FOOD MICROBIOLOGY AND SAFETY

M.Sc. - 104

Directorate of Distance Education

SWAMI VIVEKANAND SUBHARTI UNIVERSITY

MEERUT 250005

UTTAR PRADESH

SIM MOUDLE DEVELOPED BY:

Reviewed by the study Material Assessment Committed Comprising:

1. Dr. N.K.Ahuja, Vice Chancellor

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CONTENTS

UNIT

1

MICROBIOLOGY OF FOODS

STRUCTURE

1.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- Understand the history and historical development of food microbiology,
- Describe what is biotechnology and its role in the food industry,
- Enumerate the various fermented food preparations produced by the use of microorganisms, and
- Discuss other uses of microorganisms in the food industry.

1.2 INTRODUCTION

This course introduces you to the discipline called food microbiology. In this unit, we will try to understand the historical aspects and development of food microbiology over the years. Food microbiology, as a discipline, has evolved to accommodate various modern developments. We will look at the role of microbiology in biotechnology and see how efficiently a microorganism can be improved by bio-engineering. Further, we will understand the role of microorganisms- in preparing different fermented products and discuss other uses of microorganisms in the food industry.

1.3 FOOD MICROBIOLOGY

We start our learning of food microbiology by first understanding what microbiology is.

Food microbiology is the study of the microorganisms that inhibit, create, or contaminate food. This includes the study of microorganisms causing food spoilage; as well as, 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. Then those researchers with other useful roles such as producing probiotics. Microbiology is the branch of biolou that deals with microorganisms and their effects on other living organisms.

Microorganism, as you may already know, is a microscopic organism, such as a bacteria, virus, algae, fungus, protozoan etc. So why do we need to study and learn about these microbes? Microbes can spoil the foods, can cause food borne diseases and interestingly, some of them are also useful. The relationship between microorganisms and food has been a subject of study for long and has been recognized as a separate area of study referred to as 'food microbiolou'. It is, in fact, a branch of microbiology concerned with the relationships between microorganisms and food. Food microbiology concerns with the interactions between microorganisms, food and us the community. It covers food borne disease, food hygiene, food spoilage, fermented foods and beverages, use of microorganisms to produce food ingredients and processing aids, microbiological aspects of quality control, conventional and novel methods for the microbiological analysis of foods and aspects of food legislation. Food microbiology therefore, is a vast field of study in itself.

1.4 HISTORY OF FOOD MICROBIOLOGY

The microorganisms were first observed using primitive microscopes as early as the late 1600s. The science of microbiology is barely 150 years old. A dramatic development and broadening of the subject of microbiology has taken place since World War II. It is extremely difficult to pinpoint the precise beginnings of man's awareness of the presence and role of microorganisms in foods, evidence available at this time indicates that this knowledge preceded the establishment of microbiology as a science. The era prior to this may be further divided into what has been called as man's 'food gathering period' and the 'food producing period'.

The food-gathering period may be from origin of man to 10,000 years ago. During this period, man was presumably carnivorous in his eating habits, with plant foods coming into his diet later in this period. The food producing period dates from 10,000 years ago to present time. Between 3000 BC and 1200 BC, the Jews employed salt in the preservation of various foods. The use of curds involving fermentation of milk was known in India since the Vedic period. The epic Mahabharata dating 5000 BC contains references to milk products like curd and butter.

It is presumed that man first encountered problems of spoilage and food poisoning early in the period with the advent of prepared foods. The problem of disease transmission by food and taste spoilage due to improper storage both made their appearance.

The first man to suggest the role of microorganism, in spoiling food was A. Kiremer. In 1658, he examined decaying bodies, meat, milk or other solutions and saw what he referred to as "worms" invisible to the naked eye. Subsequently, L. Pasteur (1837) was the first man to appreciate and understand the presence and role of microorganisms in food. In 1860, he employed heat to destroy undesirable organisms present in wine and beer.

