raw and cooked food
- Pre-preparation of food
- Actual cooking process
- Holding of food
- During service of food
- Clearing process
- Disposal of garbage

The raw material should be purchased from reputed suppliers who can also ensure the hygienic food stuffs. The raw material received at the receiving section should be received according to the standard purchase specifications in terms to quality and quantity. The goods which are not up to the mark should be returned back to the supplier.

The goods should be checked according to the standard check list form. For example- freshness, discoloration, insect infestation, color, firmness, odor, date of manufacture/ expiry date, damaged packs/cans etc.

The food products should be stored properly in the storage areas. There are different temperatures to be stored for various types of foods such as perishable & semi perishable food products need refrigeration that is cold storage temperature whereas the non-perishable products could be stored at room temperatures. The refrigeration temperature would be between 2 to 6 °C, whereas the frozen temperature could be around -15 to -20 ° C. The dry or non-perishable products could be stored at the room temperature with air-tight containers.

The humidity in the products also plays a very important role. The dry storage products should not have any humidity or else the molds can be developed in the form of fungus hence it could be spoiled.

The presence of infestation may make the food unfit for human consumption. This type of infestation could occur during the preliminary preparation of the food; hence the food should be cleaned thoroughly before use. The vegetables should be cleaned properly to make it dust/ dirt free, whereas the non-vegetarian products should be cleaned to make it free from microorganisms if any. The chicken or mutton if stored in the deep freezer should be thawed before use.

The food while cooking should be cooked at the right temperatures, the microorganisms get killed above 100 degrees and they get damaged above 63 °C. The danger zone of the temperature is between 9 to 63 °C. The microorganisms hence develop at a greater speed between this temperature. Hence the food if has to be stored should be stored below 9 degrees and if it has to be warmed then the temperature should be above 63 °C to be on a safer side.

After the food is cooked, sometimes it is required to keep the food in the holding stage. The food should be either stored in the cold or hot temperatures as said above. The food should be stored with the airtight container. They should be placed properly. The containers should be clean enough to avoid contamination.

At the time of service, the food handler should take care that the plates should be hot enough(sterilized) to serve hot food whereas the cold food should be served in cold plates. The temperature of the hot food should be above 63 degrees.

CHECK YOUR PROGRESS

What do you understand by food handling?
Explain the precautions taken while handling food.
Explain the points to be kept in mind before receiving the food from the supplier.

3.08 PERSONAL HYGIENE

The word hygiene means sanitary principles to maintain health. The food handlers should maintain cleanliness while working in the food preparation areas & service areas.

Employees who remain sick should not come to work. They should report about their illness to their seniors. If a food handler is sick, then he becomes the carrier of the microorganisms. This could be hazardous if the handler coughs, sneezes on the food or can even contaminate the food by his hands. Hence food handlers should remain clean regarding the personal hygiene;

Skin- The food handlers should be cautious about their skin. They should not have any skin infections as they handle the food rottenly. Poor skin care and skin disorders also cause bacterial infections like boils. Boils are severe infections in hair follicles or skin glands after the outer layer of skin (epidermis) is damaged, for example by irritating clothing. Staphylococci or other microorganisms multiply in the hair follicle or skin gland and produce a toxin that kills the cells around it and causes swelling and soreness. Similarly cuts and septic spots also provide an ideal place for bacterial multiplication. To prevent contamination of food by harmful bacteria, employees should therefore cover boils, cuts, septic spots with water proof dressings.

Hands- Hands should always be washed before touching the raw materials. Employees should wash hands frequently with soap and use a hand dip sanitizer after touching these things so that they do not contaminate the food. Food handlers must wash their hands after touching the non-vegetarian products, after using the wash room, after touching their hair, after eating, smoking, coughing, sneezing etc.

Nails- one of the easiest ways to spread bacteria is through dirt under the finger nails. Employees should never handle the food if the nails are dirty, hence nails are to be trimmed very oftenly. Washing the hands with soap removes the transient bacteria and by using a hand soap that contains an antiseptic or sanitizer controls resident bacteria.

Nose, Mouth & Ears- Upto 40 % of the adults carry staphylococci in the nose, mouth and ears. Hence by coughing or sneezing, these bacteria gets transferred in the food causing hazards to the guests. Hence lot of care has to be taken while coughing or sneezing. Always putting hands in the hair, nose or ears should be avoided. Food handlers should not blow their mouth on foods such as hot milk to remove the cream.

Jewelry& perfume- Employees should not wear any jewelry or rings, as they are handling the food. This could be hazardous if any ring or any crystal falls in the food. Further there are bacteria which form under the rings as this area remains very humid hence there is a presence of bacteria under the rings. Whereas perfumes should not be applied as it hampers the food taste if it comes in deep contact with the same.

Hair- The hair of the food handlers should be tied or covered with the chefs cap. Long hair tends to fall in the food &these contain lot of microorganisms on them, thus causing guest complaints as well.

Smoking- Smoking is totally prohibited in the food preparation and service areas. This is because the food handlers touch their lips and then again to the food products which tends for the cross contamination of the food. Hence separate smoking zones can be used for the same and they should again wash their hands thoroughly and sanitized.

Protective Clothing- Persons handling food must wear clean and washable clothing preferably light colored or pure white. Press studs are preferable to buttons. Suitable footwear should be worm to prevent slipping and to protect one's feet. The Uniform should include- the chef cap, scarf to absorb the sweat of the handler, chef coat & apron. All the material should be quite thick so as to protect against fire. The food handler should always keep a clean duster along with him/her.

3.09 FOOD SAFETY MANAGEMENT SYSTEMS IN FOOD SERVICE ESTABLISHMENTS

Apart from following the hygienic practices in food service establishments there are many hazard occurring frequently due to many reasons, hence a proper food safety management system has to be installed to follow the same and avoid such hazards. These hazards occur due to certain negligence and due to not following certain rules and regulations in terms of the food safety management. Such negligence or ignorance are discussed below-

- The food does not meet the required temperature during service or they are not cooked at the required temperatures.
- Utensils are not clean.
- Storage practices are not followed properly or inadequate storage facilities.
- Thermometers are not provided or are not located conspicuously.
- Dishwashing facilities are not performed up to the standard.
- Food handlers do not follow personal hygiene.
- Pests controlling inadequate.
- Drainage systems not functioning properly.
- No proper garbage disposal.
- No toilet and hand washing facilities provided for the staff.
- Maintenance of the kitchen inadequate.
- Floors, walls are faulty.
- Inadequate lighting facility in the kitchen.
- Windows not covered by wire mesh.
- Insect killing machine not installed.
- Housekeeping services & kitchen stewarding services not functioning properly.

Hazard Analysis and Critical Control Points (HACCP)

The HACCP is a system which identifies, evaluates and control hazards which are significant for the food safety. The hazard is an incidence which has a potential to cause adverse effect on the health of anyone.

HACCP is originally known and developed as a safety precautionary system in the early days of the US manned space programme. This original system was founded by the Pillsbury Company working alongside NASA army laboratories at Natick.

The National Advisory Committee on Microbiological Criteria for Foods ((Committee) reconvened HACCP working group in 1995. The primary goal was to review the Committee's November, 1992, HACCP document, comparing it to current HACCP guidance prepared by the Codex Committee on Food Hygiene. Based upon its review, the Committee made the HACCP principles more concise & in a more revised form to provide more detailed explanation of the application of HACCP principles and the identification of the Critical Control Points. Seven basic principles are employed in the development of HACCP plans that meet the stated goal. These principles include:

- Hazard Analysis
- CCP identification
- Establishing Critical limits
- Monitoring procedures
- Corrective actions
- Verification procedures
- Record keeping and documentation.

Under such systems, if a deviation occurs indicating that control has been lost , the deviation is detected and appropriate steps are taken to re-establish control in a timely manner t assure that potentially hazardous products do not reach the consumer.

The Committee believes that the HACCP principles should be standardized to provide uniformity in training and applying the HACCP system by industry and government. In accordance with the National Academy of Sciences recommendation, the HACCP system must be developed by each food establishment and tailored to its individual product processing and distribution conditions. For successful HACCP programme to be properly implemented, management must be committed to a HACCP approach. A committee by management will indicate an awareness of the benefits, in addition to enhance assurance of food safety, are better use of resources and timely response to problems.

Some important steps to carry out HACCP has been provided as follows:

- Look at your process or product from start to finish.
- Decide where hazards could occur.
- Put in control and monitor them
- Write down and keep records.
- Ensure that it continues to work effectively

Food Hazards and their sources

There are 3 types of hazards that normally present in food are:

- Physical Hazards
- Chemical Hazards
- Biological Hazards

Physical Hazards- these are foreign material normally found in food, which many cause illness or injuries to the individual using the product. They may cause physical illness for example insect fragments, stone metals, wood dust, glass particles, jewelry etc.

Chemical Hazards- This could be any type of chemical getting introduced in the food. These could be the agricultural chemicals coming along with the vegetables, for example pesticides, fungicides, fertilizers etc. There could be other chemicals as well such as non-permitted food colors& other additives, lubricants, paint coatings etc.

Biological Hazards- These are the hazardous and pathogenic microorganisms. Such as- Insects or pests, microorganisms coming through the flesh of the pork, chicken, fish etc. Food handlers may also transfer microorganisms to the food.

Principles of HACCP

The HACCP team conducts a hazard analysis and identifies appropriate control measures. The purpose of the hazard analysis is to develop a list of hazards which are of such significance that they are reasonable likely to cause injury or illness if not effectively controlled. The important facts to be considered during the analysis includes the analysis of the ingredients & raw materials, each step in the process, storage practices & its distribution & the final preparation & service or transportation.

The hazard analysis and identification of associated control measures accomplish three objectives:

- The hazards and associated control measures are identified.
- The analysis may identify modifications required to process so that product safety is further ensured or improved.
- The analysis provides basis for determining CCPs (critical control points).

The process of conducting a hazard analysis involves two stages- **the first stage** hazard identification can be regarded as a brainstorming session where the HACCP team reviews the ingredients used in the product, the activities conducted at each step in the process and the equipment used, the final product and its method of storage and distribution and the intended use and consumers of the product. Based on this review, the team develops a list of potential biological, chemical or physical hazards which may be introduced, increased or controlled at each step in the production process. Hazard identification focuses on developing a list of potential hazards associated with each process step under direct control of the food operation.

After the list of potential hazards is assembled, **stage two,** the hazard evaluation is being conducted. In this stage the HACCP team decides which potential hazards must be attended to in the HACCP plan. When conducting the hazard evaluation, it is helpful to consider the likelihood of exposure and severity of the potential consequences if the hazard is not properly controlled. In addition, consideration should be given to the effects of short term as well as long term exposure to the potential hazard. During the evaluation of each potential hazard, the food, its method of preparation, transportation, storage and persons likely to consume the product should be considered to determine how each of these factors may influence the likely occurrence and severity of the hazard being controlled.

A summary of information is prepared and should be kept for future references. This information will be useful during future reviews and updates of the hazard analysis and the HACCP plan. Upon completion of the hazard analysis, the hazards associated with each step in the production of the food should be listed along with any measures. That are used to control the hazards. More than one control measure may be required for a specific hazard. On the other hand, more than one hazard may be addressed by a specific control measure (e.g. pasteurization of milk).

If a HACCP team for example, were to conduct a hazard analysis for the production of frozen cooked beef patties, enteric pathogens (example salmonella and verotoxin producing Escherichia coli) in the raw meat would be identified as hazards. Cooking is a control measure which can be used to eliminate these hazards.

A critical limit for preventive measures associated with each identified CCP is established to prevent, eliminate or reduce to an acceptable level the occurrence of a food safety hazard. A critical limit is used to distinguish between safe and unsafe operating conditions at a CCP. Each CCP will have one or more control measures to ensure that the identified hazards are prevented, eliminated or reduced to acceptable levels. Critical limits may be based upon factors such as temperature, time, physical dimensions, humidity, moisture level, water activity, pH, salt concentration, viscosity, preservatives, sensory information such as aroma and visual appearance etc. Critical limits must be based scientifically.

Establishing the CCP monitoring requirements helps to produce an accurate record for future use in verification. The monitoring purpose helps for safety food management, to correct the deviation of action so that accurate action is taken. Personnel who monitor CCPs must be trained in the monitoring technique, for which they are responsible, fully understand the purpose and importance of monitoring.

Corrective actions should be taken while monitoring the CCPs and the deviations occurring for the same. These corrective actions taken should be verified again and again so as to observe whether the HACCP system is working effectively or not. This helps to observe whether the system is according to the HACCP plan. By verifying the system whether the implementation is being done properly, helps in controlling the hazards. The verification activities are carried out by individual within the company, third party experts and regulatory agencies.

Record keeping procedures are to be maintained properly along with the supported documents which include all the CCPs, monitoring reports, corrective actions, case studies etc.

Benefits of implementing HACCP:

The most important benefit is for the consumer. It reduces the risk of any food borne diseases, increases the market access, reduction in production costs through reduced wastage of food, increases consumer and government confidence, mitigating the business risk. It increases the improved public health, enhance facilitation on international trade, increases confidence of the community in the food supply.

Good Hygienic Practices (GHP) include a set of preventive measures to keep microorganisms out of the food. Microorganisms may contaminate the food from the surroundings providing suitable conditions of growth and development or because of inappropriate handling of food.

Good Manufacturing Practice or GMP- This refers to Good Manufacturing Practices Regulations promulgated by the US Food and Drug Administration under the authority of the Federal Food, Drug and Cosmetic Act. These regulations are governed by the Law. The manufacturers, processors and packagers of drug, medical devices, food and blood take proactive steps to ensure that their products are pure, safe and effective. GMP regulations require a quality approach to manufacturing enabling companies to minimize or eliminate instances of contamination, mixups and errors. This protects the consumers from purchasing a product which is not effective or even dangerous. Failures of rims to comply with GMP regulations can result in very serious consequences including recall, seizure, fines and imprisonment.

CHECK YOUR PROGRESS

Explain what do you understand by Personal Hygiene?
What are the Principles of HACCP?
What are GHP and GMP?

3.10 SUMMARY

Hygiene and sanitation are inevitable parts of a successful catering establishment as they have an important role in increasing the customer turnover thereby increasing the profits and goodwill of the establishment.
It is the responsibility of the Management to provide information related to hygiene and sanitation to their staff.
For maintaining a healthy and hygienic atmosphere, three hygienic systems are to be followed- Environmental hygiene, safe food handling and personal hygiene.
Apart from the site and location of the hotel, proper lighting, ventilation and supply of clean water also plays an important role in maintaining a sound and healthy work atmosphere.
The selection of furniture and fixtures should be such that they should be durable as well as easy to clean.
A proper garbage disposal programme should be maintained.
Pest control is very necessary to avoid contamination of food.
The food handlers should follow safe food handling procedure.
Proper hygienic practices should be followed starting from the receiving the raw material to the final product and its transportation to the guests table.
Cooking, holding and serving temperatures of the food should be maintained correctly to avoid any hazards.
The CCP should be monitored and carried out effectively.
Good Hygienic Practices along with Good Manufacturing procedures should be carried out more effectively.

3.11 KEY TERMS

Boils: Several Local infections caused by infections in hair follicles or skin glands after the outer layer of skin gets damaged.
Contaminant- A Biological, physical or chemical agent not intentionally added to food which may comprise food safety or suitability.
Food Hygiene- All conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.
Food Processing- Encompasses all the steps that food goes through, from the tie it is harvested to the time it arrives at the shops for being sold.
Pathogens- Disease producing microorganisms and toxins.
Pesticides- Chemicals used to kill pests such as insects and rodents.
Food Borne Illness- The illness or disease caused by the ingestion of foods containing toxic or infectious agents.
Insecticides- Any substance or mixture of substances intended for preventing, killing, repelling or controlling insects.
Rodenticides- Chemicals that prevent, destroy, inhibit, kill or mitigate rodents.

3.12 END QUESTIONS

1. What are the hygienic systems followed in the hotels?
2. What are the stages at which microbes may enter the food during handling process?
3. What do you understand by HACCP?
4. What is Garbage disposal?
5. What is Personal Hygiene?
6. What do you understand by Critical Control Points?
7. What is Pest control?
8. What do you understand by Safe Food Handling?
9. Explain the concept of food contamination.
10. What are the sources of food contamination?
11. Discuss the various cases of food contamination which lead to widespread public debates.
12. Explain how food contamination is processed.
13. Explain the importance of not letting hair in food.
14. Discuss safety and regulations regarding food contamination.
15. Discuss the process of food contamination testing.
16. Explain ways in which food get contaminated.
17. Explain the concept of hygiene.
18. Discuss environment hygiene.
19. Elaborate possible sources of environment contaminations.
20. What precautions are to be taken for avoiding contaminations at the site of food preparation?
21. What precautions are to be taken for avoiding contaminations at the structure of premises of food preparation?
22. What precautions are to be taken for avoiding contaminations regarding the furniture and equipments of food preparation?
23. Explain the importance of water disposal in respect of avoiding food contamination.
24. Explain about the lighting and ventilation found in the catering establishment
25. What do you understand by garbage disposal?
26. Explain the importance of maintain kitchen hygiene.
27. What points should be kept in mind regarding the use of kitchen cloth.
28. Discuss the steps to be taken to prevent infection in the kitchen.

29. Elaborate on the various types of cleaning compound used in kitchen.
30. Explain the concept of sanitization.
31. Discuss machine drainage.
32. Elaborate on the ten rules of kitchen hygiene.
33. Explain the importance of cleaning hands in kitchen hygiene.
34. Why is it important to cook food thoroughly?
35. Why should one never defrost food on the counter?
36. How can you avoid cross contamination?
37. Explain why you should have a good kitchen bin.
38. Explain the concept of pest control.
39. What measures should be taken while implementing pest control?
40. Elaborate the importance of good housekeeping in maintaining kitchen hygiene.
41. What do you understand by cleaning & sanitizing?
42. Which are the various cleaning compounds used in hotels?
43. Explain the significance of Cleaning.
44. What are sanitizers and how do they work?
45. How is the pest control implemented in houses and cities?
46. Explain the various methods of pest control.
47. Elaborate on the methods of physical pest control as used in cities and houses.
48. Discuss the poison bait method of pest control.
49. Discuss the Fumigation method of pest control.
50. Discuss the Sterilization method of pest control.
51. Discuss the Natural rodent control method of pest control.
52. Explain the various pests in the pantry and how they may be controlled.
53. Explain how Clothes moths are controlled.
54. Explain how carpet beetle are controlled.
55. Explain how bookworms are controlled.
56. Explain how beetles are controlled.
57. Explain how termites are controlled.
58. What do you understand by food handling?
59. Explain the precautions taken while handling food.
60. Explain the points to be kept in mind before receiving the food from the supplier.
61. Explain what do you understand by Personal Hygiene?
62. What are the Principles of HACCP?
63. What are GHP and GMP?

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UNIT 4 : FOOD PRESERVATION AND STORAGE

4.00 BEFORE WE BEGIN

In the previous unit we have discussed the various methods & procedures to maintain the hygiene up to the proper standard in catering establishment. This can be achieved by maintaining a clean and healthy environment in the hotel, by carrying out safe food handling procedures, following the HACCP rules etc.

In this unit you will learn the various types of contaminants which are responsible for the spoilage of food, which can eventually cause the food borne diseases. The study includes about the various microorganisms which are responsible for the spoilage of the food & hence we will learn about the various techniques of food preservations & the correct storage practices. Preservation methods can be ancient as drying and pickling or they can be as modern as canning and pasteurizing. Foods are preserved to minimize their wastage. There is now an increasing demand by consumers for foods that have a long shelf life, that have very few synthetic additives and have undergone fewer changes during processing.

4.01 UNIT OBJECTIVES

After studying this unit you will be able to

- Describe the various types of contaminants which are responsible for the spoilage of the food.
- Explain the effect of microorganisms on the food.
- Elaborate various food borne diseases.
- Explain various preservation & storage practices.
- Discuss the significance of the various national and international government bodies and the laws formulated by them.

4.02 POISONING BY PLANTS, CHEMICALS AND ANIMALS

The Codex Alimentarius defines food contaminant as any substance not intentionally added to food, which is present in such food as a result of the production includes operations carried out in crop husbandry, animal husbandry and veterinary medicines, manufacture, processing, preparation, treatment, packing, packaging, transport, holding of such food or as a result of environmental contamination. The term does not include insects, fragments, rodent hairs and other extraneous matter.

Food can be contaminated by any of following sources such as Air, water, plants, animals, soil, food handler, machinery and equipments. Food contamination thus includes chemicals and microorganisms entering the food thus creating illness or injury to the consumer of the food.

The effects of the chemicals can be seen on the human body after a longer duration example carcinogen in food may be build up in the body causing cancers. These chemical contaminants also cannot be destroyed by thermal processing.

Thus contaminants in food can be classified as under:

- Biological
- Natural toxin
- Toxic metals and chemicals
- Pesticide residues

Let us discuss these in details.

Biological

Contaminants include microorganisms growing in food causing spoilage like nematodes and other worms and can cause infestations, protozoan infestations like amoebiasis etc. Sometimes untreated human excreta when used as fertilizers can cause serious problems to the crops. There are certain animals which move by in the fields or crops thus causing damage to the crops due to their excretions, droppings etc, they also spread diseases due to the microorganisms which they carry on their bodies.

Natural Toxins

Certain plants and animals contain natural substances that are poisonous and may produce gastro-intestinal disturbances. For exampleargemone seeds has argemone oil which contains a toxin sanguinarine which can be responsible for swelling of legs, diarrhea, breathing difficulties etc. Some green, sprouting potatoes also can cause vomiting, abdominal pain etc., kesari dal on the other hand contains neurotoxin called BOAA (beta-oxalyl amino alanin) which can cause disease related to nervous system which can result in paralysis. Thus diets containing large amounts of kesari dal can cause a disease lathuyrism. The toxins thus can be removed by steeping or parboiling before the cooking process.

There are certain funguses developed on wheat, barley and rye grains if not stored properly. These fungi are called as mycotoxins which can cause disease like ergotism. If breads are made from such grains &consumed, then symptoms of gangrene and convulsions can be seen.

On the other hand, there are some mushrooms which can be termed poisonous. Amanita phalloides and A.muscaria mushrooms are poisonous. They produce hepatotoxic factors that damage the liver and could also damage the liver.

Mussels and clams_ some oceanic mussels and clams feed on toxic or poisonous algae which in turn are hazardous to human beings, muscular weakness, respiratory paralysis, numbness of lips and tongue and also be seen as symptoms after consumption of such seafood.

Toxic Metals and Chemicals

Metals if consumed in excess may term to be harmful for human beings. Some chemical and toxic metals can come in contact with the food during the preparation or even during the final packing stage, thus causing poisoning to the human beings. Some of the toxic metals are discussed below:

Selenium

This type of metal when present in excess amount in soil, this may get transferred into the food thus causing loss of appetite, gastro-intestinal disorders etc.

Zinc

Sometimes due to wrong storage practices we store the acidic food in some galvanized containers which has chemical changes on the food thus causing anemia, dizziness, diarrhea, nausea etc.

Lead

There are certain other examples of metals which can result to toxicity; like lead can be used as adulterant in turmeric powder.

Cadmium

This metal is used for plating utensils. Thus when fruit juices, wines, soft drinks, tomatoes come in contact with such utensils there are chances of getting headaches, vomiting, diarrhoea etc.

Copper

The poisoning occurs when food is stored in copper vessels or when the copper is used to cook food. Abdominal pain, vomiting, diarrhoea, throat infections can be seen.

Brass

Brass is an alloy of copper and zinc. They are plated with tin and nickel and then can be used to cook food. If the plating wears out and if the food containing more acidity is cooked into it, then it may result in food poisoning.

Fluoride

If the amount of fluoride exceeds in water, then it is not safe to drink as it becomes toxic in nature.

Tin

Tin poisoning is seen in acidic canned foods or moist foods left in the can after opening it.

Arsenic- Exposure to arsenic for years may cause cutaneous lesions, cancer of the lungs etc. Many insecticides, weed killers and rat poisons contain arsenic.

Mercury- Sometimes water is contaminated by industrial wastes. Thus when fish bred in such water when consumed which contains mercury may lead to paralysis and brain damage. Sometimes some fungicides also contain mercury which is used in the treatment of seed grain.

Pesticide Residues

Pesticide spray residues may contaminate foods such as cereals, fresh fruits and vegetable. These pesticides may get in contact easily with soil, air and water.

The improper application of pesticides can also cause harm to the human beings. Example the improper application of pesticides like aluminum, phosphide or zinc oxide results in health hazards as these pesticides leave behind residues in the form of compounds of aluminum or zinc metals.

Presence of Extraneous Material

Contaminants may be present in food in the form of nail chippings, hair, dust, dirt, grit or small stones. Some glass fragments may also be present or even some metal fragments in the form of smaller chippings, there could be some small pins coming from stapler pins, aluminum wire etc.

CHECK YOUR PROGRESS

Explain the various sources of contaminations to the food.
Discuss the various Biological sources of contaminations to the food.
Elaborate the various natural toxin contaminations to the food.
Describe the various Toxic metals and chemicals as contaminations to the food.
Explain the various pesticide residues as contaminations to the food.

4.03 FOOD BORNE DISEASES

(Source: Wikipedia, https://en.wikipedia.org/wiki/Foodborne_illness)

Foodborne illness (also **foodborne disease** and colloquially referred to as **food poisoning**) is any illness resulting from the food spoilage of contaminated food, pathogenic bacteria, viruses, or parasites that contaminate food, as well as toxins such as poisonous mushrooms and various species of beans that have not been boiled for at least 10 minutes.

Symptoms vary depending on the cause, and are described below in this article. A few broad generalizations can be made, e.g.: The incubation period ranges from hours to days, depending on the cause and on how much was consumed. The incubation period tends to cause sufferers to not associate the symptoms with the item consumed, and so to cause sufferers to attribute the symptoms to gastroenteritis for example.

Symptoms often include vomiting, fever, and aches, and may include diarrhea. Bouts of vomiting can be repeated with an extended delay in between, because even if infected food was eliminated from the stomach in the first bout, microbes (if applicable) can pass through the stomach into the intestine and

begin to multiply. Some types of microbes stay in the intestine, some produce a toxin that is absorbed into the bloodstream, and some can directly invade deeper body tissues.

Causes

Fig 4.01: Poorly stored food in a refrigerator (Wikipedia)

Foodborne illness usually arises from improper handling, preparation, or food storage. Good hygiene practices before, during, and after food preparation can reduce the chances of contracting an illness. There is a consensus in the public health community that regular hand-washing is one of the most effective defenses against the spread of foodborne illness. The action of monitoring food to ensure that it will not cause foodborne illness is known as food safety. Foodborne disease can also be caused by a large variety of toxins that affect the environment.

Furthermore, foodborne illness can be caused by pesticides or medicines in food and natural toxic substances such as poisonous mushrooms or reef fish.

Bacteria

Bacteria are a common cause of foodborne illness. In the United Kingdom during 2000, the individual bacteria involved were the following: *Campylobacter jejuni* 77.3%, *Salmonella* 20.9%, *Escherichia coli* O157:H7 1.4%, and all others less than 0.56%. In the past, bacterial infections were thought to be

more prevalent because few places had the capability to test for norovirus and no active surveillance was being done for this particular agent. Toxins from bacterial infections are delayed because the bacteria need time to multiply. As a result, symptoms associated with intoxication are usually not seen until 12–72 hours or more after eating contaminated food. However, in some cases, such as Staphylococcal food poisoning, the onset of illness can be as soon as 30 minutes after ingesting contaminated food.

Most common bacterial foodborne pathogens are:

- *Campylobacter jejuni* which can lead to secondary Guillain–Barré syndrome and periodontitis
- *Clostridium perfringens*, the "cafeteria germ"
- *Salmonella* spp. – its *S. typhimurium* infection is caused by consumption of eggs or poultry that are not adequately cooked or by other interactive human-animal pathogens

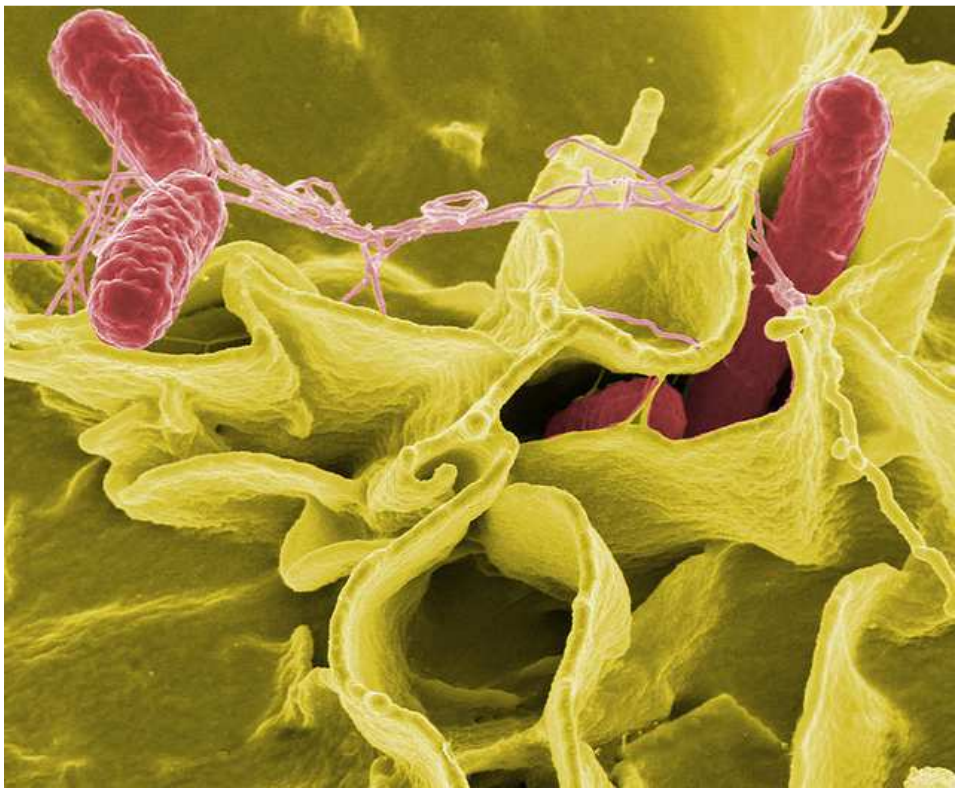

Fig 4.02: Salmonella

- *Escherichia coli O157:H7* enterohemorrhagic (EHEC) which can cause hemolytic-uremic syndrome

Other common bacterial foodborne pathogens are:

- *Bacillus cereus*
- *Escherichia coli*, other virulence properties, such as enteroinvasive (EIEC), enteropathogenic (EPEC), enterotoxigenic (ETEC), enteroaggregative (EAEC or EAgEC)
- *Listeria monocytogenes*
- *Shigella* spp.
- *Staphylococcus aureus*
- *Staphylococcal enteritis*

- *Streptococcus*
- *Vibrio cholerae*, including O1 and non-O1
- *Vibrio parahaemolyticus*
- *Vibrio vulnificus*
- *Yersinia enterocolitica* and *Yersinia pseudotuberculosis*

Less common bacterial agents:

- *Brucella* spp.
- *Corynebacterium ulcerans*
- *Coxiella burnetii* or Q fever
- *Plesiomonas shigelloides*

Enterotoxins

In addition to disease caused by direct bacterial infection, some foodborne illnesses are caused by enterotoxins (exotoxins targeting the intestines). Enterotoxins can produce illness even when the microbes that produced them have been killed. Symptom appearance varies with the toxin but may be rapid in onset, as in the case of enterotoxins of *Staphylococcus aureus* in which symptoms appear in one to six hours. This causes intense vomiting including or not including diarrhea (resulting in staphylococcal enteritis), and staphylococcal enterotoxins (most commonly staphylococcal enterotoxin A but also including staphylococcal enterotoxin B) are the most commonly reported enterotoxins although cases of poisoning are likely underestimated. It occurs mainly in cooked and processed foods due to competition with other biota in raw foods, and humans are the main cause of contamination as a substantial percentage of humans are persistent carriers of *S. aureus*. The CDC has estimated about 240,000 cases per year in the United States.

- *Clostridium botulinum*
- *Clostridium perfringens*
- *Bacillus cereus*

The rare but potentially deadly disease botulism occurs when the anaerobic bacterium *Clostridium botulinum* grows in improperly canned low-acid foods and produces botulin, a powerful paralytic toxin.

Pseudoalteromonas tetraodonis, certain species of Pseudomonas and Vibrio, and some other bacteria, produce the lethal tetrodotoxin, which is present in the tissues of some living animal species rather than being a product of decomposition.

Emerging foodborne pathogens

Many foodborne illnesses remain poorly understood.

- *Aeromonas hydrophila*, Aeromonas caviae, Aeromonas sobria

Preventing bacterial food poisoning

Fig 4.03: Proper storage and refrigeration of food help in the prevention of food poisoning

Prevention is mainly the role of the state, through the definition of strict rules of hygiene and a public services of veterinary surveying of animal products in the food chain, from farming to the transformation industry and delivery (shops and restaurants). This regulation includes:

- traceability: in a final product, it must be possible to know the origin of the ingredients (originating farm, identification of the harvesting or of the animal) and where and when it was processed; the origin of the illness can thus be tracked and solved (and possibly penalized), and the final products can be removed from the sale if a problem is detected;
- enforcement of hygiene procedures such as HACCP and the "cold chain";
- power of control and of law enforcement of veterinarians.

In August 2006, the United States Food and Drug Administration approved Phage therapy which involves spraying meat with viruses that infect bacteria, and thus preventing infection. This has raised concerns, because without mandatory labelling consumers would not be aware that meat and poultry products have been treated with the spray.

At home, prevention mainly consists of good food safety practices. Many forms of bacterial poisoning can be prevented by cooking it sufficiently, and either eating it quickly or refrigerating it effectively. Many toxins, however, are not destroyed by heat treatment.

Techniques that help prevent food borne illness in the kitchen are hand washing, rinsing produce, preventing cross-contamination, proper storage, and maintaining cooking temperatures. In general,

freezing or refrigerating prevents virtually all bacteria from growing, and heating food sufficiently kills parasites, viruses, and most bacteria. Bacteria grow most rapidly at the range of temperatures between 40 and 140 °F (4 and 60 °C), called the "danger zone". Storing food below or above the "danger zone" can effectively limit the production of toxins. For storing leftovers, the food must be put in shallow containers for quick cooling and must be refrigerated within two hours. When food is reheated, it must reach an internal temperature of 165 °F (74 °C) or until hot or steaming to kill bacteria.

Mycotoxins and alimentary mycotoxicoses

The term alimentary mycotoxicoses refers to the effect of poisoning by Mycotoxins (The term 'mycotoxin' is usually reserved for the toxic chemical products produced by fungi that readily colonize crops) through food consumption. Mycotoxins sometimes have important effects on human and animal health. For example, an outbreak which occurred in the UK in 1960 caused the death of 100,000 turkeys which had consumed aflatoxin-contaminated peanut meal. In the USSR in World War II, 5,000 people died due to Alimentary Toxic Aleukia (ALA). The common foodborne Mycotoxins include:

- Aflatoxins – originated from Aspergillus parasiticus and Aspergillus flavus. They are frequently found in tree nuts, peanuts, maize, sorghum and other oilseeds, including corn and cottonseeds. The pronounced forms of Aflatoxins are those of B1, B2, G1, and G2, amongst which Aflatoxin B1 predominantly targets the liver, which will result in necrosis, cirrhosis, and carcinoma. In the US, the acceptable level of total aflatoxins in foods is less than 20 µg/kg, except for Aflatoxin M1 in milk, which should be less than 0.5 µg/kg. The official document can be found at FDA's website.
- Altertoxins – are those of Alternariol (AOH), Alternariol methyl ether (AME), Altenuene (ALT), Altertoxin-1 (ATX-1), Tenuazonic acid (TeA) and Radicinin (RAD), originated from Alternaria spp. Some of the toxins can be present in sorghum, ragi, wheat and tomatoes. Some research has shown that the toxins can be easily cross-contaminated between grain commodities, suggesting that manufacturing and storage of grain commodities is a critical practice.
- Citrinin
- Citreoviridin
- Cyclopiazonic acid
- Cytochalasins
- Ergot alkaloids / Ergopeptine alkaloids – Ergotamine
- Fumonisins – Crop corn can be easily contaminated by the fungi Fusarium moniliforme, and its Fumonisin B1 will cause Leukoencephalomalacia (LEM) in horses, Pulmonary edema syndrome (PES) in pigs, liver cancer in rats and Esophageal cancer in humans. For human and animal health, both the FDA and the EC have regulated the content levels of toxins in food and animal feed.
- Fusaric acid
- Fusarochromanone
- Kojic acid
- Lolitrem alkaloids
- Moniliformin
- 3-Nitropropionic acid
- Nivalenol
- Ochratoxins – In Australia, The Limit of Reporting (LOR) level for Ochratoxin A (OTA) analyses in 20th Australian Total Diet Survey was 1 µg/kg, whereas the EC restricts the

content of OTA to 5 µg/kg in cereal commodities, 3 µg/kg in processed products and 10 µg/kg in dried vine fruits.
- Oosporeine
- Patulin – Currently, this toxin has been advisably regulated on fruit products. The EC and the FDA have limited it to under 50 µg/kg for fruit juice and fruit nectar, while limits of 25 µg/kg for solid-contained fruit products and 10 µg/kg for baby foods were specified by the EC.
- Phomopsins
- Sporidesmin A
- Sterigmatocystin
- Tremorgenic mycotoxins – Five of them have been reported to be associated with molds found in fermented meats. These are Fumitremorgen B, Paxilline, Penitrem A, Verrucosidin, and Verruculogen.
- Trichothecenes – sourced from Cephalosporium, Fusarium, Myrothecium, Stachybotrys and Trichoderma. The toxins are usually found in molded maize, wheat, corn, peanuts and rice, or animal feed of hay and straw. Four trichothecenes, T-2 toxin, HT-2 toxin, diacetoxyscirpenol (DAS) and deoxynivalenol (DON) have been most commonly encountered by humans and animals. The consequences of oral intake of, or dermal exposure to, the toxins will result in Alimentary toxic aleukia, neutropenia, aplastic anemia, thrombocytopenia and/or skin irritation. In 1993, the FDA issued a document for the content limits of DON in food and animal feed at an advisory level. In 2003, US published a patent that is very promising for farmers to produce a trichothecene-resistant crop.
- Zearalenone
- Zearalenols

Viruses

Viral infections make up perhaps one third of cases of food poisoning in developed countries. In the US, more than 50% of cases are viral and noroviruses are the most common foodborne illness, causing 57% of outbreaks in 2004. Foodborne viral infection are usually of intermediate (1–3 days) incubation period, causing illnesses which are self-limited in otherwise healthy individuals; they are similar to the bacterial forms described above.

- Enterovirus
- Hepatitis A is distinguished from other viral causes by its prolonged (2–6 week) incubation period and its ability to spread beyond the stomach and intestines into the liver. It often results in jaundice, or yellowing of the skin, but rarely leads to chronic liver dysfunction. The virus has been found to cause infection due to the consumption of fresh-cut produce which has fecal contamination.
- Hepatitis E
- Norovirus
- Rotavirus

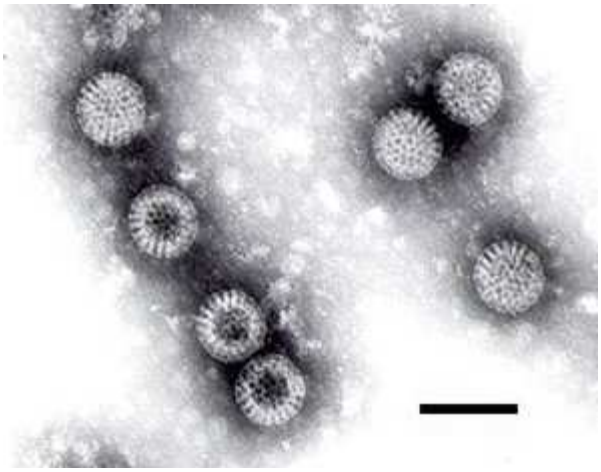

Fig 4.04: Rotavirus

Parasites

Most foodborne parasites are zoonoses.

- Platyhelminthes:
  - *Diphyllobothrium* sp.
  - *Nanophyetus* sp.
  - *Taenia saginata*
  - *Taenia solium*
  - *Fasciola hepatica*

  See also: Tapeworm and Flatworm

- Nematode:
  - *Anisakis* sp.
  - *Ascaris lumbricoides*
  - *Eustrongylides* sp.
  - *Trichinella spiralis*
  - *Trichuris trichiura*
- Protozoa:
  - *Acanthamoeba* and other free-living amoebae
  - *Cryptosporidium parvum*
  - *Cyclospora cayetanensis*
  - *Entamoeba histolytica*
  - *Giardia lamblia*

Fig 4.05: Giardia lamblia

  - *Sarcocystis hominis*
  - *Sarcocystis suihominis*

- *Toxoplasma gondii*

Natural toxins

Several foods can naturally contain toxins, many of which are not produced by bacteria. Plants in particular may be toxic; animals which are naturally poisonous to eat are rare. In evolutionary terms, animals can escape being eaten by fleeing; plants can use only passive defenses such as poisons and distasteful substances, for example capsaicin in chili peppers and pungent sulfur compounds in garlic and onions. Most animal poisons are not synthesised by the animal, but acquired by eating poisonous plants to which the animal is immune, or by bacterial action.

- Alkaloids
- Ciguatera poisoning
- Grayanotoxin (honey intoxication)
- Mushroom toxins
- Phytohaemagglutinin (red kidney bean poisoning; destroyed by boiling)
- Pyrrolizidine alkaloids
- Shellfish toxin, including paralytic shellfish poisoning, diarrhetic shellfish poisoning, neurotoxic shellfish poisoning, amnesic shellfish poisoning and ciguatera fish poisoning
- Scombrotoxin
- Tetrodotoxin (fugu fish poisoning)

Some plants contain substances which are toxic in large doses, but have therapeutic properties in appropriate dosages.

- Foxglove contains cardiac glycosides.
- Poisonous hemlock (conium) has medicinal uses.

Other pathogenic agents

- Prions, resulting in Creutzfeldt–Jakob disease (CJD) and its variant (vCJD)

"Ptomaine poisoning"

In 1883, the Italian, Professor Salmi, of Bologna, introduced the generic name *ptomaine* (from Greek *ptōma*, "fall, fallen body, corpse") for alkaloids found in decaying animal and vegetable matter, especially (as reflected in their names) putrescine and cadaverine. The 1892 *Merck's Bulletin* stated, "We name such products of bacterial origin ptomaines; and the special alkaloid produced by the comma bacillus is variously named Cadaverine, Putrescine, etc." While *The Lancet* stated, "The chemical ferments produced in the system, the...ptomaines which may exercise so disastrous an influence." It is now known that the "disastrous...influence" is due to the direct action of bacteria and only slightly to the alkaloids. Thus, the use of the phrase "ptomaine poisoning" is now obsolete.

Tainted potato salad sickening hundreds at a Communist political convention in Massillon, Ohio, and aboard a Washington DC cruise boat in separate incidents during a single week in 1932 drew national attention to the dangers of so-called "ptomaine poisoning" in the pages of the American news weekly, *Time.* Another newspaper article from 1944 told of more than 150 persons being hospitalized in Chicago with ptomaine poisoning apparently from rice pudding served by a chain of restaurants.

Mechanism of infection

Incubation period

The delay between consumption of a contaminated food and appearance of the first symptoms of illness is called the incubation period. This ranges from hours to days (and rarely months or even years, such as in the case of listeriosis or bovine spongiform encephalopathy), depending on the agent, and on how much was consumed. If symptoms occur within one to six hours after eating the food, it suggests that it is caused by a bacterial toxin or a chemical rather than live bacteria.

The long incubation period of many foodborne illnesses tends to cause sufferers to attribute their symptoms to gastroenteritis.