So then, starting from 150 years ago till date, food microbiology, as a discipline, has evolved to accommodate various modem developments. We learnt that microorganisms can cause food spoilage and disease, though not all microorganisms are harmful. Some organisms play a beneficial role in nutrition and well being of humans. This aspect has been studied and great advancements have been made in this area. Some of the recent developments in food microbiology are discussed next:

a) **Probiotics**: The word 'Probiotic' is a Greek word and it means "for life". It refers to microorganisms and their culture products, which contribute 10 the intestinal microbial balance, thus benefiting the host by protecting against disease or improvising its nutrition. It is well known that probiotics, like lactobacillus, assist in the digestion of lactose, inactivate toxins, bind cancer causing chemicals, modulate the gut flora and reduce cholesterol absorption in the gut.

b) **Biotechnology**: You must have heard the word 'biotechnology'. In today's world, it is one of the most extensively used branches of science to develop/ generate better quality foods in the market. Biotechnology is a series of enabling technologies that involve the manipulation of living organisms or their sub-cellular compounds to make or modify products to improve plants or animals or to develop microorganisms for specific uses. If these specific uses are meant to enhance the production, processing and distribution of safe, nutrition foods, then it is "food biotechnology". Microorganisms including bacteria and moulds have been used for the production of fermented meat,. vegetable products as well as wine, beer etc. and for producing food additives like flavor enhancers, stabilizers, colors and preservatives. However, with the advent of newer genetic engineering techniques developed in the last 30 years, tremendous developments have taken place in food biotechnology. Genetically engineered crops, processing and ingredients are gaining a regular approval and are entering the markets. Let us learn more about this new, interesting branch of science geared towards developing better quaky of food in the next section.

1.5 ROLE OF MICROBIOLOGY IN BIOTECHNOLOGY

The word biotechnology is derived from the word "bio" meaning 'life or living systems', while the word "technology" is defined as 'scientific methods for achieving a practical purpose'. Biotechnology, hence, is the use of biological processes to make or change a product. Biotechnology is not new to the food sector, since human beings have been exploiting microorganisms for production, processing and preservation of foods for centuries. Biotechnology is also used to genetically

modify plants or animals and control particular attributes. How is this done? Let us look at some of the uses of biotechnology through genetically modifying foods and improving the nutritional status of the population.

Genetically Modified Foods

Modern biotechnology techniques are now used by the scientists to be able to identify individual genes that control particular characteristics. The selected gene can be transferred to another plant or animal to bring about a desired change. We have talked about 'genes' here. What are gepes? Genes are composed of specific lengths of deoxyribonucleic acid (DNA) strands intertwined in a spiral called as the double helix as shown in Figure 1.1. It is this DNA which gives the individual characteristics to all plants and animals. For e.g. the color of a flower's petals, fair or dark skin complexion or the brown or blue cultured eyes.

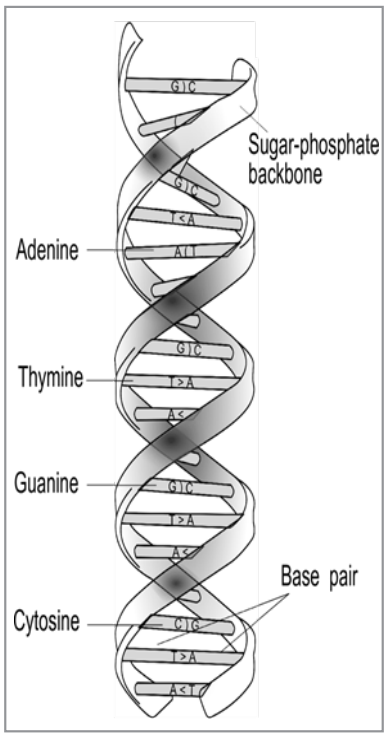

Figure 1.1: Double helical structure of DNA

The use of biotechnology and understanding the nature of DNA has led to what we call as 'genetic modification It is a technique of changing by inactivating, deleting or inserting genes to produce a desired characteristic. In this technique, selected individual genes are transferred from one organism (microbes, plant or animal) to another organism. When genes are transferred from one species to another, transgenic organisms are produced. Foods produced by genetically modified technique are called Genetically Modified or GM Foods. The term 'Recombinant technology' or 'Biotechnology' is often used to describe genetic modification process.

What is the genetic modification process?

Let us next briefly review the process. Initially, the gene that carries the desirable characteristic is identified. Then a gene from a second strain carrying the desired trait is inserted, which produces a genetically modified variety which is identical to the original variety with the improved desirable characteristics.