During the incubation period, microbes pass through the stomach into the intestine, attach to the cells lining the intestinal walls, and begin to multiply there. Some types of microbes stay in the intestine, some produce a toxin that is absorbed into the bloodstream, and some can directly invade the deeper body tissues. The symptoms produced depend on the type of microbe.

Infectious dose

The infectious dose is the amount of agent that must be consumed to give rise to symptoms of foodborne illness, and varies according to the agent and the consumer's age and overall health. Pathogens vary in minimum infectious dose; for example, *Shigella sonnei* has a low estimated minimum dose of < 500 colony-forming units (CFU) while *Staphylococcus aureus* has a relatively high estimate.

In the case of *Salmonella* a relatively large inoculum of 1 million to 1 billion organisms is necessary to produce symptoms in healthy human volunteers, as *Salmonellae* are very sensitive to acid. An unusually high stomach pH level (low acidity) greatly reduces the number of bacteria required to cause symptoms by a factor of between 10 and 100.

Epidemiology

Asymptomatic subclinical infection may help spread these diseases, particularly *Staphylococcus aureus*, *Campylobacter*, *Salmonella*, *Shigella*, *V. cholerae*, and *Yersini*. For example, as of 1984 it was estimated that in the United States, 200,000 people were asymptomatic carriers of *Salmonella*.

Infants

Globally, infants are a population that are especially vulnerable to foodborne disease. The World Health Organization has issued recommendations for the preparation, use and storage of prepared formulas. Breastfeeding remains the best preventative measure for protection of foodborne infections in infants.

United States

In the United States, using FoodNet data from 2000–2007, the CDCP estimated there were 47.8 million foodborne illnesses per year (16,000 cases for 100,000 inhabitants) with 9.4 million of these caused by 31 known identified pathogens.

- 127,839 were hospitalized (43 per 100,000 inhabitants per year).
- 3,037 people died (1.0 per 100,000 inhabitants per year).

Causes of foodborne illness in U. S.

	Cause	Annual cases	Rate (per 100,000 inhabitants)
1	*Norovirus*	5,461,731 cases	X
2	*Salmonella*	1,027,561 cases	X
3	*Clostridium perfringens*	965,958 cases	X
4	Campylobacter	845,024 cases	X

Causes of death by foodborne illness in U. S.

	Cause	Annual deaths	Rate (per 100,000 inhabitants)
1	*Salmonella*	378 cases	0.126
2	*Toxoplasma gondii*	327 cases	0.109
3	*Listeria*	255 cases	0.085
4	*Norovirus*	149 cases	0.050

France

This data pertains to reported medical cases of 23 specific pathogens, as opposed to total population estimates of all food-borne illness for the United States.

In France, for 750,000 cases (1210 per 100,000 inhabitants):

- 70,000 people consulted in the emergency department of an hospital (113 per 100,000 inhabitants.);
- 113,000 people were hospitalized (182 per 100,000 inhabitants);
- 460 people died (0.75 per 100,000 inhabitants).

Causes of foodborne illness in France

	Cause	Annual hospitalizations	Rate (per 100,000 inhabitants)
1	*Salmonella*	~8,000 cases	13
2	*Campylobacter*	~3,000 cases	4.8
3	Parasites incl. Toxoplasma	~500 cases ~400 cases	0.8 0.65
4	*Listeria*	~300 cases	0.5
5	Hepatitis A	~60 cases	0.1

Causes of death by foodborne illness in France

	Cause	Annual	Rate (per 100,000 inhabitants)
1	*Salmonella*	~300 cases	0.5
2	*Listeria*	~80 cases	0.13
3	Parasites	~37 cases	0.06 (95% due to toxoplasma)
4	*Campylobacter*	~15 cases	0.02

5	Hepatitis A	~2 cases	0.003

Australia

A study by the Australian National University, published in November 2014, found in 2010 that there were an estimated 4.1 million cases of foodborne gastroenteritis acquired in Australia on average each year, along with 5,140 cases of non-gastrointestinal illness. The study was funded by the Australian Department of Health, Food Standards Australia New Zealand and the NSW Food Authority.

The main causes were Norovirus, pathogenic Escherichia coli, Campylobacter spp. and non-typhoidal Salmonella spp., although the causes of approximately 80% of illnesses were unknown. Approximately 25% (90% CrI: 13%–42%) of the 15.9 million episodes of gastroenteritis that occur in Australia were estimated to be transmitted by contaminated food. This equates to an average of approximately one episode of foodborne gastroenteritis every five years per person. Data on the number of hospitalisations and deaths represent the occurrence of serious foodborne illness. Including gastroenteritis, non-gastroenteritis and sequelae, there were an estimated annual 31,920 (90% CrI: 29,500–35,500) hospitalisations due to foodborne illness and 86 (90% CrI: 70–105) deaths due to foodborne illness circa 2010. This study concludes that these rates are similar to recent estimates in the US and Canada.

A main aim of this study was to compare if foodborne illness incidence had increased over time. In this study, similar methods of assessment were applied to data from circa 2000, which showed that the rate of foodborne gastroenteritis had not changed significantly over time. Two key estimates were the total number of gastroenteritis episodes each year, and the proportion considered foodborne. In circa 2010, it was estimated that 25% of all episodes of gastroenteritis were foodborne. By applying this proportion of episodes due to food to the incidence of gastroenteritis circa 2000, there were an estimated 4.3 million (90% CrI: 2.2–7.3 million) episodes of foodborne gastroenteritis circa 2000, although credible intervals overlap with 2010. Taking into account changes in population size, applying these equivalent methods suggests a 17% decrease in the rate of foodborne gastroenteritis between 2000 and 2010, with considerable overlap of the 90% credible intervals.

This study replaces a previous estimate of 5.4 million cases of food-borne illness in Australia every year, causing:

- 18,000 hospitalizations
- 120 deaths (0.5 deaths per 100,000 inhabitants)
- 2.1 million lost days off work
- 1.2 million doctor consultations
- 300,000 prescriptions for antibiotics.

Most foodborne disease outbreaks in Australia have been linked to raw or minimally cooked eggs or poultry. The Australian Food Safety Information Council estimates that one third of cases of food poisoning occur in the home

Comparison between countries

Country	Annual deaths per 100,000 inhabitants	Annual hospitalization per 100,000 inhabitants
USA	1.0	43

France	0.75	182
Australia	0.5	82

Outbreaks

The vast majority of reported cases of foodborne illness occur as individual or sporadic cases. The origin of most sporadic cases is undetermined. In the United States, where people eat outside the home frequently, 58% of cases originate from commercial food facilities (2004 FoodNet data). An outbreak is defined as occurring when two or more people experience similar illness after consuming food from a common source.

Often, a combination of events contributes to an outbreak, for example, food might be left at room temperature for many hours, allowing bacteria to multiply which is compounded by inadequate cooking which results in a failure to kill the dangerously elevated bacterial levels.

Outbreaks are usually identified when those affected know each other. However, more and more, outbreaks are identified by public health staff from unexpected increases in laboratory results for certain strains of bacteria. Outbreak detection and investigation in the United States is primarily handled by local health jurisdictions and is inconsistent from district to district. It is estimated that 1–2% of outbreaks are detected.

Society and culture

United Kingdom

In postwar Aberdeen (1964) a large-scale (>400 cases) outbreak of typhoid occurred, caused by contaminated corned beef which had been imported from Argentina. The corned beef was placed in cans and because the cooling plant had failed, cold river water from the Plate estuary was used to cool the cans. One of the cans had a defect and the meat inside was contaminated. This meat was then sliced using a meat slicer in a shop in Aberdeen, and a lack of cleaning the machinery led to spreading the contamination to other meats cut in the slicer. These meats were then eaten by the people of Aberdeen who then became ill.

Serious outbreaks of foodborne illness since the 1970s prompted key changes in UK food safety law. These included the death of 19 patients in the Stanley Royd Hospital outbreak and the bovine spongiform encephalopathy (BSE, mad cow disease) outbreak identified in the 1980s. The death of 21 people in the 1996 Wishaw outbreak of *E. coli* O157 was a precursor to the establishment of the Food Standards Agency which, according to Tony Blair in the 1998 white paper *A Force for Change* Cm 3830, "would be powerful, open and dedicated to the interests of consumers".

In May 2015, for the second year running, England's Food Standards Agency devoted its annual Food Safety Week to – "The Chicken Challenge". The focus was on the handling of raw chicken in the home and in catering facilities in a drive to reduce the worryingly high levels of food poisoning from the *campylobacter* bacterium. Anne Hardy argues that widespread public education of food hygiene can be useful, particularly through media (T.V cookery programmes) and advertisement. She points to the examples set by Scandinavian societies.

United States

In 2001, the Center for Science in the Public Interest petitioned the United States Department of Agriculture to require meat packers to remove spinal cords before processing cattle carcasses for

human consumption, a measure designed to lessen the risk of infection by variant Creutzfeldt–Jakob disease. The petition was supported by the American Public Health Association, the Consumer Federation of America, the Government Accountability Project, the National Consumers League, and Safe Tables Our Priority. This was opposed by the National Cattlemen's Beef Association, the National Renderers Association, the National Meat Association, the Pork Producers Council, sheep raisers, milk producers, the Turkey Federation, and eight other organizations from the animal-derived food industry.

None of the US Department of Health and Human Services targets regarding incidence of foodborne infections were reached in 2007.

Organizations

The World Health Organization Department of Food Safety and Zoonoses (FOS) provides scientific advice for organizations and the public on issues concerning the safety of food. Its mission is to lower the burden of foodborne disease, thereby strengthening the health security and sustainable development of Member States. Foodborne and waterborne diarrhoeal diseases kill an estimated 2.2 million people annually, most of whom are children. WHO works closely with the Food and Agriculture Organization of the United Nations (FAO) to address food safety issues along the entire food production chain—from production to consumption—using new methods of risk analysis. These methods provide efficient, science-based tools to improve food safety, thereby benefiting both public health and economic development.

International Food Safety Authorities Network (INFOSAN)

The International Food Safety Authorities Network (INFOSAN) is a joint program of the WHO and FAO. INFOSAN has been connecting national authorities from around the globe since 2004, with the goal of preventing the international spread of contaminated food and foodborne disease and strengthening food safety systems globally. This is done by:

- Promoting the rapid exchange of information during food safety events;
- Sharing information on important food safety issues of global interest;
- Promoting partnership and collaboration between countries; and
- Helping countries strengthen their capacity to manage food safety risks.

Membership to INFOSAN is voluntary, but is restricted to representatives from national and regional government authorities and requires an official letter of designation. INFOSAN seeks to reflect the multidisciplinary nature of food safety and promote intersectoral collaboration by requesting the designation of Focal Points in each of the respective national authorities with a stake in food safety, and a single Emergency Contact Point in the national authority with the responsibility for coordinating national food safety emergencies; countries choosing to be members of INFOSAN are committed to sharing information between their respective food safety authorities and other INFOSAN members. The operational definition of a food safety authority includes those authorities involved in: food policy; risk assessment; food control and management; food inspection services; foodborne disease surveillance and response; laboratory services for monitoring and surveillance of foods and foodborne diseases; and food safety information, education and communication across the farm-to-table continuum.

Regulatory steps

Food may be contaminated during all stages of food production and retailing. In order to prevent viral contamination, regulatory authorities in Europe have enacted several measures:

- European Commission Regulation (EC) No 2073/2005 of November 15, 2005
- European Committee for Standardization (CEN): Standard method for the detection of norovirus and hepatitis A virus in food products (shellfish, fruits and vegetables, surfaces and bottled water)
- CODEX Committee on Food Hygiene (CCFH): Guideline for the application of general principles of food hygiene for the control of viruses in food

CHECK YOUR PROGRESS

Explain the concept of food borne illnesses.
Discuss the causes of food borne diseases.
Discuss the various bacteria which spread food-borne illnesses.
Elaborate the role of Enterotoxins in food borne illnesses.
Explain the methods to prevent bacterial food borne illnesses.
Elaborate the role of Mycotoxins in food borne illnesses.
Elaborate the role of virus in food borne illnesses.
Elaborate the role of parasites in food borne illnesses.
Elaborate the role of natural toxins in food borne illnesses.
Explain the mechanism of infection.
Elaborate the concept of incubation period.
Discuss the concept of infectious dose.
Compare the spread of food borne illness in USA and France.
Discuss the prevalence of food borne illness in Australia.

4.04 CONTAMINANTS ENTERING FOOD DURING PROCESSING & PACKAGING.

The contaminants can enter the food through the processing of certain food products. These could enter during the stages of processing like high temperatures, fermentation etc. Processing contaminants are formed by chemical reactions between natural or added food constituents during the processing stage. Examples are nitrosamines, polycyclic aromatic hydrocarbons &trans-fat. Thus due to certain regulatory process these contaminants can be eradicated. Sometimes the packaging material can also contribute in the contamination. The chemical Bisphenol-A (BPA) used in plastic food containers may contribute to the development of breast cancer.

Contaminants thus can also occur during the wrong storing practices. Always store the non-vegetarian products away from the vegetarian dishes. Do not store the non veg on the vegetarian dishes as the drippings could cause cross contamination. The chopping boards and the dusters should be used carefully and cleaned thoroughly.

When a particular food whether it is in a raw state or cooked one is spoilt, we say that it is contaminated. Food should be protected from contamination through all the stages it undergoes before it reaches the table. Sanitation affects every phase of food handling and quality control should be maintained throughout.

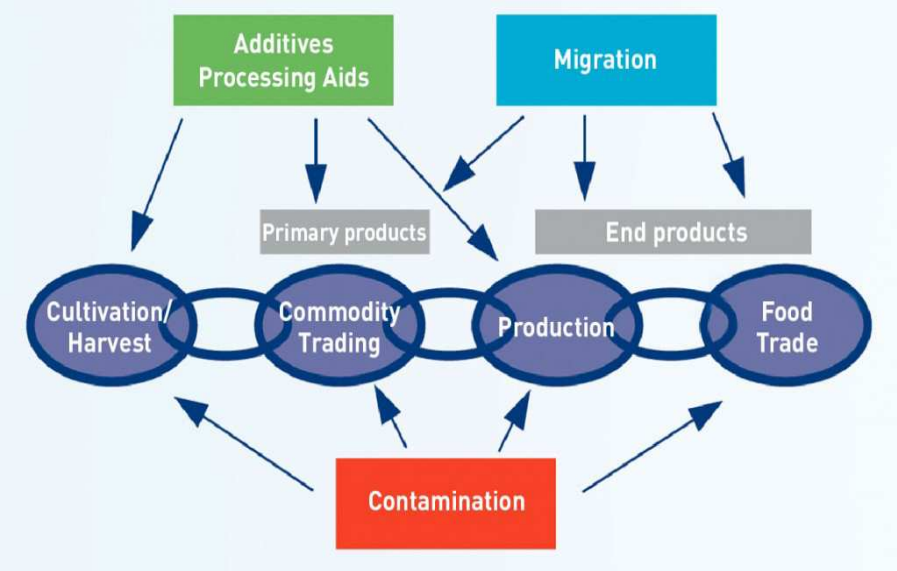

Fig 4.06: Channeling of Contamination.

Spoilage of foods begins as soon as:

1. Vegetables and fruits are harvested or picked.
2. Eggs are laid
3. Fish is caught
4. An animal is slaughtered
5. Milk is drawn from the milch animal

And it continues till the food is consumed.

To prevent food from getting spoiled it is important to know how and why food gets spoiled, which are the foods that are likely to spoil rapidly; what are the factors that bring about quicker spoilage and how food can be prevented from getting spoiled. To prevent food from spoilage it is essential that we prevent microorganisms from entering into food and prevent those that have already entered into it from multiplying. Food spoilage can be defined as decomposition and damage caused to food by various agents, making it undesirable for consumption.

What is Contamination exactly? There are various organisms found in the eco-system, which are harmful as well as useful. When we talk about contamination then the harmful micro-organisms come into existence. The term contamination is used for those foods which are not fit to be consumed for health reasons. Although they may look, smell and taste good, they may contain harmful chemicals, non-food matter and bacteria. The term spoilt is used for those foods which look harmful and unfit to eat. Spoilt food has an unattractive color, smell, taste and appearance. In both these cases, food is unfit for consumption because of the presence of undesirable changes which have taken place and the food is then labeled as spoilt.

There are basically 4 types of micro-organisms usually which are associated with food.

They are:

1. Bacteria,
2. Yeasts,
3. Molds
4. Viruses.

These micro-organisms come in contact with the food directly or with the help of the food handler. They are other ways also due to which the food can get spoilt or what we call it as contaminated.

In this unit we are going to focus on how the food can get contaminated.

Food like milk, chicken, meat, eggs, and fish gets spoilt immediately hence they are called as perishable food; hence these have to be handled very carefully as well as have to be stored hygienically. The other semi-perishable or non perishable products are handled in a different way as they have a higher shelf life.

1.4.1 Sources of Contamination

The main sources of contamination found in the food preparation areas could be due to following reasons:

i) Due to Raw meat & poultry.

ii) Animals, birds, rodents & insects

iii) Dust & refuse

iv) Food handlers.

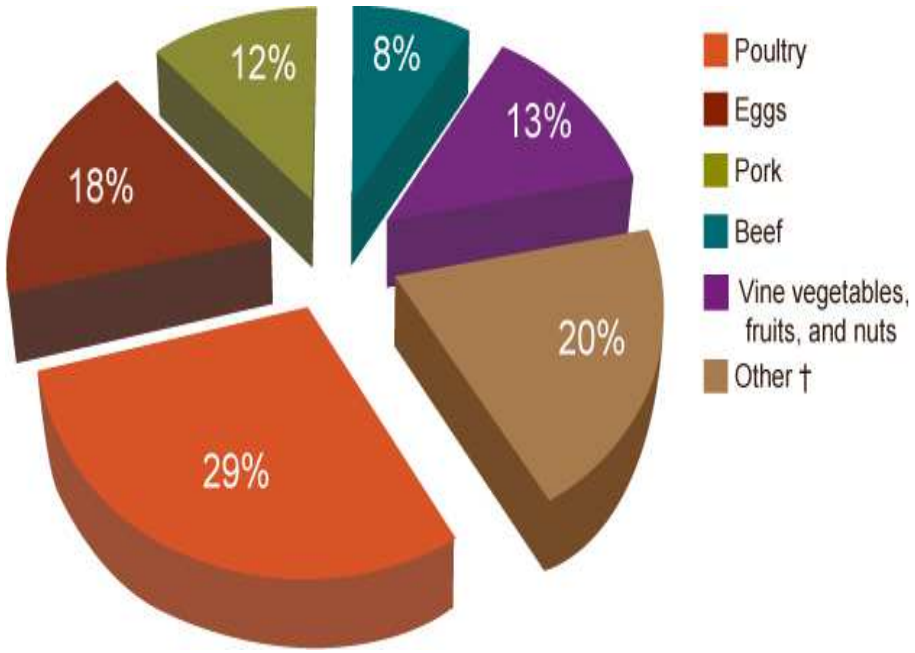

Fig 4.07: Main Sources of Contamination

i) The intestines & internal organs of Chicken & Meat contain the bacteria, called as Salmonella, hence the chicken & meat has to be cleaned properly before use. The storage of non veg material should also be in such a position that it should not drip the liquid at the lower shelf so that the other products could get contaminated.

There should be separate chopping boards for such purpose & it should not be mixed with the vegetables.

One should always wash hands after handling fish, chicken, meat & other non-vegetarian products.

ii. Due to Animals, Birds, insects & rodents.

Rodents, cockroaches, insects carry food poisoning bacteria. The birds also carry micro-organisms in their feathers. Hence these should not be allowed in the kitchen. Various arrangements should be made that these animals or birds should not be able to enter the kitchen.

The windows, doors or any open area should be covered with wire mesh. Electronic fly killers can also be installed.

ii) Due to Dust & Refuse.

Contamination also occurs due to the soil, dust & refuse. The bacteria like clostridium perfringens gets transferred through dust &soil. Hence care should be taken that all the vegetables should be cleaned before use. The dust bins or refuse bins should be covered properly; the garbage disposal should be done effectively. Kitchen should be regularly cleaned & disinfected.

iii) Due to Food Handlers.

Bacteria like staphylococcus aureus are found on hands, under the nails & on the body of a human being. This gets worse if the food handler is not following the hygienic practices. The food can get

contaminated even when the food handler is ill. Hence coughing, sneezing is not allowed while handling the food.

- Other Causes of Food Contaminations could also be seen if the utensils used for cooking are not washed thoroughly & if they contain contaminants like cleaning agents, this could also prove hazardous.

Some pesticides or fertilizers may also contaminate food such as cereals, vegetables, fruits. These pesticides could enter through water, air or soil. Hence one should wash all the raw materials before use.

Always clean water should be used for cooking. Sewage water also contaminates the crops hence this could affect indirectly without the notice of the food handler.

Contaminants can also take place if the packaging is improper. Some cans get rusted & hence such toxic metals can interfere in the food causing food poisoning.

CHECK YOUR PROGRESS

1. List down the various sources of Contamination.
2. Explain the precautionary measures to be taken against contaminations.

4.05 FOOD INFECTIONS & POISONING

There are various infections occurring due to the food. The pathogens present in the food may be bacteria, viruses, protozoan& nematodes which eventually create a food borne disease. These outbreaks have had a major impact in terms of loss of human lives and economic costs. There are various reasons how these microorganisms enter the food causing food infections.

Food Infection

Food infection is an illness caused by the microorganisms. At this stage the food ingested contains the living bacteria and are capable of producing the disease. The body thus reacts to these microorganisms causing the symptoms of illness. The gastric juices present in the stomach destroys certain bacteria at a certain level but when these bacteria enter the small intestine, the pH is neutral & thus these bacteria develop rapidly thus irritating the lining of the intestines, causing symptoms of nausea, diarrhea and abdominal pains. The incubation period for the infection to occur is around 12 hours as this is a slower process than the food poisoning case.

Food Poisoning

The food infection occurs when a person consumes food that is infected by pathogenic microorganisms. These microorganisms produce poisonous substances called as “toxins” which causes ill effect to the human body. The illness caused due to the consumption of these toxins in known as ‘food intoxication’. The toxin may be a poisonous chemical which is accidentally or intentionally added, a naturally occurring poison from the vegetables such as the green potatoes or a toxic metabolite excreted by bacteria. The toxin is already present in the spoilt food which irritates the lining of the stomach and causes vomiting. If the toxin reaches the intestine, it may cause abdominal pain and diarrhea. The incubation period for food poisonings is comparatively shorter than the food infection. This incubation period could be around 6 hours. Clostridium perfringens has the capacity to cause this ill effect.

The Causes/ Sources of Food Borne Illness

Harmful bacteria develop due to various reasons. The raw food is the most common example of source of food as they contain many bacteria which can cause the food infection. The most significant examples seen are from the raw chicken, fish, poultry and meat. These non-vegetarian food products carry these microorganisms & hence when they are cut or slaughtered, they disperse these microorganisms to another object, equipment. hence these harmful bacteria should be controlled by various correct methods of cooking, handling and storing practices.

The natural surfaces of plants and vegetable may contain various microorganisms such as, flavor bacterium, micrococcus, coli form, lactic acid bacteria etc. Some microorganisms can even be found in the inside of the core of the vegetable such as the cabbage or even inside of the undamaged fruits. Organisms also have been found in healthy root and tuber vegetables.

Sources of microorganisms from animals include the surface flora, the flora of the respiratory tract and the flora of the gastrointestinal tract. However, hides, hooves and hair contain many microorganisms due to the soil, manure, feed and water. Hence animals carry lot of spoilage microorganisms. The birds also carry microorganisms in their feathers and feet. The skin of many meat animals may contain micrococci, staphylococci and beta-hemolytic streptococci. Pig or beef carcasses may be contaminated with salmonellae. Staphylococci may get transferred from the skin and the intestines to the final product of the food if proper care is not taken which can be dangerous for human health & hence these carved or cut pieces of raw non vegetarian products should be washed thoroughly and cooked with the correct method of cooking later on it should be stored at proper temperature.

Some crops are contaminated due to the sewage which flows through them. The pathogens, coliform bacteria, anaerobes, enterococci other intestinal bacteria and virus can contaminate the foods from this source.

Natural water contains microorganisms from soil, possibly from animals or sewage. There are microbial contents found in surface waters as well as lakes and ponds. Ground water considerably pass through layers of rocks and soil hence most of the bacteria and other suspended material are removed. Hence the number of bacteria are less as compared to the above water. The kinds of bacteria found in natural waters are chiefly species of Pseudomonas, Chormobacterium, Proteus, Bacillus, Enterobacter, Streptococcus etc. From the economic point of view, a water with agreeable chemical and bacteriogical properties is desired for use in connection with the food being handled or

processed. The water thus should bear acceptable, taste, odor, clarity, purity and chemical composition etc.

Sometimes the air is used for aeration of certain food products like making of cakes or other bakery products. In such case the air used may be polluted and thus can activate the viruses accordingly. Spoilage microorganisms may also enter through air and thus can get mixed up during the fermentation process. Hence utmost care has to be taken. The food handlers especially should not blow their mouth on the food or should not sneeze or cough on the food. They should thus not report to work during illness. Mold spores, cocci, asporogenous yeasts etc. are some microorganisms which are found in air.

Food can get spoilt and thus can cause food borne illness due to the food handlers if they are not following the proper hygienic practices or if they are not using clean equipment or if they are not following the proper storage practices. Thus the role of a food handler is very important to avoid such contaminations of food.

Common Sources, Symptoms and Bacteria responsible for the illness.

Sources of Illness:	Symptoms-	Bacteria:
Raw and undercooked meat and poultry.	Abdominal pain, diarrhea, nausea and vomiting.	Campylobacter Jejuni, E. coli, Monocytogenes, Salmonella
Raw foods, unpasteurized milk and dairy products	Nausea, vomiting, fever, abdominal cramps and diarrhea.	L.monocytogens, Salmonella, Shigella, Staphylococcus aureus, C.jejuni
Raw and undercooked eggs, Raw eggs are often used in foods such as homemade hollandaise sauce, Caesar & other salad dressings, tiramisu, homemade ice cream, homemade mayonnaise, cookie dough and frostings.	Nausea, vomiting, fever, abdominal cramps and diarrhea.	Salmonelaenteritides
Raw and undercooked shellfish	Chills fever and collapse	Vibrio vulnificus, Vibrio parahaemolyticus
Improperly canned goods, smoked or salted fish	Double vision, inability to swallow, difficulty in speaking and inability to breathe.	C.botulinum.

Symptoms of Food Borne Illness

The symptoms can range from mild to a serious stage. Some of the common symptoms associated with the consumption of spoiled food is stated below:

- Abdominal cramps
- Nausea
- Vomiting
- Diarrhoea
- Fever
- Dehydration
- Difficulty in swallowing/ sore throat.
- Weak or rapid pulse or shallow breathing

The doctor can easily diagnose the disease from the symptoms by physical checking or through the laboratory tests. Most cases the food borne illness is mild and can be treated by increasing the fluid intake, either orally or intravenously to balance the fluid content of the body & the energy level. The medical advice has to be taken if the case seems serious like if one develops gastrointestinal disorder or neurological symptoms. Maintaining adequate fluid, electrolyte balance and controlling blood pressure are important.

Prevention: Most cases of food borne illness can be prevented by adopting the proper cooking or processing of food which kills bacteria. Bacteria multiply rapidly between 8 to 63 °C and hence the food has to be stored below 8 °C.

Some tips should be followed to prevent harmful bacteria from growing in food:

- Refrigerate the food below 8° C or as desired at the freezing temperature.
- Cook the food to the appropriate internal temperature- 140°F for roasts, steaks and chops of beef; 160 °F for pork, ground beef; 180° F for whole poultry. Always use a meat thermometer to check the temperature. The bacteria get destroyed above
- 100 °C.
- Prevent cross-contamination: This can be controlled by using separate chopping boards for veg and non veg products. Knife used for one purpose should not be again used for another purpose; it should be washed and wiped properly. Clean dusters should be used to avoid cross contamination.
- By handling the food properly: Hands should be washed properly before handling the raw material & also after using the bathroom, dustbin, or after touching animals.
- Utensils should be washed before use.
- Marinated food should be refrigerated immediately and should not be left at room temperature.
- Cooked food should be reheated at around 165 degrees F.

Role of Food Irradiation

Food irradiation is the treatment of food with high energy such as gamma rays, electron beams or x-rays as a means of cold pasteurization, which destroys living bacteria to control food-borne illness. Radiation of various frequencies ranging from low frequency microwaves to high frequency gamma rays are being used to preserve various foods. Radiations can be classified into two categories: low frequency and high frequency radiation.

The Government relies exclusively on the use of such rays, which are similar to the ultraviolet light and microwaves and pass through food leaving no microorganisms or residues. Ultraviolet rays are effective in killing bacteria and viruses. They are used to control mold growth on the surface of bakery products and to prevent spoilage of meat while it is tenderized and aged. Although irradiation

kills many bacteria but cannot sterilize the food to the fullest. Food irradiation is approved for cereals, potatoes, spices, seasonings, fish, pork, and poultry. Red meats, whole fresh fruits and dry or dehydrated products.

Microwaves are short radio waves that heat food by penetrating it. These waves penetrate food to a depth of 1.5 inches. Cooking is faster in a microwave oven. Here there is no loss of heat and the flavor is also retained in this method of cooking.

Food is exposed to ionizing radiation or cold sterilization to extend its shelf life. These rays kill the pathogens and spoilage causing microorganisms.

The advantages of irradiation are:

- It can be used for heat sensitive food and frozen food, nutritive value of food is preserved as compared to other methods of preservation, food can also be sterilized after it is packed.
- Irradiated food should be refrigerated and handled properly to safeguard against any surviving organisms.

4.06 MYCOTOXINS

The name mycotoxins combines the Greek word ‘mykes’’ which means the fungus and the Latin word ‘toxicum’ meaning poison. The term ‘mycotoxins’ is used for the toxic chemical products formed by a few fungal species that readily colonise crops in the field or after harvest and thus pose a potential threat to human and animal health when consumed. Each mycotoxinsis produced by one or more very specific fungal species. In some cases, one species can form more than one mycotoxins. Any crop that is stored for more than a few days is a target for mold growth and mycotoxinsformation. Major food commodities affected are cereals, nuts, dried fruit, coffee, cocoa, spices, oil seeds, dried peas and beans and fruit particularly apples. Mycotoxins may also be found in beer and wine resulting from the use of contaminated barley, other cereals, grapes etc.

Mycotoxins cause a diverse range of toxic effects as their chemical structures differ from each other. Most of the mycotoxins are carcinogenic & may damage the kidneys, liver or the immune system.

Ergot

Ergot is a mycotoxins produced by Clavicepspurpurea, a parasitic fungus that attacks wheat, barley and rye grains and causes the disease ergotism, when bread made from such infected cereal is consumed, symptoms like convulsions and gangrene is found.

Cereals and Groundnuts

The cereals and groundnuts if not stored properly then a mold Aspergillus flavus and A.parasiticus grows on it. The mold produces a mycotoxin called as ‘aflatoxin’. This toxin damages the liver. Other important mycotoxins are ‘patulin’ produced by **Penicillium species.**

Poisonous Mushrooms

Mushrooms are edible fungi but some varieties are poisonous, like Amanitaphalloides, A. muscaria. They produce hepatotoxic factors that damage the liver and may result in death. The toxin muscarin is produced by A.muscaria that stimulates the nerves. Symptoms are nausea, headache, dizziness, confusion, excessive salivation and tears.

There are many other mycotoxins which occurs in maize such as 'fumonisims' which can cause esophageal cancer. Deoxynivalenol also known as DON or vomitoxin, is one of about 150 related compounds known as the trichothecenes that are formed by a number of species of Fusarium and some other fungi. It is nearly always formed before harvest when crops are invaded by certain species of Fusarium. Studies suggest that deoxynivalenol may have effects on the immune system. The main commodities affected are cereals and deoxynivalenol is a frequent contaminant of grains such as wheat, barley, oats, rye, maize, sorghum and rice.

Water and Food-Associated Viruses

Several viruses like hepatitis A. Norwalk and Norwalk like viruses, poliovirus and Echovirus may cause food-borne diseases in consumers of virus contaminated water and foods. Some viruses that are associated with food are astrovirus, calcivirus, enteric adenovirus, parvovirus, and rotavirus. These enteric viruses enter through the oral route and enter the intestines. However, the most common types of food borne viral diseases are hepatitis A (infectious hepatitis) and acute viral gastroenteritis. These hepatitis viruses are presumed to develop in the gastrointestinal tract and then spread primarily to liver, where it infects hepatocytes and Kupffer cells. Food borne viral gastroenteritis, is usually a mild disease with various degrees of nausea, diarrhea, malaise, abdominal pain, muscle pain, anorexia, headache and low-grade fever. Illness develops 20-50 hours after the consumption of contaminated food and lasts for 1 to 8 days.

Ice, water, ice cream, milk, pastries, sandwiches, shellfish, salads and other raw foods consumed raw or subjected to additional handling after cooking are major food vehicles for virus transmission. However, it may be remembered that viruses cannot replicate in contaminated foods but are transmitted as small, latent particles.

Methods Of Analysis Of Bacteria, Viruses And Fungi

Bacillus cereus

Samples can be directly plated on the selective Mannitol yeast extract polymyxin agar, without the need of any pre-enrichment. The plates are examined after 24 hours of incubation at 35 degrees centigrade for blue colored colonies. The biochemical identification is usually done by Lecithovitellin reaction and for toxigenicity, the loop technique is generally performed.

Clostridium Botulinum and C.Perfringens

Samples are spread-plated on selective clostridia agar. Cooked meat medium along with neomycin sulfate can be used for enrichment. The plates are incubated for 48 hours at 30-35 degrees centigrade in an anaerobic atmosphere such as that produced by the BBL Gaspak system or a Case jar, evacuated and refilled with nitrogen. Pour plates can also be prepared by pouring Anderson agar with

thioglycolate agar. Such plates are incubated for 5-6 days at 32 degrees centigrade. The interpretation given to positive growth in any anaerobic culture should be made carefully, since the growth observed may be due totally or in part to facultative anaerobes (usually aerobic spore-formers) rather than clostridia.

Enteropathogenic Escherichia coli

Samples are enriched in brain heart infusion broth and incubated at room temperature for 10 minutes to resuscitate damaged cells. Further enrichment is done in tryptone phosphate broth by incubating for 18-20 hours at 44°C. Isolation is done by direct streaking on Eosine methylene blue agar. After 18-20 hours of incubation at 35°C, examine EMB Plates for typical lactose fermenting biotypes as dark centred colonies and red colonies on MacConkey plates. Some of the important bio typing tests are hydrogen sulphide, arabinose fermentation, urease test, ONPG test and cytochrome oxidase for the final determination of enteropathogenicity.

Salmonella

Salmonella is diagonised based on a medical history and a physical exam. The doctor will ask questions about the symptoms, food consumed, work and home environment. A stool culture and blood tests may be done to confirm the diagnosis.

You can get salmonellosis by eating food contaminated with salmonella.

Beef, poultry, milk, and eggs are most often infected with salmonella. But vegetables may also be contaminated. Contaminated foods usually look and smell normal.

Samples are non-selectively enriched in 1 % peptone water by incubating for 18-24 hours at 35°C. Selective enrichments is done in selenite cysteine broth and tetrathionate broth for 24 hours at 35°C. Isolation is done on any of the selective agars like brilliant green agar, bismuth sulfite agar. Examine BGA for pink colonies, BSA for brown, black or gray colonies, HE for blue-green to blue colonies. Biotyping is generally done by examining triple sugar iron agar reactions, urease test and motility etc.

Listeria monocytogenes

Samples are enriched in Listeria enrichment broth and incubated for 2 days at 30°C, streaking on Oxford agar medium and lithium choride-phenylethanol-moxalactam agar and incubation plates for 24-48 hours at 35°C & 30°C respectively, does the isolation. Examine OXA plates for black colonies surrounded by black zone and use oblique-transmitted light for examining LPM plates for sparkling blue colonies. Some of the important biotyping tests are nitrate reduction, CAMP test.

Staphylococcus aureus

The method of choice is Baird-Parker plate count method. This method provides for isolation and enumeration of injured organisms without the use of non-selective enrichment step. Examine BPA plates for black colonies with a light colored margin and an outer clear zone (halo) after 48 hours at 35°C. Coagulase and Dnase tests are essentially done to confirm the pathogenicity. Some of the other biochemical identification tests are anaerobic utilization of glucose and mannitol, lysostaphin sensitivity and enterotoxin production.

4.07 FOOD SPOILAGE

Spoilage of food is a natural phenomenon. Food is considered as spoiled food when it is observed that there is some change in the colour, texture, odour and flavor & it becomes an unacceptable product.

There are many factors which are involved in causing the food spoilage. It could be because of wrong storage practices, mishandling the food, wrong method of cooking, due to undesirable packaging material, types of additives used.

When the food is spoiled, its shelf life gets decreased, its nutritional value also gets lowered it is becomes very dangerous to consume such products. Hence it is very important to be very careful while observing the spoilage.

Food spoilage is of two types:

Microbial food spoilage

Non-microbial food spoilage

The microbial food spoilage is caused by microorganisms and their products while non-microbial spoilage can be caused by foreign material in the foodstuff or by enzymes that occur in the foodstuff naturally.

Signs of Food Spoilage

The signs of food spoilage are as under:

Off Odors- Off odors are produced on putrefaction of food by bacteria. Putrefaction is the breakdown of proteins of food by bacteria. Taints may also appear as a result of flavor changes that makes the food unacceptable.

Sliminess- These slimy layers are developed due to the bacterial or fungal growth on the surface. This is the excreta developed by the bacteria.

Discoloration- This discoloration of food usually occurs because of the growth of the molds. For example, black pin mold on bread, blue and green molds on citrus fruits and cheese.

Souring- Souring of food is observed on the production of lactic acid by bacteria. The most common example seen is the souring of milk.

Microbial Food Spoilage

Microorganisms require special food products of their own choice, especially the perishable products. They require moisture, desired temperature to grow and time. When they get such favorable condition they start multiplying rapidly. As we have seen earlier that food products gets spoilt due to the microorganisms growing on the surface of the product, the wrong method of handling & storing. When the number of bacteria increases to 1 million in the food product & if it is consumed then it tends to the food poisoning. Thus the microorganisms which can affect the food are bacteria, molds &yeasts. The viruses also get transferred to the food through the food handlers to cause the toxicity.

Some common examples seen in the spoilage of food by the following microorganisms:

Food which are spoilt by Bacteria:

- Soft rot of tomato cause by Erwinia.
- Putrefaction of fresh meat by Pseudomonas, Proteus and Clostridium.
- Souring of cured meat by Pseudomonas and Micrococcus.
- Putrefaction of fish by Chomobacterium.
- Spoilage of poultry by Pseudomonas, Alcaligens.
- Ropiness of sugar syrup by Aerobacter.

Food spoiled by Molds:

Molds are filamentous structure and form a tough filamentous mass in the food known as 'mold growth'. Spores are produced by the molds are disseminated in the air. These spores again germinate on any substrate (food), whenever any favorable conditions are provided to them. They prefer high acid foods like fruits, jams, jellies and pickles.

Some of the examples of the foods spoiled by molds are as follows;

- Moldy bread by Rhizopus
- Ropy bread by Penicillium
- Black mold rot of fresh fruits and vegetable by Aspergillus and Alternaria.
- Fungal rot of eggs is caused by Penicillium and Mucor.
- Watery soft rot in apple caused by Sclerotinium.
- Storage rots in strawberry caused by Botrytis.

Food spoiled by Yeasts

Yeast causes fermentation of the food products. There are two types of yeasts: True yeast and False yeast. The true yeast causes the fermentation giving alcohol and carbon dioxide, while the false yeast causes a film over the surface of the food and forms a film of high acidity. Chocolates and Confectionery contain high sugar content and are spoiled by the yeast 'zygosaccharomycesrouxii'. Most of the canned juices, bottled drinks also get spoilt due to the development of the yeast giving it a 'fizziness.

Non-Microbial Food Spoilage.

Apart from the spoilage caused by microorganism, food may also get spoiled by the chemical changes occurring in the food itself. Food can also get spoilt due to the reaction between the food and the packaging material. There is a higher content of fact in certain meat products like sausage and bacon. This fact eventually becomes rancid and starts giving off flavors. Thus it is observed that fats and oils breaks down giving out the free fatty acids of low molecular weight along with certain odoriferous substances. Foods are often spoiled by the enzymes present in the food itself. This is known as enzymatic spoilage of food. The action of the enzymes can be observed in ripening of fruits like

bananas where the color of banana changes from green to yellow on ripening and maturing. The enzymes are sensitive to the heat treatment; hence proper heat treatment or application is required for its preservation. Methods like blanching or freezing helps to inactivate or kill the enzymes and prevents the maturing and ripening of fruits and vegetables thus increasing its shelf life.

Food products can even get spoiled by the inclusion of certain foreign objects into the food thus causing contamination. Such contaminants could be nuts, bolts, pins, insect fragments, flies, hair etc.

Some Common Examples of spoilages found in foods:

Spoilage of Milk & Milk products

A bacterium contains enzymes similar to the casein coagulating enzyme, rennin found in the rennet extracted from the stomach of the calf. This is used in the manufacturing process of cheese. Foreign particles may drop into the milk during milking such as manure, soil, hair etc these could also tend towards the contamination. Sometimes the utensils used are also not clean which also causes adverse effects of contamination.

Spoilage of cereal and cereal products

The exterior of the harvested grains retains some microorganisms from soil, insects, water and other sources. Such harvested grains may contain thousands and millions of bacteria like Pseudomonas, Lactobacillus, Micrococcus, Bacillus etc. In wheat flour, spores of bacteria especially Bacillus and Coliform are found. Corn meal contains species of Fusarium and Penicilium.

Flours

Dry Cleaning and washing grains, sifting and milling reduces the number of microorganisms to some extent. Whole grain wheat flour is usually bleached with oxidizing agents such as nitrogen, fluorine, benzoyl peroxide, which serves to reduce the microbial count. Acid forming bacteria produce fermentation giving out the lactic acid, alcohol and gases which gives it a characteristic odor of acetic acid and esters.

Bread

Acid fermentation is observed when the bread is kept for a longer duration. Due to the presence of proteolytic bacteria, the proteins present in the dough i.e. the gluten, is destroyed which leads to the formation of sticky dough. The molds involved are Rhizopus stolonifera, Penicillium. Ropiness of bread is found mainly in homemade breads which is caused by Bacillus subtilis. The spores of these species can withstand high temperature (baking temperature) which is up to 100°C. This ropiness is caused due to the hydrolysis of the gluten by the action of proteinase, capsulation of bacillus & due to the hydrolysis of starch by the action of carbohydrate splitting enzymes.

Meat Spoilage

Meat spoilage is seen in two ways: one in aerobic condition and the other in the anaerobic one. In aerobic conditions the surface of the meat becomes slimy, change in color of the meat is observed, oxidation of fat takes place resulting in off flavor. Whereas, in anaerobic conditions, molds are seen in the form of stickiness, formation of black spores, white & green spots.

Spoilage of Poultry

Freshly dressed eviscerated poultry carry a bacterial flora on their surface that is on their skin. These bacteria could range from 100 to 1000 bacteria per sq.cm. of the skin surface. Pseudomonades constitute the major contaminants on the skin of the freshly dressed poultry.

Spoilage of Eggs

The microbial content of egg is determined by the sanitary conditions under which it is held, as well as the conditions of storage. i.e. the temperature and humidity. Microorganisms particularly bacteria and molds, may enter the egg through cracks in the shells or penetrate the shells when the 'bloom' covering the shell deteriorates. 'Bloom' is the thin protein coat that covers the shell. Salmonella is the main spoilage organism. A defected egg may show presence of cracks, loss of gloss, dirty or stains on the exterior part of the egg. It is also observed that certain translucentspot in egg yolk is found in stale or spoiled egg. The bacterial spoilage in eggs is known as 'rots' which may be green rots, black rots, pint and red rots. A fishy flavor is also observed due to the E.coli bacteria. In general, more spoilageare seen in eggs due to the bacteria rather than molds.