The first GM plants were created in 1983. Since then a variety of crop plants such as maize, soybean, rice, rapeseed (mustard), tomato, cotton, potato etc. have been modified by this technique. What are the benefits of genetic modification? Among the many benefits of genetic modification, reduction in the use of pesticides or herbicides, higher yields, better quality food, foods with greater shelf life, nutritional improvement and enhancement in processing qualities are some of the important benefits of genetic modification. Let us understand this concept better by looking at the benefits of genetically modifying a few of the food items:

a) **Tomatoes**: It was discovered in the Nottingham University in the UK that it• is possible to slow down the softening process of tomatoes by genetically modifying the tomato plant. This helped to increase the shelf-life of tomato, keeping it fit to eat for longer and reducing waste during processing.

b) **Maize**: The European corn was made pest-resistant by inserting a gene from the naturally occurring soil bacterium Bacillus thuringiensis. The gene produces a protein that acts as an insecticide, but is harmless to other creatures.

c) **Golden rice**: The natural varieties of rice do not provide vitamin A. Vitamin A deficiency, as you may already know, could lead to blindness, decreased immunity to diseases and deaths of more than a million children. So, the scientists in Switzerland genetically enhanced rice to be rich in ß carotene (a precursor of vitamin A, to be converted to vitamin A in the body) by re-engineering the genes that imparts yellow color to daffodils. Interesting isn't it!

d) **Vaccines**: In US, foods such as potatoes, tomatoes and bananas that can carry vaccine for the infectious liver disease — Hepatitis B, have been successfully produced on a small scale. Feasibility studies are being conducted to investigate whether these modified crops would help to deliver the vaccines to people living in developing countries. If the positive outcomes are indicated in these studies, it would help to save lives of many millions.

In India, so far 3 hybrids of cotton containing Bt gene produced by Mahyco,Monsanto has been approved for commercialization by the Genetic Engineering Approval Committee (GEAC) in 2002. One variety of cotton, again containing Bt gene produced by rasi seed was allowed seed production for one hybrid. Other GM crops undergoing

Field trials include:

Mustard containing barnase-bar star gene, produced by the company Proagro and another variety produced by Jawahar Lal Nehru University, Delhi. Rice and brinjal with Bt gene and tomato by the Indian Agricultural Research Institute, New Delhi.

Potato containing lysine protein gene from amaranth plant by Jawahar Lal Nehru University, New Delhi.

Besides the benefits, apprehensions about the use of genetically modified foods have been expressed and you will study about them in the next Unit. In fact, because of these apprehensions, the Government of various countries have introduced legislations to cover the development, release, cultivation, sale, import etc. of these foods. We will get to know more on this topic subsequently.

So far we have looked at the benefits of genetically modifying a few of the food items. We saw how com was made pest-resistant by inserting a gene from the naturally occurring soil bacterium. Likewise, microorganisms have other beneficial roles as well. Microorganisms i.e. bacteria, yeasts and moulds have been used since the beginning of the recorded history for the production of fermented dairy, cereal, meat and vegetable products, as well as, for fermenting the beverages such as wine and beer. Many ingredients used in foods as vitamins, stabilizers, flavor and flavor enhancers, colors and preservatives are produced by microbes.

Next, we shall briefly focus on a variety of fermentation food preparations, method of preparation and microorganisms involved in this process. This information will help you understand the role 9f microorganisms in food fermentation and in the food industry. But first, let us take a break and recapitulate what we have learrnt so far,

STUDENTS ACTIVITY - 1

1) State whether the following statements are true or false. Correct the false statement.
   a) All microbes are harmful, since they spoil foods and cause food-borne diseases.
   b) Man was primarily carnivorous during the food-gathering period.
   c) A. Kiremer was the first one to discover microorganisms in food.

1.6 ROLE OF MICROORGANISMS IN FERMENTED FOODS

Fermentation is one of the oldest forms of food preservation technologies in the world. Indigenous fermented foods such as bread, cheese and wine have been prepared and consumed for thousands of years and are strongly linked to culture and tradition, especially in the rural households and village communities.

The development of fermentation technologies is lost in the mists of history. Anthropologists have suggested that it was the production of alcohol that motivated primitive people to settle down and become agriculturists. Some even think that the consumption of fermented foods is pre-human. The first fermented foods consumed probably were fermented fruits. Hunter-gatherers would have consumed fresh fruits but at times of scarcity would have eaten rotten and fermented fruits. Repeated

NOTES

consumption would have led to the development of the taste for fermented fruits. There is reliable information that fermented drinks were being produced over 7,000 years ago in Babylon (now Iraq), 5,000 years ago in Egypt, 4,000 years ago in Mexico and 3,500 years ago in Sudan.