Spoilage of Fruits and Vegetables

Fruits and vegetables are normally susceptible to infection by bacteria, fungi and viruses. These microorganisms destroy the tissues of these vegetables and fruits thus causing the spoilages. A post harvesting handling of these fruits also allow the contamination to occur. Mechanical handling is likely to produce breaks in the tissue which facilitates invasion by microorganisms. The pH of fruits is relatively acidic, ranging from 2.3 for lemons to 5.0 for bananas. This restricts bacterial growth but does not retard fungal growth, the pH range for vegetables is slightly higher, pH 5.0 to 7.0 and hence they are more susceptible than fruits to attack by bacteria.

Spoilage in Fish

We find much retardation in the quality of fish. Fish looks slimy, the flesh from the bones oozes out, they form a depression when touched, they give off odors, their eyes are not bright etc which are the symptoms of the spoilt fish. The bacteria responsible for the spoilage of the fish are Alcaligenes, Vibrio, Serratia, Micrococcus. The type of processing, handling & storing largely depends on the spoilage of fish.

Spoilage of Canned products.

The spoilage of canned foods totally depends on the chemical changes found inside of the container. This happens due to the action of the microorganisms inside the container, or the contaminated container itself which produces hydrogen. The improper method of application of heat during the packing of the food during the sterilization of the cans may also tend to spoil the food inside the can. Sometimes the cans seem 'bulging' due to the toxic gas produced in the can. The contents of the cans may undergo putrefaction when they are attacked by the thermophilic bacteria. However, acid production, gas formation and blackening are also observed in some cases. The canned foods if not handled or treated properly then there is a possibility to lead a food borne illness called as "Botulism".

CHECK YOUR PROGRESS

Which are the microorganisms that cause spoilage of the Meat?

Which are the microorganisms that cause spoilage of the Fish

Which are the microorganisms that cause spoilage of the Poultry

What are the non-microbiological causes of spoilage?

4.08 FOOD PRESERVATION

Food preservation can be defined as the branch of science which deals with the storing or preservation of the food in suitable conditions to increase its shelf life.

The preservation of the food is to safeguard the food by the microorganisms. Thus we can keep the activities of the microorganisms under control by applying a suitable method of preservation. Thus we can prevent the food from spoiling.

Basic Principles of Food Preservation

Prevention of contaminants which inhibit microbial growth.

- By keeping the microorganisms away from the food (Asepsis).
- By hindering the growth of microorganisms by suitable applications of preservation.
- By killing the microorganisms
- By destruction or inactivation of food enzymes eg. Blanching or boiling.
- By prevention or delay of chemical reactions, example-prevention of oxidation by means of antioxidants.

Prevention of damage by insects, animals, mechanical causes etc by storing the food properly.

Methods of Food Preservation

Preservation can be divided into short and long period preservation:

Short Period Preservation:

This method is applied to the food which is kept away from the microorganisms for a shorter duration. In this type of preservation, the microorganisms are not killed but their growth is retarded or they are made inactive temporarily.

Following methods can be applied for this method:

Asepsis

Washing the raw material carefully keeps the microorganisms away to certain extent. Applying the proper handling procedure also helps to keep the microorganisms away. Packing the food in sanitary packages also is also a good method of keeping food safe.

Low Temperature

In this method the food is stored under low temperature, here the microorganisms remain inactive or in a dormant state. This method keeps the food intact for a shorter period.

By Heating

Cooking food by heat treatment eg. Boiling of milk helps to keep the food in a good quality for few hours. The heating process kills the microorganisms & thus keeps the food in safer condition.

By using Mild antiseptic

Sugar and salt can be sprinkled over fruits and vegetables respectively for few hours thus keeping the food intact temporarily.

By removal or blocking of air

For preserving the eggs, they are dipped in a wax emulsion. This can prevent the air in penetrating in the egg shell and thus spoiling the same. Waxing fruits by means of sugarcane wax is another traditional method of preservation which is recently revived for better results.

Long Period Preservation

By using this method, the storage life of the food is increased to a larger extent.

Sun Drying method

In this method the moisture content is reduced by exposing the food products to the sunlight which keeps the food sterilized to certain extent. As the moisture content is removed by this method, the

microorganisms does not multiply, thus increasing its the shelf life. Example: dried fish, dried peas, lentils, chilies etc.

Dehydration

Dehydration is another way of removing the moisture content by mechanical means so that there is no chance for the molds to grow on the products. This method is applied under carefully controlled temperature, air flow and humidity in a special piece of apparatus called as the dehydrator. Examples are: dehydrated vegetables such as potatoes, peas, carrots, cabbage are extensively used.

Salting

This is another method which accompanies with the dehydration process. This has to be done at a lower temperatures. This can be done rubbing the salt on the product or by dipping the food product in a brine solution. Sometimes this brine solution is also injected in the meat product. The microbial growth is restricted due to the application of salt or the salt solution.

Smoking

This is an old method of preservation. Fish, meat, pork is subjected to heat. The special woods are burnt and the product is imparted with the smoky flavor. The smoke, by its antiseptic action inhibits the growth of microorganisms. Thus bacterial growth is stopped by this antiseptic action of the smoke and the drying of the food product thus preserving the meat product.

Deep Freeze

Freezing is one of the most effective method of preserving food & this is applicable more on the perishable food products. Freezing can be done at an approximate temperature of -18°C or even lower. The palatability and nutritive value are best preserved at this temperature. Thus perishable products such as chicken, fish, milk, dairy products etc can thus be preserved using such techniques.

Hermetically sealed containers

The removal of air or due to the absence of air in the container, the food can also be preserved. Some examples could be of biscuits, cereals and preserved food in bottles.

Canning and Bottling of food products is done in hermetically sealed containers, sterilized by heat. The canning of vegetables, fruits, meat, fish, dairy products and edible products (cooked and uncooked) has proved to be safe. Each food item needs special techniques for canning & bottling. Only permitted food additives prescribed according to the Food & Drugs Act are allowed.

Food products containing 60% sugar do not spoil the jam, jelly, marmalade, candy fruits, fruit syrups, preserves & confectionery.

By Gas Storage

Here Oxygen (air) is replaced by the inert gases. Example-Soft drinks.

By Spices

The essential oils present in the herbs and spices control the growth of microorganisms thus keeping it safe. Example- In pickles.

By using Acids

Acids due to its concentration of hydrogen ion produces a toxic effect on the microorganisms thus controlling their growth. Example pickles in vinegar, Chili vinegar.

By Vacuum Packing

Coffee powder, milk powder is packed by the vacuum packing method.

By Fermentation method

Alcoholic beverages are preserved using this fermentation method , as this fermentation method produces alcohol content which itself acts as a preservative.

By Chemical Preservatives

Some preservatives are permitted to be added to the food so as to keep it safe for a longer period of time. Example- Sodium benzoate and potassium metabisulphite are used commonly for the preservation.Common antimicrobial preservatives include sorbic acid and its salts, benzoic acid and its salts, calcium propionate, sodium nitrite, sulfites (sulfur dioxide, sodium bisulfite, potassium hydrogen sulfite, etc.) and disodium EDTA.

Irradiation

This method is applied by enforcing the electric current in the form of gamma rays in the food thus disinfecting & sterilizing the food product. It is seen that products like bacon, beans, peaches etc can be kept for longer duration It is also observed that ionized radiation causes destruction to the product causing certain amount of nutritional loss. Color & flavor changes are also observed to a minimum level.

Preservation by Antibiotics

Preservation is done using antibiotics using penicillium, streptomycin, tetramycin, chloromycetin, subtlin etc. These process are still in experimental stage but most of the products are seen in good condition after the application of these antibiotics. Some cheeses are preserved by using antibiotics during its manufacturing process. Eg. Blue veined cheese.

Some of the natural food additives used in the food are acids, acidity regulators, anticaking agents, antifoaming agents, antioxidants, bulking agents like starch, natural food c olors& flavors, emulsifyers, flour improvers, etc.

CHECK YOUR PROGRESS

What do you understand by preservation?

What is a short term preservation? Give examples.

Explain dehydration & smoking method of preservation.

4.09 FOOD PRESERVATION IN DETAILS

Food preservation is to prevent the growth of microorganisms (such as yeasts), or other microorganisms (although some methods work by introducing benign bacteria or fungi to the food), as well as slowing the oxidation of fats that cause rancidity. Food preservation may also include processes that inhibit visual deterioration, such as the enzymatic browning reaction in apples after they are cut during food preparation.

Many processes designed to preserve food involve more than one food preservation method. Preserving fruit by turning it into jam, for example, involves boiling (to reduce the fruit's moisture content and to kill bacteria, etc.), sugaring (to prevent their re-growth) and sealing within an airtight jar (to prevent recontamination). Some traditional methods of preserving food have been shown to have a lower energy input and carbon footprint, when compared to modern methods.

Some methods of food preservation are known to create carcinogens. In 2015, the International Agency for Research on Cancer of the World Health Organization classified processed meat, i.e. meat that has undergone salting, curing, fermenting, and smoking, as "carcinogenic to humans".

Maintaining or creating nutritional value, texture and flavor is an important aspect of food preservation.

Traditional techniques

New techniques of food preservation became available to the home chef from the dawn of agriculture until the Industrial Revolution.

Curing

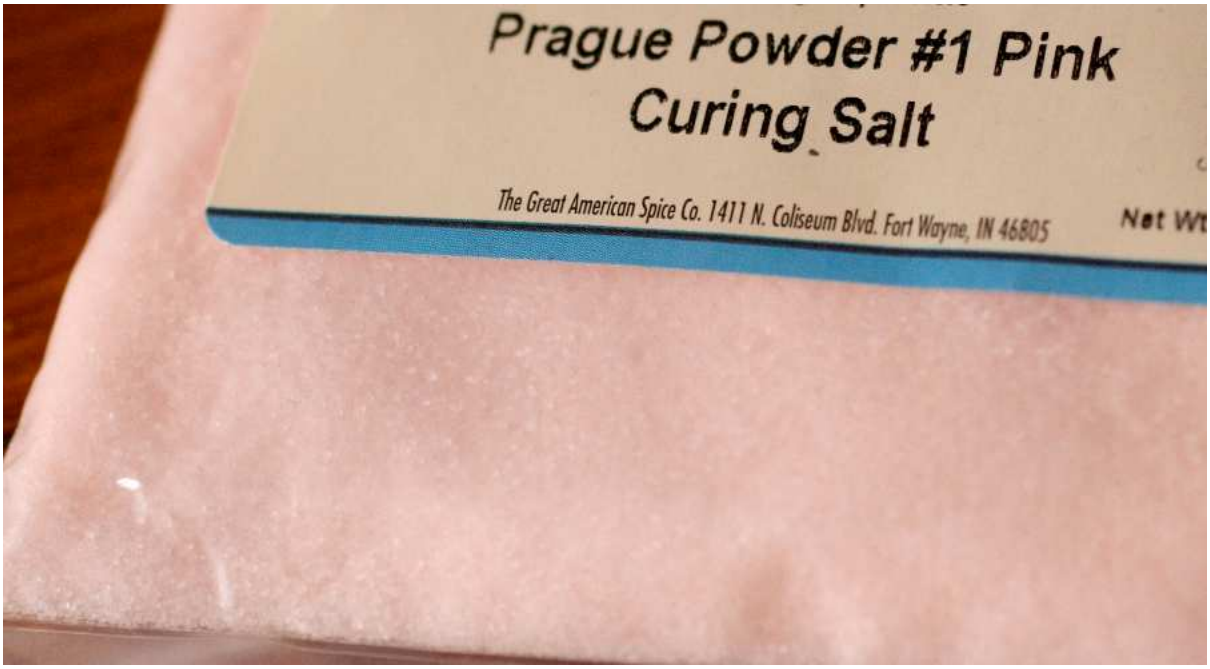

Fig 4.08: Bag of Prague powder #1, also known as "curing salt" or "pink salt". It is typically a combination of salt and sodium nitrite, with the pink color added to distinguish it from ordinary salt.

The earliest form of curing was dehydration or drying, used as early as 12,000 BC. Smoking and salting techniques improve on the drying process and add antimicrobial agents that aid in preservation. Smoke deposits a number of pyrolysis products onto the food, including the phenols syringol, guaiacol and catechol. Salt accelerates the drying process using osmosis and also inhibits the growth of several common strains of bacteria. More recently nitrites have been used to cure meat, contributing a characteristic pink colour.

Curing is any of various food preservation and flavoring processes of foods such as meat, fish and vegetables, by the addition of combinations of salt, nitrates, nitrites, or sugar, with the aim of drawing moisture out of the food by the process of osmosis. Many curing processes also involve smoking, spicing, or cooking. Dehydration was the earliest form of food curing. Because curing increases the solute concentration in the food and hence decreases its water potential, the food becomes inhospitable for the microbe growth that causes food spoilage. Curing can be traced back to antiquity, and was the primary way of preserving meat and fish until the late 19th century.

Nitrates and nitrites, in conjunction with salt, are the most common agents in curing meat, because they further inhibit the growth of *Clostridium botulinum.* They also contribute to the characteristic pink color.

Fig 4.09: Sea salt being added to raw ham to make prosciutto

Meat preservation in general (of meat from livestock, game, and poultry) is the set of all treatment processes for preserving the properties, taste, texture, and color of raw, partially cooked, or cooked meats while keeping them edible and safe to consume. Curing has been the dominant method of meat preservation for thousands of years, although modern developments like refrigeration and synthetic preservatives are now beginning to complement and supplant it.

While meat preservation processes like curing were mainly developed in order to prevent disease and increase food security, the advent of modern preservation methods mean that in most developed countries today, curing is instead mainly practised for its cultural value and desirable impact on the texture and taste of food. For lesser-developed countries, curing remains a key process in ensuring the viability of meat production, transport and access.

Untreated meat decomposes rapidly if it is not preserved, at a speed that depends on several factors, including ambient humidity, temperature, and the presence of pathogens. Most meats cannot be kept at room temperature in excess of a few days without spoiling.

If kept in excess of this time, meat begins to change colour and exude a foul odour, indicating the decomposition of the food. Ingestion of such spoiled meat can cause serious food poisonings, like botulism.

While the short shelf life of fresh meat does not pose a significant problem when access to it is easy and supply is abundant, in times of scarcity and famine, or when the meat must be carried over long voyages, it spoils very quickly. In such circumstances the usefulness of preserving foods containing nutritional value for transport and storage is obvious.

Curing can significantly extend the life of meat before it spoils, by making it inhospitable to the growth of spoilage microbes.

Cooling

Cooling preserves food by slowing down the growth and reproduction of microorganisms and the action of enzymes that causes the food to rot. The introduction of commercial and domestic refrigerators drastically improved the diets of many in the Western world by allowing food such as fresh fruit, salads and dairy products to be stored safely for longer periods, particularly during warm weather.

Before the era of mechanical refrigeration, cooling for food storage occurred in the forms of root cellars and iceboxes. Rural people often did their own ice cutting, whereas town and city dwellers often relied on the ice trade. Today, root cellaring remains popular among people who value various goals, including local food, heirloom crops, traditional home cooking techniques, family farming, frugality, self-sufficiency, organic farming, and others.

Freezing

Freezing is also one of the most commonly used processes, both commercially and domestically, for preserving a very wide range of foods, including prepared foods that would not have required freezing in their unprepared state. For example, potato waffles are stored in the freezer, but potatoes themselves require only a cool dark place to ensure many months' storage. Cold stores provide large-volume, long-term storage for strategic food stocks held in case of national emergency in many countries.

Freezing food preserves it from the time it is prepared to the time it is eaten. Since early times, farmers, fishermen, and trappers have preserved grains and produce in unheated buildings during the winter season. Freezing food slows down decomposition by turning residual moisture into ice, inhibiting the growth of most bacterial species. In the food commodity industry, there are two processes: mechanical and cryogenic (or flash freezing). The freezing kinetics is important to preserve the food quality and texture. Quicker freezing generates smaller ice crystals and maintains cellular structure. Cryogenic freezing is the quickest freezing technology available due to the ultra low liquid nitrogen temperature −196 °C (−320 °F).

Preserving food in domestic kitchens during modern times is achieved using household freezers. Accepted advice to householders was to freeze food on the day of purchase. An initiative by a supermarket group in 2012 (backed by the UK's Waste & Resources Action Programme) promotes the freezing of food "as soon as possible up to the product's 'use by' date". The Food Standards Agency was reported as supporting the change, providing the food had been stored correctly up to that time.

The freezing technique itself, just like the frozen food market, is developing to become faster, more efficient and more cost-effective.

Mechanical freezers were the first to be used in the food industry and are used in the vast majority of freezing / refrigerating lines. They function by circulating a refrigerant, normally ammonia, around the system, which withdraws heat from the food product. This heat is then transferred to a condenser and dissipated into air or water. The refrigerant itself, now a high pressure, hot liquid, is directed into an evaporator. As it passes through an expansion valve, it is cooled and then vaporises into a gaseous state. Now a low pressure, low temperature gas again, it can be reintroduced into the system.

Cryogenic or (flash freezing) of food is a more recent development, but is used by many leading food manufacturers all over the world. Cryogenic equipment uses very low temperature gases – usually liquid nitrogen or solid carbon dioxide – which are applied directly to the food product.

Packaging

Frozen food packaging must maintain its integrity throughout filling, sealing, freezing, storage, transportation, thawing, and often cooking. As many frozen foods are cooked in a microwave oven, manufacturers have developed packaging that can go straight from freezer to the microwave.

In 1974, the first differential heating container (DHC) was sold to the public. A DHC is a sleeve of metal designed to allow frozen foods to receive the correct amount of heat. Various sized apertures were positioned around the sleeve. The consumer would put the frozen dinner into the sleeve according to what needed the most heat. This ensured proper cooking.

Today there are multiple options for packaging frozen foods. Boxes, cartons, bags, pouches, Boil-in-Bags, lidded trays and pans, crystallized PET trays, and composite and plastic cans.

Scientists are continually researching new aspects of frozen food packaging. Active packaging offers a host of new technologies that can actively sense and then neutralize the presence of bacteria or other harmful species. Active packaging can extend shelf-life, maintain product safety, and help preserve the food over a longer period of time. Several functions of active packaging are being researched:

- Oxygen scavengers
- Time Temperature Indicators and digital temperature data loggers
- Antimicrobials
- Carbon Dioxide controllers
- Microwave susceptors
- Moisture control: Water activity, Moisture vapor transmission rate, etc.

- Flavor enhancers
- Odor generators
- Oxygen-permeable films
- Oxygen generators

Effects on nutrients

Vitamin content of frozen foods

- Vitamin C: Usually lost in a higher concentration than any other vitamin. A study was performed on peas to determine the cause of vitamin C loss. A vitamin loss of ten percent occurred during the blanching phase with the rest of the loss occurring during the cooling and washing stages. The vitamin loss was not actually accredited to the freezing process. Another experiment was performed involving peas and lima beans. Frozen and canned vegetables were both used in the experiment. The frozen vegetables were stored at −23 °C (−10 °F) and the canned vegetables were stored at room temperature 24 °C (75 °F). After 0, 3, 6, and 12 months of storage, the vegetables were analyzed with and without cooking. O'Hara, the scientist performing the experiment said, "From the view point of the vitamin content of the two vegetables when they were ready for the plate of the consumer, there did not appear to be any marked advantages attributable to method of preservation, frozen storage, processed in a tin, or processed in glass."
- Vitamin B_1 (Thiamin): A vitamin loss of 25 percent is normal. Thiamin is easily soluble in water and is destroyed by heat.
- Vitamin B_2 (Riboflavin): Not much research has been done to see how much freezing affects Riboflavin levels. Studies that have been performed are inconclusive; one study found an 18 percent vitamin loss in green vegetables, while another determined a 4 percent loss. It is commonly accepted that the loss of Riboflavin has to do with the preparation for freezing rather than the actual freezing process itself.
- Vitamin A (Carotene): There is little loss of carotene during preparation for freezing and freezing of most vegetables. Much of the vitamin loss is incurred during the extended storage period.

Boiling

Boiling liquid food items can kill any existing microbes. Milk and water are often boiled to kill any harmful microbes that may be present in them.

Boiling is the rapid vaporization of a liquid, which occurs when a liquid is heated to its boiling point, the temperature at which the vapour pressure of the liquid is equal to the pressure exerted on the liquid by the surrounding atmosphere. The higher the pressure the higher the boiling point. There are two main types of boiling; nucleate boiling where small bubbles of vapour form at discrete points, and critical heat flux boiling where the boiling surface is heated above a certain critical temperature and a film of vapor forms on the surface. Transition boiling is an intermediate, unstable form of boiling with elements of both types. The boiling point of water is 100 °C or 212 °F but is lower with the decreased atmospheric pressure found at higher altitudes.

Boiling water is used as a method of making it potable by killing microbes that may be present. The sensitivity of different micro-organisms to heat varies, but if water is held at 70 °C (158 °F) for ten

minutes, many organisms are killed, but some are more resistant to heat and require one minute at the boiling point of water.

Boiling is also used in cooking. Foods suitable for boiling include vegetables, starchy foods such as rice, noodles and potatoes, eggs, meats, sauces, stocks, and soups. As a cooking method, it is simple and suitable for large-scale cookery. Tough meats or poultry can be given a long, slow cooking and a nutritious stock is produced. Disadvantages include loss of water-soluble vitamins and minerals. Commercially prepared foodstuffs are sometimes packed in polythene sachets and sold as "boil-in-the-bag" products.

Heating

Heating to temperatures which are sufficient to kill microorganisms inside the food is a method used with perpetual stews. Milk is also boiled before storing to kill many microorganisms.

Fig 4.10: Highland stew, Cantabrian typical dish.

A perpetual stew, also known as hunter's pot or hunter's stew, is a pot into which whatever one can find is placed and cooked. The pot is never or rarely emptied all the way, and ingredients and liquid are replenished as necessary. The concept is often a common element in descriptions of medieval inns. Foods prepared in a perpetual stew have been described as being flavorful due to the manner in which the foodstuffs blend together, in which the flavor may improve with age

Sugaring

The earliest cultures have used sugar as a preservative, and it was commonplace to store fruit in honey. Similar to pickled foods, sugar cane was brought to Europe through the trade routes. In northern climates without sufficient sun to dry foods, preserves are made by heating the fruit with sugar. "Sugar tends to draw water from the microbes (plasmolysis). This process leaves the microbial cells dehydrated, thus killing them. In this way, the food will remain safe from microbial spoilage." Sugar is used to preserve fruits, either in an antimicrobial syrup with fruit such as apples, pears, peaches, apricots, and plums, or in crystallized form where the preserved material is cooked in sugar to the point of crystallization and the resultant product is then stored dry. This method is used for the skins of citrus fruit (candied peel), angelica, and ginger. Also, sugaring can be used in the production of jam and jelly.

Sugaring is a food preservation method similar to pickling. Sugaring is the process of desiccating a food by first dehydrating it, then packing it with pure sugar. This sugar can be crystalline in the form of table or raw sugar, or it can be a high sugar density liquid such as honey, syrup or molasses.

The purpose of sugaring is to create an environment hostile to microbial life and prevent food spoilage. Sugaring is commonly used to preserve fruits as well as vegetables such as ginger. From time to time sugaring has also been used for non-food preservations. For example, honey was used as part of the mummification process in some ancient Egyptian rites.

A risk in sugaring is that sugar itself attracts moisture. Once a sufficient moisture level is reached, native yeast in the environment will come out of dormancy and begin to ferment the sugars into alcohol and carbon dioxide. This leads to the process of fermentation. Although fermentation can be used as a food preservation method, it must be intentionally controlled, or the results will tend to be unpleasant.

Pickling

Pickling is a method of preserving food in an edible, antimicrobial liquid. Pickling can be broadly classified into two categories: chemical pickling and fermentation pickling.

In chemical pickling, the food is placed in an edible liquid that inhibits or kills bacteria and other microorganisms. Typical pickling agents include brine (high in salt), vinegar, alcohol, and vegetable oil. Many chemical pickling processes also involve heating or boiling so that the food being preserved becomes saturated with the pickling agent. Common chemically pickled foods include cucumbers, peppers, corned beef, herring, and eggs, as well as mixed vegetables such as piccalilli.

In fermentation pickling, bacteria in the liquid produce organic acids as preservation agents, typically by a process that produces lactic acid through the presence of lactobacillales. Fermented pickles include sauerkraut, nukazuke, kimchi, and surströmming.

Pickling is the process of preserving or expanding the lifespan of food by either anaerobic fermentation in brine or immersion in vinegar. The resulting food is called a pickle, or, to prevent ambiguity, prefaced with the adjective pickled. The pickling procedure will typically affect the food's texture and flavor. In East Asia, vinaigrette (vegetable oil and vinegar) is also used as a pickling medium. Foods that are pickled include meats, fruits, eggs, and vegetables.

Another distinguishing characteristic is a pH of 4.6 or lower, which is sufficient to kill most bacteria. Pickling can preserve perishable foods for months. Antimicrobial herbs and spices, such as mustard seed, garlic, cinnamon or cloves, are often added. If the food contains sufficient moisture, a pickling brine may be produced simply by adding dry salt. For example, German sauerkraut and Korean kimchi are produced by salting the vegetables to draw out excess water. Natural fermentation at room temperature, by lactic acid bacteria, produces the required acidity. Other pickles are made by placing vegetables in vinegar. Unlike the canning process, pickling (which includes fermentation) does not require that the food be completely sterile before it is sealed. The acidity or salinity of the solution,

the temperature of fermentation, and the exclusion of oxygen determine which microorganisms dominate, and determine the flavor of the end product.

Fig 4.11: Pickled tomatoes are very popular in CIS

When both salt concentration and temperature are low, Leuconostoc mesenteroides dominates, producing a mix of acids, alcohol, and aroma compounds. At higher temperatures Lactobacillus plantarum dominates, which produces primarily lactic acid. Many pickles start with Leuconostoc, and change to Lactobacillus with higher acidity.

Lye

Sodium hydroxide (lye) makes food too alkaline for bacterial growth. Lye will saponify fats in the food, which will change its flavor and texture. Lutefisk uses lye in its preparation, as do some olive recipes. Modern recipes for century eggs also call for lye.

Canning

Fig 4.12: Preserved food

Canning involves cooking food, sealing it in sterilized cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization. It was invented by the French confectioner Nicolas Appert. By 1806, this process was used by the French Navy to preserve meat, fruit, vegetables, and even milk. Although Appert had discovered a new way of preservation, it wasn't understood until 1864 when Louis Pasteur found the relationship between microorganisms, food spoilage, and illness.

Foods have varying degrees of natural protection against spoilage and may require that the final step occur in a pressure cooker. High-acid fruits like strawberries require no preservatives to can and only a short boiling cycle, whereas marginal vegetables such as carrots require longer boiling and addition of other acidic elements. Low-acid foods, such as vegetables and meats, require pressure canning. Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened.

Lack of quality control in the canning process may allow ingress of water or micro-organisms. Most such failures are rapidly detected as decomposition within the can causes gas production and the can will swell or burst. However, there have been examples of poor manufacture (underprocessing) and poor hygiene allowing contamination of canned food by the obligate anaerobe *Clostridium botulinum*,

which produces an acute toxin within the food, leading to severe illness or death. This organism produces no gas or obvious taste and remains undetected by taste or smell. Its toxin is denatured by cooking, however. Cooked mushrooms, handled poorly and then canned, can support the growth of Staphylococcus aureus, which produces a toxin that is not destroyed by canning or subsequent reheating.

Canning is a method of preserving food in which the food contents are processed and sealed in an airtight container. Canning provides a shelf life typically ranging from one to five years, although under specific circumstances it can be much longer. A freeze-dried canned product, such as canned dried lentils, could last as long as 30 years in an edible state. In 1974, samples of canned food from the wreck of the Bertrand, a steamboat that sank in the Missouri River in 1865, were tested by the National Food Processors Association. Although appearance, smell and vitamin content had deteriorated, there was no trace of microbial growth and the 109-year-old food was determined to be still safe to eat.

The original fragile and heavy glass containers presented challenges for transportation, and glass jars were largely replaced in commercial canneries with cylindrical tin or wrought-iron canisters (later shortened to "cans") following the work of Peter Durand (1810). Cans are cheaper and quicker to make, and much less fragile than glass jars. Glass jars have remained popular for some high-value products and in home canning. Can openers were not invented for another thirty years — at first, soldiers had to cut the cans open with bayonets or smash them open with rocks. Today, tin-coated steel is the material most commonly used. Laminate vacuum pouches are also used for canning, such as used in MREs and Capri Sun drinks.

To prevent the food from being spoiled before and during containment, a number of methods are used: pasteurisation, boiling (and other applications of high temperature over a period of time), refrigeration, freezing, drying, vacuum treatment, antimicrobial agents that are natural to the recipe of the foods being preserved, a sufficient dose of ionizing radiation, submersion in a strong saline solution, acid, base, osmotically extreme (for example very sugary) or other microbially-challenging environments.

Other than sterilization, no method is perfectly dependable as a preservative. For example, the microorganism Clostridium botulinum (which causes botulism) can only be eliminated at temperatures above the boiling point of water.

From a public safety point of view, foods with low acidity (a pH more than 4.6) need sterilization under high temperature (116–130 °C). To achieve temperatures above the boiling point requires the use of a pressure canner. Foods that must be pressure canned include most vegetables, meat, seafood, poultry, and dairy products. The only foods that may be safely canned in an ordinary boiling water bath are highly acidic ones with a pH below 4.6, such as fruits, pickled vegetables, or other foods to which acidic additives have been added.

Double seams

Invented in 1888 by Max Ams, modern double seams provide an airtight seal to the tin can. This airtight nature is crucial to keeping micro-organisms out of the can and keeping its contents sealed inside. Thus, double seamed cans are also known as Sanitary Cans. Developed in 1900 in Europe, this sort of can was made of the traditional cylindrical body made with tin plate. The two ends (lids) were attached using what is now called a double seam. A can thus sealed is impervious to contamination by creating two tight continuous folds between the can's cylindrical body and the lids. This eliminated the need for solder and allowed improvements in manufacturing speed, reducing cost.

Double seaming uses rollers to shape the can, lid and the final double seam. To make a sanitary can and lid suitable for double seaming, manufacture begins with a sheet of coated tin plate. To create the can body, rectangles are cut and curled around a die, and welded together creating a cylinder with a side seam.

Rollers are then used to flare out one or both ends of the cylinder to create a quarter circle flange around the circumference. Precision is required to ensure that the welded sides are perfectly aligned, as any misalignment will cause inconsistent flange shape, compromising its integrity.

A circle is then cut from the sheet using a die cutter. The circle is shaped in a stamping press to create a downward countersink to fit snugly into the can body. The result can be compared to an upside down and very flat top hat. The outer edge is then curled down and around about 140 degrees using rollers to create the end curl.

The result is a steel tube with a flanged edge, and a countersunk steel disc with a curled edge. A rubber compound is put inside the curl.

Jellying

Food may be preserved by cooking in a material that solidifies to form a gel. Such materials include gelatin, agar, maize flour, and arrowroot flour. Some foods naturally form a protein gel when cooked, such as eels and elvers, and sipunculid worms, which are a delicacy in Xiamen, in the Fujian province of the People's Republic of China. Jellied eels are a delicacy in the East End of London, where they are eaten with mashed potatoes. Potted meats in aspic (a gel made from gelatin and clarified meat broth) were a common way of serving meat off-cuts in the UK until the 1950s. Many jugged meats are also jellied.

A traditional British way of preserving meat (particularly shrimp) is by setting it in a pot and sealing it with a layer of fat. Also common is potted chicken liver; jellying is one of the steps in producing traditional pâtés.

Aspic is a dish in which ingredients are set into a gelatin made from a meat stock or consommé. Non-savory dishes, often made with commercial gelatin mixes without stock or consommé, are usually called gelatin salads.

Fig 4.13: An aspic with chicken and eggs.

When cooled, stock that is made from meat congeals because of the natural gelatin found in the meat. The stock can be clarified with egg whites, and then filled and flavored just before the aspic sets. Almost any type of food can be set into aspics. Most common are meat pieces, fruits, or vegetables. Aspics are usually served on cold plates so that the gel will not melt before being eaten. A meat jelly that includes cream is called a chaud-froid.

Nearly any type of meat can be used to make the gelatin: pork, beef, veal, chicken, turkey, or fish. The aspic may need additional gelatin in order to set properly. Veal stock provides a great deal of gelatin; in making stock, veal is often included with other meat for that reason. Fish consommés usually have too little natural gelatin, so the fish stock may be double-cooked or supplemented. Since fish gelatin melts at a lower temperature than gelatins of other meats, fish aspic is more delicate and melts more readily in the mouth.

Vegetables and fish stocks need gelatin to maintain a molded shape.

Jugging

Meat can be preserved by jugging. Jugging is the process of stewing the meat (commonly game or fish) in a covered earthenware jug or casserole. The animal to be jugged is usually cut into pieces, placed into a tightly-sealed jug with brine or gravy, and stewed. Red wine and/or the animal's own blood is sometimes added to the cooking liquid. Jugging was a popular method of preserving meat up until the middle of the 20th century.

Burial

Burial of food can preserve it due to a variety of factors: lack of light, lack of oxygen, cool temperatures, pH level, or desiccants in the soil. Burial may be combined with other methods such as salting or fermentation. Most foods can be preserved in soil that is very dry and salty (thus a desiccant) such as sand, or soil that is frozen.

Many root vegetables are very resistant to spoilage and require no other preservation than storage in cool dark conditions, for example by burial in the ground, such as in a storage clamp. Century eggs are traditionally created by placing eggs in alkaline mud (or other alkaline substance), resulting in their "inorganic" fermentation through raised pH instead of spoiling. The fermentation preserves them and breaks down some of the complex, less flavorful proteins and fats into simpler, more flavorful ones. Cabbage was traditionally buried during Autumn in northern US farms for preservation. Some methods keep it crispy while other methods produce sauerkraut. A similar process is used in the traditional production of kimchi. Sometimes meat is buried under conditions that cause preservation. If buried on hot coals or ashes, the heat can kill pathogens, the dry ash can desiccate, and the earth can block oxygen and further contamination. If buried where the earth is very cold, the earth acts like a refrigerator. Before burial, meat (pig/boar) can be fatted. The tallow of the animal is heated and poured over meat in a barrel. Once the fat hardens the barrel is sealed and buried in a cold cellar or ground.

In Orissa, India, it is practical to store rice by burying it underground. This method helps to store for three to six months during the dry season.

Butter and similar substances have been preserved as bog butter in Irish peat bogs for centuries.

Fermentation

See also: Fermentation (food)

Some foods, such as many cheeses, wines, and beers, use specific micro-organisms that combat spoilage from other less-benign organisms. These micro-organisms keep pathogens in check by creating an environment toxic for themselves and other micro-organisms by producing acid or alcohol. Methods of fermentation include, but are not limited to, starter micro-organisms, salt, hops, controlled (usually cool) temperatures and controlled (usually low) levels of oxygen. These methods are used to create the specific controlled conditions that will support the desirable organisms that produce food fit for human consumption.

Fermentation is the microbial conversion of starch and sugars into alcohol. Not only can fermentation produce alcohol, but it can also be a valuable preservation technique. Fermentation can also make foods more nutritious and palatable. For example, drinking water in the Middle Ages was dangerous because it often contained pathogens that could spread disease. When the water is made into beer, the boiling during the brewing process kills any bacteria in the water that could make people sick. Additionally, the water now has the nutrients from the barley and other ingredients, and the microorganisms can also produce vitamins as they ferment.

Modern industrial techniques

Techniques of food preservation were developed in research laboratories for commercial applications.

Pasteurization

Pasteurization is a process for preservation of liquid food. It was originally applied to combat the souring of young local wines. Today, the process is mainly applied to dairy products. In this method, milk is heated at about 70 °C (158 °F) for 15–30 seconds to kill the bacteria present in it and cooling it quickly to 10 °C (50 °F) to prevent the remaining bacteria from growing. The milk is then stored in sterilized bottles or pouches in cold places. This method was invented by Louis Pasteur, a French chemist, in 1862.

Pasteurization or pasteurisation is a process that kills microbes (mainly bacteria) in food and drink, such as milk, juice, canned food, and others.

Fig 4.14: 180 kg Milk in cheese vat

It was invented by French scientist Louis Pasteur during the nineteenth century. In 1864 Pasteur discovered that heating beer and wine was enough to kill most of the bacteria that caused spoilage, preventing these beverages from turning sour. The process achieves this by eliminating pathogenic microbes and lowering microbial numbers to prolong the quality of the beverage. Today, pasteurization is used widely in the dairy industry and other food processing industries to achieve food preservation and food safety.

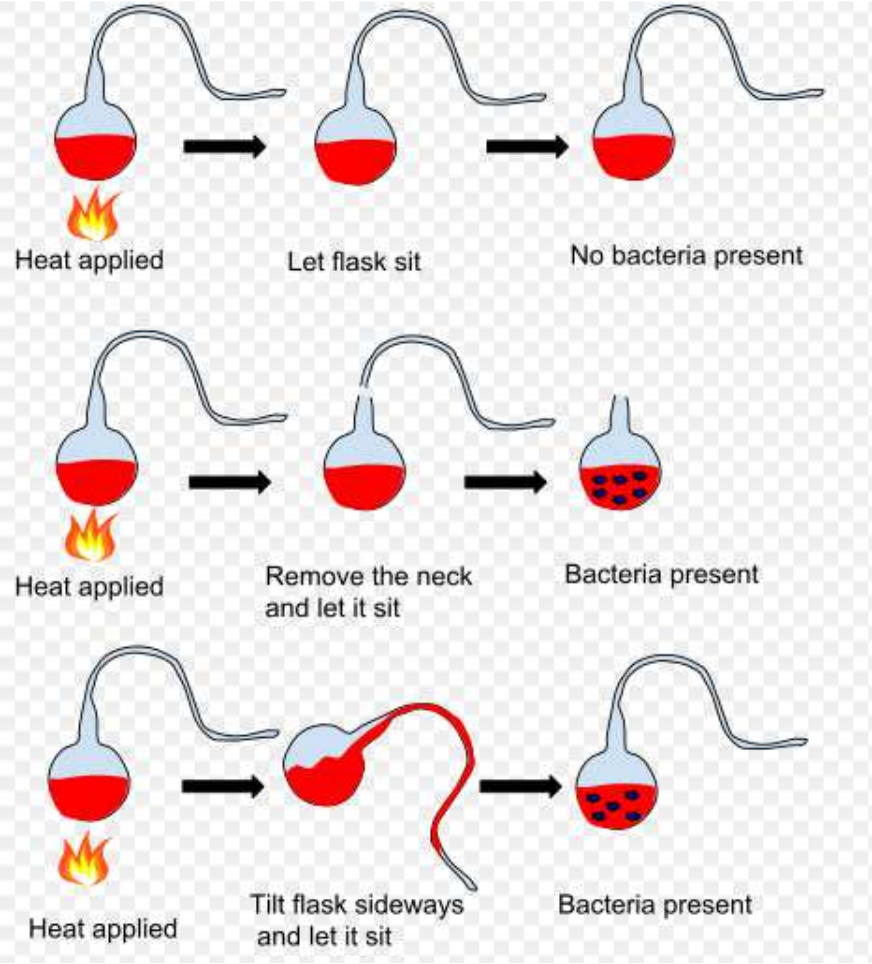

Fig 4.15: Louis Pasteur's pasteurization experiment illustrates the fact that the spoilage of liquid was caused by particles in the air rather than the air itself. These experiments were important pieces of evidence supporting the idea of Germ Theory of Disease.

Unlike sterilization, pasteurization is not intended to kill all microorganisms in the food. Instead, it aims to reduce the number of viable pathogens so they are unlikely to cause disease (assuming the pasteurized product is stored as indicated and is consumed before its expiration date). Commercial-scale sterilization of food is not common because it adversely affects the taste and quality of the product. Certain foods, such as dairy products, may be superheated to ensure pathogenic microbes are destroyed.

Process

Older pasteurization methods used temperatures below boiling, since at very high temperatures, micelles of the milk protein casein irreversibly aggregate, or curdle. Newer methods use higher temperature, but shorten the time. Among the pasteurization methods listed below, the two main types of pasteurization used today are high-temperature, short-time (HTST, also known as "flash") and extended shelf life (ESL):

- HTST milk is forced between metal plates or through pipes heated on the outside by hot water, and the milk is heated to 72 °C (161 °F) for 15 seconds.:8 Milk simply labeled "pasteurized" is usually treated with the HTST method.
- UHT, also known as ultra-heat-treating, processing holds the milk at a temperature of 140 °C (284 °F) for four seconds. During UHT processing milk is sterilized and not pasteurized. This process lets consumers store milk or juice for several months without refrigeration. The process is achieved by spraying the milk or juice through a nozzle into a chamber filled with high-temperature steam under pressure. After the temperature reaches 140 °C the fluid is cooled instantly in a vacuum chamber, and packed in a pre-sterilized airtight container. Milk labeled "ultra-pasteurized" or simply "UHT" has been treated with the UHT method.
- ESL milk has a microbial filtration step and lower temperatures than UHT milk. Since 2007, it is no longer a legal requirement in European countries (for example in Germany) to declare ESL milk as ultra-heated; consequently, it is now often labeled as "fresh milk" and just advertised as having an "extended shelf life", making it increasingly difficult to distinguish ESL milk from traditionally pasteurized fresh milk.
- A less conventional, but US FDA–legal, alternative (typically for home pasteurization) is to heat milk at 63 °C (145 °F) for 30 minutes.

Pasteurization methods are usually standardized and controlled by national food safety agencies (such as the USDA in the United States and the Food Standards Agency in the United Kingdom). These agencies require that milk be HTST pasteurized to qualify for the pasteurized label. Dairy product standards differ, depending on fat content and intended usage. For example, pasteurization standards for cream differ from standards for fluid milk, and standards for pasteurizing cheese are designed to preserve the enzyme phosphatase, which aids cutting. In Canada, all milk produced at a processor and intended for consumption must be pasteurized, which legally requires that it be heated to at least 72 °C for at least 1 seconds, then cooling it to 4 °C to ensure any harmful bacteria are destroyed. The UK Dairy Products Hygiene Regulations 1995 requires that milk be heat treated for 15 seconds at 71.7 °C or other effective time/temperature combination.

Some older references point to one or multiple cycles of heating and cooling (to ambient temperature or below) as either a definition of pasteurization or a general method thereof.

A process similar to pasteurization is thermization, which uses lower temperatures to kill bacteria in milk. It allows a milk product, such as cheese, to retain more of the original taste, but thermized foods are not considered pasteurized by food regulators.

Microwave volumetric heating

Microwave volumetric heating (MVH) is the newest available pasteurization technology. It uses microwaves to heat liquids, suspensions, or semi-solids in a continuous flow. Because MVH delivers energy evenly and deeply into the whole body of a flowing product, it allows for gentler and shorter heating, so that almost all heat-sensitive substances in the milk are preserved.

Vacuum packing

Vacuum-packing stores food in a vacuum environment, usually in an air-tight bag or bottle. The vacuum environment strips bacteria of oxygen needed for survival. Vacuum-packing is commonly used for storing nuts to reduce loss of flavor from oxidization. A major drawback to vacuum packaging, at the consumer level, is that vacuum sealing can deform contents and rob certain foods, such as cheese, of its flavor.

Vacuum packing is a method of packaging that removes air from the package prior to sealing. This method involves (manually or automatically) placing items in a plastic film package, removing air from inside, and sealing the package. Shrink film is sometimes used to have a tight fit to the contents. The intent of vacuum packing is usually to remove oxygen from the container to extend the shelf life of foods and, with flexible package forms, to reduce the volume of the contents and package.