Bread-making probably originated in Egypt over 3,500 years ago. Several triangular loaves of bread have been found in ancient tombs. Fermentation of milk started in many places with an evidence of fermented products in use in Babylon over 5,000 years ago. There is also evidence of fermented meat products being produced for King Nebuchadnezzar of Babylon. China is thought to be the birth place of fermented vegetables and the use of Aspergillus and Rhizopus moulds to make food. The book called "Shu-Ching" written in the Chou dynasty in China (1121-256 BC) refers to the use of "chu"- a fermented grain product.

Having looked at the history of fermentation, let us review and see what fermentation is? Fermentation is the slow decomposition process of organic substances induced by microorganisms, or by complex nitrogenous substances (enzymes) of plant or animal origin. It can be described as a biochemical change, which is brought about by the anaerobic or partially anaerobic oxidation of carbohydrates by either microorganisms or enzymes.

You know that microorganisms are naturally found in foods, since there is no environment where some type of microbes cannot live. These microbes either living or dead and their cellular byproducts all have specific uses in some foods. These include such products as fermented food products. Fermented foods use microbes to convert the original food into a fermented product by the use of specific microbes. These microorganisms use the original product for growth and reproduction, and in the process, they excrete byproducts into the environment surrounding themselves and the food. These byproducts plus the part of the original product that is not consumed is the fermented food. Fermented foods include fermented dairy, meat, fish, cereals, fruits, vegetable products etc. They may be fermented separately or in conjunction with each other to produce the desirable end product.

From our discussion, so far, it is evident that, fermentation involves the introduction of the desirable microbes into the original product. Some of the common microbes used in food fermentation are highlighted herewith.

- Lactococcus lactis — used in dairy fermentation.
- Steptococcus thermophilus — used in dairy fermentation.
- Leuconostoc sp. used in wine making, dairy fermentation.
- Pediococcus sp. — meat fermentation, vegetable fermentation, ripening of some cheeses.
- Lactobacillus sp. — meat fermentation, vegetable fermentation, dairy fermentation, sourdough bread.
- Bifidobacterium sp. added to dairy products to promote intestinal health.
- Propionibacterium sp. — Swiss cheese.
- Yeasts — bread, beer, wine, liquors.

- Moulds ripening cheeses, soy sauce.
- Lactobacillus delbruekii, subspecies bulgaricus and streptococcus thermophilus making of yogurt.

Although fermentation of foods has been in use for thousands of years, it is likely that the microbial and enzymatic processes responsible for the transformations were largely unknown. It is only recently that there has been a development in the understanding of these processes and their adaptation for commercialization.

1.6.1 Fermented Baked Preparations

In baked products such as bread and bun, the yeast Saccharomyces cerevisiae which is popularly known as "baker's yeast", helps by raising the dough giving it the texture and also adding flavors? The different ingredients added gives distinctly different tastes to each of the products. The nan, which is popular in India, is made from Maida (refined wheat flour) to which salt, yeast or curd is added. It is kneaded vigorously for 15 minutes adding vegetable oil for softening. It is allowed to ferment for 30 minutes — I hour. It is then baked rapidly for 5 to 10 minutes. Intense heat causes center of the dough to expand rapidly and create a central pouch. Saccharomyces cerevisiae is mainly responsible for leavening by carbon dioxide production.

1.6.2 Fermented Vegetable Foods

We all consume vegetables either in raw or cooked form as salad preparations, soup, dry vegetables and curry or as stuffing in a variety of snacks. But, do you know, we can even consume these by making fermented products. Can you think of any such food item? Yes, of course, it is pickles which all of us relish sometimes or the other. Let us learn about these fermented vegetable products and see which microorganisms are involved in their preparation.

i) Sauerkraut

Sauerkraut is a fermented fresh cabbage product. It is popular in USA and Europe. The main organism which is involved in the fermentation of this pickle is lactic acid bacteria, Leuconostoc mesenteroides followed by Lactobacillus plantarum.

ii) Cucumber pickle

Cucumber pickle is a fermentation product of fresh cucumbers. Several lactic acid bacteria are involved in the preparation of this pickle. Lactobacillus plantarum is the most important organism required for the fermentation of cucumber pickle. Next, we shall look at the commonly consumed fermented soya products.

1.6.3 Fermented Soya bean Products

Do you enjoy Chinese food? If you have tried making it at home, you would have realized that soya sauce is a basic ingredient in Chinese cooking. In fact two of the most commonly consumed soya products are tempeh and soya sauce. We will briefly focus on the preparation of these products.

i) Tempeh

Tempeh is a highly popular soyabean preparation in Indonesia. The chief organism in this preparation is the species belonging to mould Rhizopus oligosporis soyabean mash is wrapped in a banana leaf or plastic box and the mash is inoculated with tempeh fungus by the addition of a portion of previous batch and allowed to ferment for about 24-48 hours at a temperature 30-400C, until there is a good mycelium growth. This is then sliced and prepared as per the taste, such as roasting or frying. The taste of the tempeh is considered to be bland, but it is highly nutritious.

ii) Soya sauce

Soya sauce is a very popular preparation of Japan which has received wide acceptance in many countries. This is prepared by inoculating an Aspergillus species, mostly Aspergillus oryzae in a mixture of soaked and steamed soya bean with roasted wheat in the ratio of 2:1. The mixture is allowed to be incubated for 3 to 5 days. Subsequently, it is subjected to various processing with Lactobacillus bacteria and the yeast Saccharomyces rouxii. After 3 months, the final product is filtered, pasteurized and bottled for use. We will learn more about the fermented soya products in the Principles of Food Science Course, Unit 11.

1.6.4 Fermented Dairy Products

A large number of fermented dairy products are available in our markets. These are prepared at our homes as well. How are they made and what are the microorganisms involved in their preparation?

The fermented dairy products assume greater importance in the human diets in India, as invariably, the diets mostly include milk byproducts especially the cheese, butter, yogurt, dahi etc. A variety of bacterial yeasts and moulds are involved with the fermentation of dairy products. We will begin our discussion with cheese.

i) Cheese

There are several varieties of cheese manufactured all over the world. All types of cheese are the byproducts of lactic fermentation of milk. There are several varieties of cheese which are classified as hard, semi-hard and soft cheese. These are prepared with culturing of the milk either with bacterial or mould species. Among the several varieties, the popular ones are cheddar cheese and swiss cheese which are known as 'hard cheese' whereas roquefort cheese (blue cheese) is a semi-soft cheese and the soft variety is the camembert cheese. The cheddar cheese originated from England and was adopted in USA, the color of which ranges from white to orange- yellow, depending upon the color added. The curing is done with the help of Streptococcus and Lactobacillus. The cheese is without the gas holes (the eyes), which characterizes the Swiss cheese. The Swiss cheese is cultured with the help of a mixed culture, L. bulgaricus, Streptococcus thermophilus and Propionibacterium shermanii which imparts the characteristic eye formation. The roquefort cheese is prepared by the inoculation of curd with Penicillium roqueforti and the camembert cheese is produced by the fermentation with Penicillium

camemberti.

ii) Dahi and Yogurt

Dahi or curd is the Indian variety, a version of yogurt and is widely used in the daily menu of an average Indian. Several organisms are involved in the preparation of dahi which contains lactic acid. Yogurt is the preparation with the action of two organisms, Streptococcus thermophilus and Lactobacilius bulgaricus. The ideal ratio of these two organisms is 1:1 for best results. In common usage, dahi refers to 'the domestically prepared fermented milk using a starter of the previous day' while yogurt refers to the 'industrially produced fermented milk using a particular bacteria as the starter.'

iii) Butter

The microorganisms which are involved in the preparation of butter are Streptococcus lactis and Streptococcus cremoris which convert the lactose in the milk to lactic acid. Then the organisms like Streptococcus diacetilactis, Leuconostoc dextranicum and Leuconostoc citrovorum are involved in imparting the aromatic flavors to the butter. The preparation of commercial butter involves aging of cream overnight at 5- 100C and culturing for 15-16 hours with bacteria.

STUDENTS ACTIVITY - 2

1) Fill in the blanks:
   a) Saccharomyces cerevisiae, popularly known as is used in the fermentation of dough by raising the dough and giving it . and
   b) A few fermented dairy products are ..and
   c) Dahi is prepared while yogurt is prepared.
   d) Roquefort cheese is prepared by inoculation with . bacteria and camembert cheese with bacteria.
   e) Organisms . and .....are involved in imparting aromatic flavors to the butter.