Vacuum packing reduces atmospheric oxygen, limiting the growth of aerobic bacteria or fungi, and preventing the evaporation of volatile components. It is also commonly used to store dry foods over a long period of time, such as cereals, nuts, cured meats, cheese, smoked fish, coffee, and potato chips (crisps). On a more short term basis, vacuum packing can also be used to store fresh foods, such as vegetables, meats, and liquids, because it inhibits bacterial growth.

Vacuum packing greatly reduces the bulk of non-food items. For example, clothing and bedding can be stored in bags evacuated with a domestic vacuum cleaner or a dedicated vacuum sealer. This technique is sometimes used to compact household waste, for example where a charge is made for each full bag collected.

Vacuum packaging products, using plastic bags, canisters, bottles, or mason jars, are available for home use.

For delicate food items which might be crushed by the vacuum packing process (such as potato chips), an alternative is to replace the interior gas with nitrogen. This has the same effect of inhibiting deterioration due to the removal of oxygen.

Artificial food additives

Preservative food additives can be *antimicrobial*—which inhibit the growth of bacteria or fungi, including mold—or *antioxidant*, such as oxygen absorbers, which inhibit the oxidation of food constituents. Common antimicrobial preservatives include calcium propionate, sodium nitrate, sodium nitrite, sulfites (sulfur dioxide, sodium bisulfite, potassium hydrogen sulfite, etc.), and EDTA. Antioxidants include butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). Other preservatives include formaldehyde (usually in solution), glutaraldehyde (insecticide), ethanol, and methylchloroisothiazolinone.

Irradiation

Irradiation of food is the exposure of food to ionizing radiation. The two types of ionizing radiation used are beta particles (high-energy electrons) and gamma rays (emitted from radioactive sources such as cobalt-60 or cesium-137). Treatment effects include killing bacteria, molds, and insect pests, reducing the ripening and spoiling of fruits, and at higher doses inducing sterility. The technology may be compared to pasteurization; it is sometimes called "cold pasteurization", as the product is not heated.

The irradiation process is not directly related to nuclear energy, but does use radioactive isotopes produced in nuclear reactors. Cobalt-60, for example does not occur naturally and can only be produced through neutron bombardment of cobalt-59. Ionizing radiation at high energy levels is hazardous to life (hence its usefulness in sterilisation); for this reason, irradiation facilities have a heavily shielded irradiation room where the process takes place. Radiation safety procedures are used to ensure that neither the workers in such facilities nor the environment receives any radiation dose above administrative limits. Irradiated food does not and cannot become radioactive, and national and international expert bodies have declared food irradiation as wholesome. However, the wholesomeness of consuming such food is disputed by opponents and consumer organizations. National and international expert bodies have declared food irradiation as "wholesome"; organizations of the United Nations, such as the World Health Organization and Food and Agriculture Organization, endorse food irradiation. International legislation on whether food may be irradiated or not varies worldwide from no regulation to full banning. Irradiation may allow lower-quality or contaminated foods to be rendered marketable.

Approximately 500,000 tons of food items are irradiated per year worldwide in over 40 countries. These are mainly spices and condiments with an increasing segment of fresh fruit irradiated for fruit fly quarantine.

Pulsed electric field electroporation

Pulsed electric field (PEF) electroporation is a method for processing cells by means of brief pulses of a strong electric field. PEF holds potential as a type of low-temperature alternative pasteurization process for sterilizing food products. In PEF processing, a substance is placed between two electrodes, then the pulsed electric field is applied. The electric field enlarges the pores of the cell membranes, which kills the cells and releases their contents. PEF for food processing is a developing technology still being researched. There have been limited industrial applications of PEF processing for the pasteurization of fruit juices. To date, several PEF treated juices are available on the market in Europe. Furthermore, for several years a juice pasteurization application in the US has used PEF. For cell disintegration purposes especially potato processors show great interest in PEF technology as an efficient alternative for their preheaters. Potato applications are already operational in the US and Canada. There are also commercial PEF potato applications in various countries in Europe, as well as in Australia, India, and China.

Modified atmosphere

Modifying atmosphere is a way to preserve food by operating on the atmosphere around it. Salad crops that are notoriously difficult to preserve are now being packaged in sealed bags with an atmosphere modified to reduce the oxygen (O_2) concentration and increase the carbon dioxide (CO_2) concentration. There is concern that, although salad vegetables retain their appearance and texture in

such conditions, this method of preservation may not retain nutrients, especially vitamins. There are two methods for preserving grains with carbon dioxide. One method is placing a block of dry ice in the bottom and filling the can with the grain. Another method is purging the container from the bottom by gaseous carbon dioxide from a cylinder or bulk supply vessel.

Carbon dioxide prevents insects and, depending on concentration, mold and oxidation from damaging the grain. Grain stored in this way can remain edible for approximately five years.

Nitrogen gas (N_2) at concentrations of 98% or higher is also used effectively to kill insects in the grain through hypoxia. However, carbon dioxide has an advantage in this respect, as it kills organisms through hypercarbia and hypoxia (depending on concentration), but it requires concentrations of above 35%, or so. This makes carbon dioxide preferable for fumigation in situations where a hermetic seal cannot be maintained.

Controlled Atmospheric Storage (CA): "CA storage is a non-chemical process. Oxygen levels in the sealed rooms are reduced, usually by the infusion of nitrogen gas, from the approximate 21 percent in the air we breathe to 1 percent or 2 percent. Temperatures are kept at a constant 0–2 °C (32–36 °F). Humidity is maintained at 95 percent and carbon dioxide levels are also controlled. Exact conditions in the rooms are set according to the apple variety. Researchers develop specific regimens for each variety to achieve the best quality. Computers help keep conditions constant." "Eastern Washington, where most of Washington's apples are grown, has enough warehouse storage for 181 million boxes of fruit, according to a report done in 1997 by managers for the Washington State Department of Agriculture Plant Services Division. The storage capacity study shows that 67 percent of that space—enough for 121,008,000 boxes of apples—is CA storage."

Air-tight storage of grains (sometimes called hermetic storage) relies on the respiration of grain, insects, and fungi that can modify the enclosed atmosphere sufficiently to control insect pests. This is a method of great antiquity, as well as having modern equivalents. The success of the method relies on having the correct mix of sealing, grain moisture, and temperature.

A patented process uses fuel cells to exhaust and automatically maintain the exhaustion of oxygen in a shipping container, containing, for example, fresh fish.

Nonthermal plasma

This process subjects the surface of food to a "flame" of ionized gas molecules, such as helium or nitrogen. This causes micro-organisms to die off on the surface.

High-pressure food preservation

High-pressure food preservation or pascalization refers to the use of a food preservation technique that makes use of high pressure. "Pressed inside a vessel exerting 70,000 pounds per square inch (480 MPa) or more, food can be processed so that it retains its fresh appearance, flavor, texture and nutrients while disabling harmful microorganisms and slowing spoilage." By 2005, the process was being used for products ranging from orange juice to guacamole to deli meats and widely sold.

Biopreservation

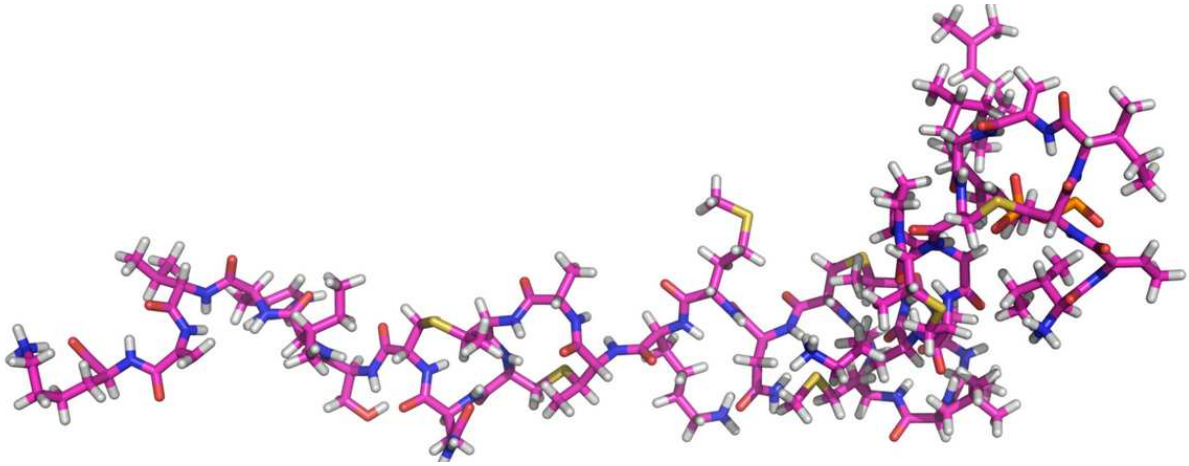

Fig 4.16: 3D stick model of nisin. Some lactic acid bacteria manufacture nisin. It is a particularly effective preservative.

Biopreservation is the use of natural or controlled microbiota or antimicrobials as a way of preserving food and extending its shelf life. Beneficial bacteria or the fermentation products produced by these bacteria are used in biopreservation to control spoilage and render pathogens inactive in food. It is a benign ecological approach which is gaining increasing attention.

Of special interest are lactic acid bacteria (LAB). Lactic acid bacteria have antagonistic properties that make them particularly useful as biopreservatives. When LABs compete for nutrients, their metabolites often include active antimicrobials such as lactic acid, acetic acid, hydrogen peroxide, and peptide bacteriocins. Some LABs produce the antimicrobial nisin, which is a particularly effective preservative.

These days, LAB bacteriocins are used as an integral part of hurdle technology. Using them in combination with other preservative techniques can effectively control spoilage bacteria and other pathogens, and can inhibit the activities of a wide spectrum of organisms, including inherently resistant Gram-negative bacteria.

Hurdle technology

Hurdle technology is a method of ensuring that pathogens in food products can be eliminated or controlled by combining more than one approach. These approaches can be thought of as "hurdles" the pathogen has to overcome if it is to remain active in the food. The right combination of hurdles can ensure all pathogens are eliminated or rendered harmless in the final product.

Hurdle technology has been defined by Leistner (2000) as an intelligent combination of hurdles that secures the microbial safety and stability as well as the organoleptic and nutritional quality and the economic viability of food products. The organoleptic quality of the food refers to its sensory properties, that is its look, taste, smell, and texture.

Examples of hurdles in a food system are high temperature during processing, low temperature during storage, increasing the acidity, lowering the water activity or redox potential, and the presence of preservatives or biopreservatives. According to the type of pathogens and how risky they are, the

intensity of the hurdles can be adjusted individually to meet consumer preferences in an economical way, without sacrificing the safety of the product.

Principal hurdles used for food preservation (after Leistner, 1995)

Parameter	Symbol	Application
High temperature	F	Heating
Low temperature	T	Chilling, freezing
Reduced water activity	a_w	Drying, curing, conserving
Increased acidity	pH	Acid addition or formation
Reduced redox potential	E_h	Removal of oxygen or addition of ascorbate
Biopreservatives		Competitive flora such as microbial fermentation
Other preservatives		Sorbates, sulfites, nitrites

CHECK YOUR PROGRESS

Explain the concept of food preservation.
Elaborate on the traditional methods of food preservation.
Explain how curing works in preserving the food.
Explain how cooling works in preserving the food.
Explain how freezing works in preserving the food.
What is the difference between freezing and cooling methods of preserving food.
What is the effect on nutrients for frozen food?
Explain how boiling works in preserving the food.
Explain how heating works in preserving the food.
What is the difference between boiling and heating methods of preserving food.
Explain how sugaring works in preserving the food.
Explain how pickling works in preserving the food.
What is the difference between sugaring and pickling methods of preserving food.
Explain how lye (NaOH) works in preserving the food.
Explain how canning works in preserving the food.
Explain how jellying works in preserving the food.
Explain how jugging works in preserving the food.
Explain how burial works in preserving the food.
Explain how fermentation works in preserving the food.
Explain how pasteurization works in preserving the food.
Explain how vacuum packing works in preserving the food.
Explain how food additives works in preserving the food.
Explain how modified atmosphere works in preserving the food.
Explain how irradiation works in preserving the food.
Explain how pulse electrical field elctroporation works in preserving the food.
Explain how high pressure (pascalisation) works in preserving the food.

Explain how biopreservatives works in preserving the food.
Explain concept of hurdle technology in preserving the food.

4.10 NATIONAL FOOD LAWS

The laws regulating the safety and quality of food in India dates back to 1899. Until 1954, several states formulated their own food laws, which led to considerable variance in the rules and specifications of food items and thus created conflicts in interprovincial trade. The central legislation that brings in uniformity across the country. With the Constitution of India providing the powers to the Central government for passing legislation on the subject of foods and drugs adulteration and including it in the Concurrent list, the Government of India enacted a Central Legislation called the Prevention of Food Adulteration Act, 1954, which came into effect from 1st June 1955.

The Prevention of Food Adulteration Act

The Salient features of this legislation are as follows:

- The powers to the Central and State Government to appoint public analysts and food inspectors to prescribe the list of permissible additives & their limits & the tolerance limits of the contaminants.

- Packaging and labelling of food.
- Role of the Government of India- Central PFA Cell

The legislation, namely Prevention of Food Adulteration Act has been enacted by the Ministry of Health and Family welfare in the Government of India. Rules and standards framed under this act are applicable throughout the country. Besides framing the rules and regulations the following activities are also undertaken by the Cell:

- Liasoning with the Local bodies of the States for implementation of food laws.
- Monitoring the activities of the State by collecting periodical reports of the food poisoning cases, visiting states from time to time.
- Arranging training programs very often for the senior officers/inspectors or the food analysts.
- Creating consumer awareness programme by organizing exhibitions/ seminars/ training programs. Publishing informative pamphlets etc.
- Approving proprietary products of infant milk substitute and infant food and their labels so as to safeguard the health of infants.
- Liasoning with the ministries of Central Government working in the field of food standardization.
- Coordinating with the International bodies like FAO/WHO and Codex.
- Giving Financial, technical and administrative support to the Food laboratories.
- To monitor on policies issued on Food Irradiation.
- Formulating of manual of method of analysis of food.

Other Legislations or Authorities and their role

These legislations are divided into two groups:

Voluntary: Product Certifications, example ISI mark of BIS and AGMARK

Compulsory: All orders under Essential Commodities Act, 1955, which focus more on the hygiene and food safety requirements.

Fruit Product Order are harmonized with the PFA.

Some common acts mentioned below:

Essential Commodities Act, 1955.

The main objective of this act is to regulate the production, supply and distribution of, and trade and commerce in certain essential commodities, the principle of them being the foodstuff.

Standard of Weights and Measures Act. 1976.

The standard of Weights and Measures Act, 1976 was enacted to establish standards of weights and measures to regulate the interstate trade or commerce in weights, measures and other goods which are sold or distributed by weight, measure or number, and to provide for matters connected therewith or incidental thereto. The packages must have clear information and declarations of the product, its net quantity, price, name of the manufacturer etc.

Bureau of Indian Standards Act, 1986.

The product certification scheme of BIS aims at providing quality, safety and dependability to the ultimate customer. The Indian Standard Institution (ISI) was set up in 1947, as a registered society, under the Government of India resolution. It gave the nation the standards it required for nationalization, orderly industrial and commercial growth, quality production, competitive efficiency and safeguarding the health of the consumers. The BIS was formed in 1986 and thus took over the staff assets, liabilities and functions of erstwhile ISI.

Agricultural Grading and Marketing Act Rules, 1937(AGMARK).

Under the Grading and Marking Act the Directorate of Marketing and Inspection was constituted in the Ministry of Rural areas and Employment and Employment which operates a voluntary scheme of certification of agricultural products (raw and processed) for safeguarding the health of consumers. Under 'Agmark' each batch of consignment is tested by an approved chemist before certification is granted. The PFA rules, 1955 provide compulsory Agmark certification of blended oils, carbiacallosa and honey dew; kangra tea; ghee moving from one state to another; til oil produced in Tripura, Assam and West Bengal. Further, certain food items meant for export have been brought under compulsory Agmark certification viz. walnuts, black pepper, cardamom, chillies, ginger, turmeric etc. The Directorate of Marketing and Inspection has 21 laboratories and 50 sub offices spread all over the country. The Central Agmark Laboratory at Nagpur carries out research and development work in this field.

Export Act 1963. (Quality Control & Inspection).

The Export Inspection Council (EIC) is an advisory body to the Central Government, which is empowered under the Act to, notify commodities which will be subject to quality control and/ or inspection prior to export, to establish standards of quality for such notified commodities and to specify the type of quality control and/ or inspection to be applied to such commodities.

CHECK YOUR PROGRESS

Explain the features of the PFA Act

Explain the features of the The Essential Commodities Act

Explain the features of the AGMARK

Explain the features of the BIS

4.11 INTERNATIONAL ORGANIZATIONS AND AGREEEMENTS IN FOOD STANDARDIZA-TION, QUALITY RESEARCH AND TRADE

Evidence from the earliest historical writings indicates that since ancient times governing authorities made attempts to codify foods in order to protect consumers from dishonest practices in the sale of food. In the later 1800s a new era of long distance food transportation is ushered in by the first international shipments of frozen meat from Australia and New Zealand to the United Kingdom. In late 1800s and early 1900 Food Trade Associations attempt to facilitate world trade through the use of harmonized standards. In the Austro-Hungarian Empire between 1897 and 1911, a collection of standards and product descriptions for a wide variety of foods was developed as the Codex AlimentariusAustriacus. Although lacking legal force, it was used as a reference by the courts to determine standards of identity for specific foods. The present days Codex Alimentarius draws its name from Austrian code. The second half of the nineteenth century saw the first general food laws adopted and basic food control systems put in place to monitor compliance. During the same period, food chemistry came in recognition as a reputed discipline and the determination of the purity of a food was then based on chemical parameters of simple food composition.

When harmful industrial chemicals were used to disguise the true color or nature of the food, the concept of adulteration was extended to include the use of hazardous chemicals in food. Science had begun providing tools with which to disclose dishonest practices in the sale of food and to distinguish between safe and unsafe edible products. This leaded to a greater apprehension on the part of consumers. Whereas, previously consumers' concerns had extended only as far as the 'visible'- the underweight contents, size variations, misleading labeling and poor quality. - they now embraced a fear of the' invisibles', i.e. health hazards could not be seen, smelled or tasted, such as microorganisms, pesticide residues, environmental contaminants and food additives. With the blossoming of well-organized and informed consumers' groups, both internationally and nationally, there was growing pressure on governments worldwide to protect the communities from the hazardous and the poor quality of goods.

In 1945, Food and Agriculture Organization (FAO) was founded with responsibilities covering nutrition and associated international food standards. In 1948, World Health Organization was founded (WHO) with responsibilities covering human health and in particular, a mandate to establish food standards. In 1950, Joint FAO/WHO expert meetings began on nutrition, food additives, and related areas. In 1960, the first FAO Regional Conference for Europe endorsed the desirability of international as distinct from regional agreement on minimum food standards and invited the Organization's Director General to submit proposals for a joint FAO/WHO programme on food standards to the Conference of FAO.

In 1961, with the support of WHO, the Economic Commission for Europe (ECE), the Organization for Economic Co-operation and Development (OECD) and the Council of the Codex AlimentariusEuropaeus, the FAO Conference establishes the Codex Alimentarius and resolves to create an international foods programme. In 1985, the United Nations General Assembly Guidelines for Consumer Protection evolved which stated that 'When formulating national policies and plans with regards to food, Governments should take into account the need of all consumers for food security and should support and, as far as possible, adopt standards from the Food and Agriculture Organization's and the World Health Organization's Codex Alimentarius.

In 1992, the FAO/WHO International Conference on Nutrition recognized that access to nutritionally adequate and safe food is a right of each individual and that the Food Regulations of all countries should fully take into account the recommended international standards of the Codex Alimentarius Commission. In 1995, the agreement on the Application of Sanitary and Phytosanitary Measures and the Agreement on Technical Barriers to Trade formally recognized international standards, guidelines and recommendations, including the Codex Alimentarius, as reference points for facilitating international trade and resolving trade disputes in International law.

In 1996, the FAO World Food Summit committed itself to: implement policies aimed at improving physical and economic access by all, at all times, to sufficient nutritionally adequate and safe food and its effective utilization and to apply measures, in conformity with the Agreement and the Application of Sanitary and Phytosanitary Measures and other relevant international agreements, that ensure the quality and safety of food supply.

While there have been several international organizations and agreements playing a role in enhancing food safety, quality and security; facilitating research and trade worldwide, the major organizations and agreements which are playing a key role are being taken up here.

Food and Agriculture Organization (FAO).

In 1943, 44 governments, meetings in Hot Springs, Virginia, the United States, committed themselves to founding a permanent organization for food and agriculture. Subsequently, in 1945, at the First session of FAO Conference, Quebec City, Canada,establishes FAO as a specialized United Nations agency. In 1951, FAO headquarters moved to Rome, Italy from Washington DC, the United States.

The Food and Agriculture Organization of the United Nations was founded with a mandate to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the condition of rural populations. Today, FAO is one of the largest specialized agencies in the United system and the lead agency for agriculture, forestry, fisheries and rural development. An intergovernmental organization, FAO has 183 member countries plus one-member organization, the European Community.

Activities of FAO

It gives practical help to the developing countries through a wide range of technical assistance projects. FAO collects, analyses, interprets and discriminates information relating to nutrition, food, agriculture, forestry and fisheries. The Organization serves as a clearing-house, providing farmers, scientists, governmental planners, traders and non-governmental organizations with the information they need to make rational decisions on planning, investment, marketing, research and training. The organization also advises on national strategies for rural development, food security and poverty. It provides neutral form for all nations to meet and discuss about the policies on major food and agriculture issues. FAO approves international standards and helps frame international conventions and agreements. It also hosts major conferences, technical meetings and consultations of experts.

World Health Organization (WHO)

The World Health Organization, the United Nations Specialized agency for health was established on 7th April 1948. The Objectives of WHO as set out in its Constitution, is the attainment by all people of the highest possible level of health. WHO is governed by 192 Member States through the World Health Assembly.