1.6.5 Other Fermented Food Preparations

In this section, we shall discuss food preparations that involve a combination of raw food products, which on fermentation, give appetizing and nutritious preparations. Can you list a few of such fermented food products which are formed by combination of raw food materials. Yes, these include idli, dosa, vada, dhokla etc. Let us get to know about these fermented products, starting with idli — a salty sponge cake, prepared from cereal and pulse.

i) Idli

Idli is prepared from rice and black gram dal. They are cleaned, washed and ground in equal proportions and left overnight for fermentation. The microorganisms

involved in this preparation are Leuconostoc mesenteroides, which grows first in the batter followed by Streptococcus faecalis and Pediococcus cerevisiae. Once the batter rises sufficiently, it is steam-cooked and served.

ii) Vada

Vada is prepared by soaking black gram dal in water for some time, and then ground to paste. It is then left to ferment at 23-320C for 3-12 hours, usually overnight. It IS ogy and then made into balls and deep fried in vegetable oil. The Black gram paste is fermented by lactic acid bacteria, with heterofermentative Leuconostoc mesenteroides being the major organism. The organism produces carbon dioxide which aerates the product.

iii) Dosa

Dosa is a light, shallow-fried, thin pan-cake. It is prepared from fermenting rice and black gram overnight. The aeration of batter is caused by lactic acid bacterial fermentation by Streptococcus faecalis with carbon dioxide production by Leuconostoc mesenteroides.

iv) Bhatura

Bhatura is prepared from refined wheat flour, salt and sometimes with pepper, cumin or turmeric and made into dough with water. Curd is used as a starter and the dough is fermented at 20 300C overnight. It is rolled and flattened into discs and deep fried in vegetable oil. The major organisms involved in fermentation are Streptococcus and Lactobacillus species, introduced by curd.

v) Dhokla

Dhokla is similar to idli, where rice and Bengal gram dal are used in making it yellow- coloured. Leuconostoc mesenteroids and Streptococcus faecalis are the bacteria involved in the fermentation. The batter is poured into large sheets, then steamed and cut into pieces and seasoned. Apart from helping man in preparing his foods, the microorganisms have contributed to a great extent in perpetuating man's desire for alcoholic beverages, which are the products of plant fermentation. Now let us see how these alcoholic products are prepared.

1.6.6 Economically Important Fermentation Products

Alcoholic drinks fall into two broad categories: wines and beers. Wines are made from the juice of fruits and beers from cereal grains. Primitive wines and beers have been produced, with the aid of yeasts, for thousands of years, although it was not until about four hundred years ago that microorganisms associated with the fermentation were observed and identified. It was not until the 1850's that Louis Pasteur demonstrated unequivocally the involvement of yeasts in the production of wines and beers. Since then, the knowledge of yeasts and the conditions necessary for fermentation of wine and beer has increased to the point where pure culture fermentations are now used to ensure consistent product quality. Originally,

alcoholic fermentations would have been the spontaneous events that resulted from the activity of microorganisms naturally present. These non-scientific methods are still used today for the home preparation of many of the world's traditional beers and wines. Let us learn about these products.

i) Beer

Beer is an alcoholic product, produced by brewing. It is a principal malt beverage where the fermentation of carbohydrates to alcohol takes place. Barley is used in the preparation of beer. Yeasts play a major role in the preparation of beer. Lager beer is produced by Saccharomyces uvarum, which settles at the bottom of the fermenting vat and is known as the 'bottom yeast'.

ii) Ale

Ale is produced by the strains of S. cerevisiae, which is collected at the top and is called as the 'top yeast'.

iii) Rice beer

Rice beer is a low-alcohol beverage made from rice, which is more popular in North Eastern India. The rice is milled, water is added and cooked. It is cooled and then the Starter is added and fermented for 18 hours at 20-280C. Rice beer is then decanted from the solid residue, which often is used as a breakfast cereal. The starter introduces a mixture of moulds and yeasts. The rice starch is broken down to sugars by amylase enzymes of moulds of Rhizopus, Mucor and Aspergillus species. The yeasts of Endomycopsis and Hansenula then convert the sugars to ethanol and carbon dioxide. The ragi starter contains moulds, yeasts and lactic acid bacteria. It is produced by fermenting rice or other starchy powders. This is used as a starter for several fermented foods.

iv) Wine

Wine is one of the oldest and well-known fermented alcoholic beverages produced by the fermentation of good and sound grapes which is further processed, known as aging, before consumption. Although there are other fruit wines, they are not as popular as grape wine. The grape fruits are crushed to give a "must". The fermentation of "must" is initiated by yeasts Kloeckera apiculatus and Metschnikowia pulcherrima together with the yeasts of Torulopsis, Candida etc. The main fermentation is by the yeasts, Saccharomyces cerevisiae and S. uvarum or S. bayanus which converts sugars to ethanol and carbon dioxide.

v) Champagne

Champagne is a product of secondary fermentation. Fresh must, yeast and sugar are added to the wine selected for champagne preparation. vi) Distilled liquor products The distilled alcoholic products of interest are rum, brandy and whisky. These products are manufactured from the distillation of yeast fermentations of sugar cane juice, molasses, grains and grain products.

a) Rum

Rum is an alcoholic distillate of fermented sugarcane juice or molasses.

b) Brandy

An alcoholic beverage produced after distillation from fruit wines/grape wine. The brandy is produced by distilling grapes or other fruit wines.

c) Whisky

Whisky is produced by distilling the fermented mash of wheat, barley, malt and other grains with Saccharomyces cerevisiae. After learning about the economically important fermented products, we move on to studying the other uses of microbes in the industry.

1.6.7 Other Uses of Microbes in Industry

Here in this section, we shall study about the different microbes used in the food industry to manufacture the products of commercial value namely vinegar citric acid, antibiotics etc.

i) Vinegar

If the alcohol produced by the fermentation process is further oxidized to acetic acid by the acetic acid-producing bacteria, the product is vinegar. Vinegar is made by different processes. It can be made from fruit juices, starchy vegetables, malted cereals, sugars and alcohol. Vinegar is widely used as a preservative in food preparation.

ii) Enzymes

Enzymes are the protein substances produced by the living cells which catalyzes a biochemical reaction. They accelerate a specific chemical reaction. Enzymes, which are known as biocatalysts, are very useful in the manufacturing of several products of commercial value. The enzymes are widely used for the manufacture of alcoholic beverages etc. The enzyme a-amylase used in bread- making, is commercially prepared from Aspergillus oryzae. The amyloglucosidase, used as a substitute for malt in the production of beer and spirits, is commercially prepared from Aspergillus niger. Pectolytic enzymes are produced from a number of fungi for use in fruit processing. Cellulase enzyme used for removing cellulose cloud and clarifying juices is produced from the mould Trichoderma viride and proteases used in cheese-making from Aspergillus niger.

iii) Amino acids and Vitamins

The importance of amino acids and vitamins in human health is well-recognized. Several microbes have been used for their productions which are biologically suitable. Yeast is one of the best sources of the vitamin B complex. A number of preparations of high potency vitamin B-complex made from dried yeast and yeast extracts are available in the market. Riboflavin, one of the B-group vitamins,

is produced from the yeast Eremothecium ashbyii. Ergosterol, the precursor of vitamin D is synthesized by a number of moulds and yeasts. ß-carotene is produced commercially by fermentation using the mngus Rhodotorula.

iv) Citric acid

Citric acid is one of the widely used chemical which finds applications in several divergent industries such as pharmaceuticals, flavouring extracts in food preparations, dyeing etc. Citric acid is produced by the mould Aspergillus niger, which converts sugars to citric acid where molasses is generally the raw material.

v) Antibiotics

Apart from giving man several food products, certain microorganisms, especially moulds have given products which are life-saving. The antibiotics are the products of living organisms, which in small proportions could be acting as inhibitory agent for the growth of other microbes. The discovery of Penicillin produced by Penicillium notatuni by Sir Alexander Fleming in 1929 has triggered off the manufacturing of modern antibiotics. There are over 600 antibiotics derived from bacteria and over 150 from fungi. The genus Streptomyces has yielded a wide range of useful antibiotics such as streptomycin, aureomycin, chloromycetin and terramycin.

From our discussion above, it is evident that there is a tremendous scope and potential for the use of microorganisms towards meeting the growing world demand for food, through an efficient utilization of available natural food and feed stocks and the transformation of waste materials.