The main tasks of the World Health Assembly are to approve the WHO programme and the budget and to decide major policy questions. In carrying out its activities, WHO secretariat focuses its work on the following core functions:

- Articulating consistent, ethical and evidence based policy and advocacy positions.
- Managing information by assessing trends and comparing performance, setting agenda for, and stimulating research and development.
- Setting, validating, monitoring and pursuing the proper implementation of norms and standards.
- Stimulating the development and testing of new technologies, tools and guidelines for disease control, risk reduction, health care management and service delivery.

The WHO Secretariat is headed by the Director General, who is nominated by the Executive board and elected by member states for a period of five years.

Codex Alimentarius

The Codex Alimentarius came into being in response to a widely recognized need. It was the product of a long evolutionary process involving a wide cross-section of the global community. Many people representing many interests and disciplines were involved in the process, and it is not unreasonable to suppose that, as long as the need perceived by those people remains, so the Codex Alimentarius will remain.

The role of the Codex Alimentarius Commission has evolved with the development of the Codex itself. Creating standards that at once protect consumers ensure fair practices in the sale of food and facilitate trade, is a process that involves specialists in numerous food related scientific disciplines, together with consumers' organizations, production and processing industries, food control administrators and traders. The Codex Alimentarius Commission sensitizes the global community to the danger of food hazards as well as to the importance of food quality; and hence to the need for food standards. By providing an international focal point and forum for informed dialogue on issues relevant to food, Commission fulfils a crucial role, it generates reputable scientific texts, convenes numerous expert committees and consultations as well as international meetings attended by the best informed individuals and organizations concerned with food and related fields. Countries have responded by introducing long overdue food legislation and Codex based standards and by establishing or strengthening food control agencies to monitor compliance with such regulations.

The Codex Alimentarius has:

- Formulated 237 food standards for commodities
- Formulated 41 codes of hygienic or technological practices.
- Evaluated 185 Pesticides
- Prescribed limits for pesticide residues
- Developed guidelines for 25 contaminants
- Evaluated 1005 food additives
- Evaluated 54 veterinary drugs

World Trade Organization (WTO).

The World Trade Organization came into existence in 1995. One of the youngest International Organizations, WTO is the Successor to the General Agreement on Tariffs and Trade (GATT) established in the wake of the Second World War.

The past 50 years have seen an exceptional growth in world trade. Merchandise exports grew on average by 6% annually. Total trade in 2002 was 22 times the level of 1950. GATT and the WTO have helped to create a strong and prosperous trading system contributing to unprecedented growth. The WTO's objective is to help trade flow smoothly, freely, fairly and predictably. It does this by administering trade agreements, setting trade disputes, acting as a forum for trade negotiations, reviewing national trade policies, assisting developing countries in trade policy issues through technical assistance and training programs& cooperating with other international organizations.

The WTO has more than 140 members, accounting for over 97 % of world trade. Decisions are made by the entire membership and typically by consensus. The WTO's top level decision making body is the Ministerial Conference which meets at least once every two years.

The Benefits of WTO Trading system includes:

- The system helps promote peace
- Disputes are handled constructively
- Rules make life easier for all
- Free trade cuts the costs of living
- It provides more choice of products and qualities
- Trade raises incomes
- Governments are shielded from lobbying
- Trade stimulates economic growth.

International Plant Protection Convention (IPPC).

The IIPC is a multilateral treaty deposited with the Director General of the Food and Agriculture Organization of the United Nations (FAO) and administered through the IPPC Secretariat located in FAO's Plant Protection Service. 117 Governments are currently contracting parties to the IPPC. The IPPC came into force in 1952 and has been amended once in 1979 and again in 1997. The purpose of the IPPC is to secure common and effective action to prevent the spread and introduction of pests and plants and plant products and to promote measures for their control. The Convention provides a framework and forum for international cooperation, harmonization and technical exchange in collaboration with the regional and national plant protection organizations. The IPPC plays an important role as the international standard setting body for International Standards for Phytosanitary measures (ISPMs). Although, the IPPC has strong implications for international trade, it has international cooperation for plant protection as its focus. Its application to plants is not limited only to the protection of cultivated plants or direct damage from pests. The scope of the Convention extends to the protection of cultivated and natural flora as well as plant products and includes both direct and indirect damage by pests.

Agreements on Sanitary and Phytosanitary measures (SPS) and Technical Barriers to Trade (TBT).

The Agreement on Sanitary and Phytosanitary Measures sets out the basic rules for food safety and animal and plant health standards, it allows countries to set their own standards. It also says regulations must be based on science. They should be applied only to the extent necessary to protect human, animal or plant life or health. They should not arbitrarily or unjustifiably discriminate between countries where identical or similar conditions prevail. Member countries are encouraging to use the international standards, guidelines and recommendations where they exist. However, members may use measures which result in higher standards if there is scientific justification.

The key features of SPS

All countries maintain measures to ensure that food is safe for consumers, and to prevent the spread of pests or diseases among animals and plants. The sanitary and phytosanitary measures can take many forms, such as requiring the products to come from a disease free area, inspection of products, specific treatment or processing of products, setting of allowable maximum levels of pesticide residues or permitted additives in food. Sanitary (human and animal health) and phytosanitary (plant health) measures apply to domestically produced food or local animal and plant diseases, as well as to products coming from other countries. All Governments accept the fact that some trade restrictions may be necessary to ensure food safety and animal and plant health protection. A sanitary or phytosanitary restriction can be very effective protectionist device for health reasons.

The basic aim of the SPS Agreement is to maintain the sovereign right of any government to provide the level of health protection and also to ensure that these sovereign rights are not misused for protectionist purposes and do not result in unnecessary barriers to international trade. Measures to ensure food safety and to protect the health of animals and plants should be based as far as possible on the analysis and assessment of objective and accurate scientific data. The SPS encourages governments to establish national SPS measures consistent with international standards, guidelines and recommendations. Most of the WTO members' governments participate in the development of these standards in other international bodies. The standards are developed by leading scientists in the field and governmental experts on health protection and are subject to international security and review.

Due to differences in climate, existing pests or diseases, or food safety conditions, is not always appropriate to impose the same sanitary and phytosanitary requirements on food, animal or plant products coming from different countries. Therefore, sanitary and phytosanitary measures sometimes vary, depending on the country of origin of the food, animal, or plant product concerned. This is taken into account in the SPS Agreement. Many Governments use risk assessment in their management of food safety and animal and plant health, the SPS agreement encourages the wider use of systematic risk assessment among all WTO member governments and for all relevant products.

In the Tokyo Round of multilateral trade negotiations (1974-79), an agreement on Technical Barriers to Trade was negotiated (the 1979 TBT Agreement or 'Standards Code'.). Although this agreement was not developed primarily for the purpose of regulating sanitary and phytosanitary measures, it covered technical requirements resulting from food safety and animal and plant health measures, including pesticide residue limits, inspection requirement and labeling. The TBT agreement covers all technical regulations, voluntary standards and the procedures to ensure that these are met, except when these are sanitary or phytosanitary measures as defined by the SPS Agreement. The TBT measures could cover any subject, most measures related to human disease control are under the TBT Agreement. In terms of food, labeling requirements, nutrition claims and concerns, quality and packaging regulations are generally not considered to be sanitary or phytosanitary measures and hence are normally subject to the TBT Agreement.

ISO 9000 and ISO 14000

The ISO 9000 and ISO 14000 families are among ISO's most widely known and successful standards ever. ISO 9000 has become an international reference for quality requirements in business to business dealings, and ISO 14000 looks set to achieve at least as much, if not more, in helping to meet their environmental challenges.

ISO 9000 is concerned with 'quality management', this means what the organization does to enhance customer satisfaction by meeting customer and applicable regulatory requirements and continually to improve its performance in this regard. ISO 14000 is primarily concerned with 'environmental management'. This means what the organization does to minimize harmful effects on the environment caused by its activities and continually to improve its environment performance.

Both ISO 9000 and ISO 14000 concern the way an organization goes about its work, and not directly the result of this work. They both are concerned with processes, and not products, at least not directly. Nevertheless, the way in which the organization manages its processes is obviously going to

affect its final product, in the case of ISO 9000, it is going to affect whether or not everything has been done to ensure that the product meets the customers' requirements. In the case of ISO 14000, it is going to affect whether or not everything has been done to ensure a product will have the least harmful impact on the environment either during production or disposal, either by pollution or by depleting natural resources. The earlier three standards ISO 9001, ISO 9002 and ISO 9003 have been integrated into new ISO 9001-2000.

4.12 CONSUMER CHALLENGES

Food safety is the most important issue for all the countries. There are various challenges in the food production cycle. Starting from harvesting to the making of the end product and transportation there is a number of risk factors involved in the cycle. The safety of food has thus increased because of the increased urbanization resulting in greater requirements for transport, storage, preparation of food etc. Thus the responsibility of the food safety agencies has increased and a need of communication is being developed to prevent the outbreak of the food borne diseases.

It has been observed that significant progress has been made in many countries in making the food safer but unawareness of the consumer is also one of the reasons in causing the mishaps in safety of food. The government is trying to make the consumers aware of risks posed by the pathogenic microorganisms and chemical substances in the food supply. The introduction of new food processing technologies like irradiation is one of the most special challenges in this field. The Government of India enforced the Consumer Protection Act (1986) to empower the consumers.

According to the Consumer Protection Act, the rights are as follows:

- Right to be protected against marketing of goods and services which are hazardous to life and property.
- Right to be informed about the quality, quantity, potency, purity, standard and price of goods and services so as to protect the consumer against unfair trade and practices.
- Right to be assured, wherever possible, of access to variety of goods and services at competitive prices.
- Right to be heard and to be assured that consumers' interests will receive due consideration to appropriate forums.
- Right to seek redressal against unfair trade practices and unscrupulous exploitation of consumers.
- Right to consume education.

4.13 SUMMARY

- Food-borne diseases are one of the biggest threat to the consumer health.
- A food borne diseases outbreak is possible if the foods are not properly handled and subjected to various types of contaminants. These contaminants can be of natural origin like biogenic amines, alkaloids, phenolic compounds, protease inhibitors and phytates.
- Apart from the natural contaminants there are certain contaminants that may enter the food from the environment due to unhygienic practices. Such contaminants may include residues, certain heavy metals like arsenic.
- Contaminants of biological origin include the pathogenic microorganisms and the toxins produced by them.
- The entry of contaminants leads to serious disease outbreaks like botulism, which is caused by the pathogenic bacteria, clostridium botulinum.
- To keep away the microorganisms, proper storage practices have to be developed. The temperature and moisture of the storage area should be such that it does not permit the microbial growth.
- If the factors are controlled which favor the growth of microorganisms, then the spoilage of food can be controlled.
- The microorganisms responsible for causing spoilage of food are bacteria, yeasts and molds. The growth of microorganisms in food largely depends on the pH of the foodstuff.
- There are various methods of preservations used to preserve the food.
- The short period preservation and the long period preservation are the two methods utilized for the preservation of the food.
- The danger zonetemperature ranges from around 8°C to 63°C.
- The microorganisms are harmful as well as useful in nature.
- Food infections occur when a person consumes food that is infected by pathogenic microorganisms. The illness caused due to consumption of toxins produced by microorganisms in food is known as food intoxication.
- Food borne illness is caused by eating food or drinking beverages contaminated with bacteria, parasites or viruses. Harmful chemicals can also cause food borne illness if they have contaminated food during harvesting or processing. These illnesses can cause symptoms such as diarrhea, fever, vomiting, abdominal cramps and dehydration.
- Food irradiation is the treatment of food with high energy such as gamma rays, electron beams or X-rays as a means of cold pasteurization, which destroys living bacteria to control

food borne illnesses. The government relies exclusively on the use of gamma rays, which are similar to ultraviolet light and microwaves and pass through food leaving no residue.

- The term mycotoxinsis used for the toxic chemical products formed by a few fungal species that readily colonise crops in the field or after harvest and thus pose a potential threat to human and animal health through the ingestion of food products prepared from these commodities.
- Several viruses like hepatitis A, Norwalk, Norwalk like viruses, poliovirus and echovirus may cause food borne disease in consumers of virus contaminated water and foods.
- There are various methods for the analysis of the bacteria, viruses and fungi. These can be done for bacillus cereus, clostridium botulinum, clostridium perfringens, salmonella, listeria, staphylococcus aureus etc.
- There are many symptoms seen during the food spoilage such as off odors, sliminess, deterioration, souring etc. There are two types of spoilages seen: microbial and non microbial.
- Various examples can be given under the spoilage of food such as spoilage of milk and milk products, spoilage of cereal and cereal products, spoilage of poultry, meat, fish, eggs, vegetables, canned products etc.
- PFA, Commodities Act, standard of weights and Measures Act, Bureau of Indian Standards Act, AGMARK rules, Export Act etc are all designed on the National level to safeguard the interest of the consumer's health.
- International Organizations and Agreements in Food standardizations like FAO, WHO, WTO, Codex Alimentarius, GATT, SPS and TBT all comprise with the rules and regulations to guarantee and safeguard the human health to keep them away from hazards. Thus the work of these international organizations is to give a platform to the members of various countries to meet a common task of safeguarding the human health on this planet.

4.14 KEY TERMS

- Contaminant- it is any substance not intentionally added to food.
- Toxins- Poisononous substances.
- Brass- An alloy of copper and zinc.
- Pesticide-Chemicals used to kill pests.
- Food infection- It is an illness caused by the microorganisms.
- Food poisoning- This is an infection when a person consumes food that is infected by pathogenic microorganisms.
- Danger zone-Temperature between 5 to 63 degrees centigrade where bacteria multiply.
- Food irradiation- It is the treatment of food with high energy such a gamma rays, electron beams or x-rays.
- Mycotoxins-Poisonous substance formed due to fungus.
- Food spoilage- A process where the food changes its color, texture, odor and flavor producing toxins into it.
- Preservation- A process to keep the food safe or increase its shelf life.
- Dehydration- A process in which the moisture content is removed.
- Smoking- A process of preservation where the food product is subjected to heat imparting a smoky flavor.
- Deep freeze- Temperature around -18 degrees centigrade or even less.

4.15 END QUESTIONS

1. What do you understand by Preservatives?
2. What are mycotoxins? Give examples.
3. What do you understand by Food Spoilage?
4. What is food preservation? Discuss the importance and its principles.
5. What are the signs of food spoilage?
6. Discuss the spoilage microorganisms.
7. Elaborate the methods of analysis of microorganisms. Any 2.
8. Elaborate the functions of FAO
9. Elaborate the functions of WHO
10. Elaborate the functions of WTO
11. Elaborate the functions of FAO
12. Elaborate the functions of Codex Alimentarius.
13. Explain the various sources of contaminations to the food.
14. Discuss the various Biological sources of contaminations to the food.
15. Elaborate the various natural toxin contaminations to the food.
16. Describe the various Toxic metals and chemicals as contaminations to the food.
17. Explain the various pesticide residues as contaminations to the food.
18. Explain the concept of food borne illnesses.
19. Discuss the causes of food borne diseases.
20. Discuss the various bacteria which spread food-borne illnesses.
21. Elaborate the role of Enterotoxins in food borne illnesses.
22. Explain the methods to prevent bacterial food borne illnesses.
23. Elaborate the role of Mycotoxins in food borne illnesses.
24. Elaborate the role of virus in food borne illnesses.
25. Elaborate the role of parasites in food borne illnesses.
26. Elaborate the role of natural toxins in food borne illnesses.
27. Explain the mechanism of infection.
28. Elaborate the concept of incubation period.
29. Discuss the concept of infectious dose.
30. Compare the spread of food borne illness in USA and France.
31. Discuss the prevalence of food borne illness in Australia.
32. Explain how contaminants enter the food during processing.
33. Elaborate the main sources of contaminations in food.
34. Explain the concept of food preservation.
35. Elaborate on the traditional methods of food preservation.
36. Explain how curing works in preserving the food.
37. Explain how cooling works in preserving the food.
38. Explain how freezing works in preserving the food.
39. What is the difference between freezing and cooling methods of preserving food.
40. What is the effect on nutrients for frozen food?
41. Explain how boiling works in preserving the food.
42. Explain how heating works in preserving the food.
43. What is the difference between boiling and heating methods of preserving food.
44. Explain how sugaring works in preserving the food.
45. Explain how pickling works in preserving the food.
46. What is the difference between sugaring and pickling methods of preserving food.
47. Explain how lye (NaOH) works in preserving the food.
48. Explain how canning works in preserving the food.
49. Explain how jellying works in preserving the food.

50. Explain how jugging works in preserving the food.
51. Explain how burial works in preserving the food.
52. Explain how fermentation works in preserving the food.
53. Explain how pasteurization works in preserving the food.
54. Explain how vacuum packing works in preserving the food.
55. Explain how food additives works in preserving the food.
56. Explain how modified atmosphere works in preserving the food.
57. Explain how irradiation works in preserving the food.
58. Explain how pulse electrical field elctroporation works in preserving the food.
59. Explain how high pressure (pascalisation) works in preserving the food.
60. Explain how biopreservatives works in preserving the food.
61. Explain concept of hurdle technology in preserving the food.
62. Explain the features of the PFA Act
63. Explain the features of the The Essential Commodities Act
64. Explain the features of the AGMARK
65. Explain the features of the BIS

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APPENDIX

Guide showing the storage of certain fruits and vegetables

Commodity	Temperature (° C)	Temperature (° F)	Storage life (Weeks)	Post storage life (Days)
Apples	2-3	35-38	12-18	9
Apricots	-1to 0	31-32	1-2	-
Beans	0-2	23-35	2-3	-
Beetroot	0-2	32-35	6-8	-
Brinjal	8-10	47-50	3-4	-
Cherries	-1 to 0	30-32	2-3	-
Carrots	0-2	32-35	13-17	-
Cabbage	0-2	32-35	9-13	-
Cauliflower	1-2	34-35	4-6	-
Guavas	8-10	47-50	4	-
Grapes	0-2	32-35	8	-
Lemons	5-7	42-45	6	3
Mangoes(Alphonso)	8-10	47-50	4	-

Oranges	5.5-7	42-44	18	-
Papaya	4-5.5	39-42	5	3
Pears	-1 to 0	30-32	12	-
Peaches	-1 to 0	30-32	4-6	-
Peas	0-2	32-35	2-3	-
Turnips	0-2	32-35	2-3	-
Tomatoes	4-7	40-45	3-4	-

Food	**Storage time**	**Special Handling**
Baking powder	18 months	Keep covered & dry
Breadcrumbs(dried)	6months	Keep covered & dry
Cereals	4 months	Keep covered & dry
Coffee (tinned)	1 month	Keep covered & dry
Condensed & evaporated milk	1 year	Refrigerate after opening
Flour (All types)	6-8 months	Airtight container

Honey/jams/syrups	One year	Airtight container
Pastas	One year	Airtight container
Rice	2years	Tightly closed
Salad oil	1-3 months	-
Shortening, solid	8 months	-
Sugar, brown, confectioners	4 months	Airtight container
Tea	2 years	Airtight container
Fruits-Canned	1year	Keep it in cool place
Fruits-Dried	6 months	Airtight container
Meat/Fish/Poultry (canned)	1year	-
Vegetables, canned & dried	1 year	Keep in cool place
Gravies-canned	1 year	-
Ketchup opened	1 year	Keep in cool place
Herbs & spices	-	Keep in airtight containers
Tabasco, Worcester	18 months – 2 years	Keep away from sunlight

Butter, margarine	1-2 weeks	Keep it refrigerated
Cheese	5 days to 2 weeks	Keep refrigerated & nicely wrapped
Cheese (unopened)	3-6 months	Keep refrigerated & nicely wrapped
Eggs	2-3 weeks	Keep in cool place, away from sunlight.
Milk	3-4days	Keep refrigerated & tightly covered

Fresh Fruits & Vegetables

Apples	1 week	Keep in cool place
Berries, cherries	1-2 days	Keep in a cool place
Citrus fruits	1 week	Keep in a cool place
Melons	1 week	Keep in a cool place
Beets, Carrots, Radishes	2 weeks	Keep in crisper
Onions, potatoes	2-3 days	Refrigeration not required
Mushrooms	1-2 days	Refrigeration not required, but keep in a cool place.

Greens, cabbage	1-2 days	Keep in moisture resistant wraps or bags. Keep in a cool place.
Unshelled peas	3-5 days	Keep in crisper or moisture resistant wraps or bags.
Other vegetables	3-5 days	Keep in crisper or moisture resistant wraps or bags.

Meat, Fish and Poultry (Fresh Uncooked).

Beef, Lamb, Pork	3-4 days	Store in the coldest part of the refrigerator or in meat keeper.
Fish & Shellfish	1-2 days	Store in the coldest part of the refrigerator or in a meat keeper
Poultry	2 days	Keep in a refrigerator or meat keeper.

Canned Food after Opening

Fish & Sea Food	1 day	Keep in the coldest part of a refrigerator.
Fruits	1 week	Keep in a refrigerator
Gravies, Broths	2 days	Keep in the coldest part of the refrigerator.
Sauce, tomato based	4-5 days	Keep it refrigerated
Vegetables	2-3 days	Keep it refrigerated
Pickles, Olives	1 month	Olives can be refrigerated. Pickles could be kept in a cool place away from sunlight.

Other Foods

Coffee	2 weeks	Keep tightly covered after opening
Honey, jam, jellies, syrups	2 weeks	Can be refrigerated or kept in cool place.
Nuts	9 months	Keep in airtight container, keep in cool place.
Onions & Potatoes	2 weeks	Keep at room temperature or in a cool place.
Parmesan cheese	2 months	Keep tightly closed in a refrigerator.

Soft drinks	3-6 months	Refrigerate for longer storage
Wines	2-3 days	Keep refrigerated.

Freezer Storage

Bacon	1 month
Minced Beef, lamb	4 months
Ham slices	1 month
Roasts (Beef)	1 year
Roasts (Lamb)	9 months
Sausages-Dry-Smoked	1 month
Sausages (Fresh Beef)	2 months
Steaks ()	1 year
Steaks (lamb)	9 months
Steaks (Pork)	06 months
Lean fish	6 months
Fatty fish	3 months
Oysters	4 months

Shrimps	1 year
Clams	3 months
Poultry	9-10 months.
Fruits	Before 1 year
Vegetables	6-8 months
Milk	3 months
Cream-light & heavy	2 months

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