1.7 LET US SUM UP

In this unit we started our study of food microbiology by first understanding the concept and historical development of the discipline. The modern development in the field of microbiology with respect to biotechnology and probiotics was highlighted.

Further, we studied about various fermented preparations belonging to different food groups such as vegetables, pulses, cereals, milk etc. The discussion involved a brief description of the method of preparation and the organism used for fermentation. Further, preparation of commonly consumed beverages differing in the alcoholic contents was described. Finally, a few other uses of microbes in food industry were discussed. These included vinegar and citric acid, preparations as antibiotics, and in amino acids and vitamin synthesis.

1.8 GLOSSARY

- Antibiotics : products of living organisms, which in small proportions could act as inhibitory agents for growth of other microbes.
- Baker's yeast : Saccharomyces cerevisiae, which helps in raising the

dough giving it the texture and flavors.

- Enzymes : protein substances produced by living cells which catalyze a biochemical reaction.
- Microorganism : a microscopic organism such as a bacteria, virus, alga, fungus, protozoan etc.
- Probiotics : microorganisms and their culture products which contribute to the intestinal microbial balance.

1.9 CHECK YOUR PROGRESS

Check Your Progress Exercise 1

1). What is food microbiology? What areas does it cover?

2). Define the following terms:

a) Probiotics

b) Biotechnology

c) Genetic modification

3). What are antibiotics? name few antibiotics.

4) Explain role of microbes other than food industry.

5) Explain role of genetic modification in food industry.

UNIT

2

FOOD SAFETY

STRUCTURE

2.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- Define food safety and hazards,
- Discuss the physical hazards to food safety
- Discuss the chemical hazards to food safety
- Discuss the biological hazards to food safety, and
- Describe microorgnisms associated with food borne hazards.

2.2 INTRODUCTION

Microorganisms are naturally found in foods since there is no environment where some type of microbes cannot live. It is important for us to understand that microbes can spoil the foods, cause food borne diseases and also some of them are useful. In this unit, we will learn about microorganisms, which are associated with food and are of concern with respect to food safety. In addition to microbes, there are physical and chemical agents which can also affect food safety. We shall also learn about these agents in this unit and focus on the importance of safe food.

2.3 FOOD SAFETY AND IMPORTANCE OF SAFE FOOD

Food safety has always been an important issue. The reasons for this are manifold.

More than ever before, there is a strong consumer awareness of food quality and safety and this continues to increase. New risks and challenges are emerging as a result of changes in the methods of food production at the farm and processing levels. Further challenges arise from the emergence and re emergence of food-borne pathogens. Consumption patterns are changing and consumer demands regarding such issues as the variety and shelf-life of foods, as well as, the preservation techniques used are changing. International trade in food has also increased the risk of infectious agents being disseminated from the original point of production to locations thousands of kilometers away. The consequence of this is that there is an increased risk to human health, as well as, implications for interna!ional trade in food. As a result, there has recently been a realization in many countries of the need for an integrated approach to food safety.

Maintaining food safety and quality, you would agree, is essential in the entire chain of food production ranging from:

i) primary food production at the level of farmers

ii) primary food processing at the farm, dairy and abattoir and grain mills

iii) secondary food processing level such a's canning, freezing, drying and brewing

iv) food distribution, both at the National and International level of import/export

v) food retailing and food catering, and

vi) domestic food preparation level.

While focusing on food and its safety concerns, an understanding of a few basic terms used in this context i.e. food safety, food quality, hazard and toxicity, is of utmost importance. Let us learn about them. We begin with food safety. Food safety is concerned with acute and chronic hazards that make food injurious to the health of the consumer.

Food safety can be defined in both absolute and relative terms.

'Absolute food safety' is the assurance that damage or injury from use of a substance is impossible. 'Relative food safety' is the assurance that damage or injury will not result from a food or ingredients used in a reasonable and customary manner and quantity.

An understanding of food safety is improved by defining two other basic concepts hazard and toxicity. 'Hazard' is the relative probability that harm or injury' will result when the substance is used in a proposed manner and quantity while 'toxicity' is the capacity of a substance to produce harm or injury of any kind under any conditions. Remember, assessment of whether a food or ingredient is safe should not be based on its inherent toxicity but on whether or not a hazard is created.

Next, let us understand what is meant by the term 'food quality'.

Food quality refers to the attributes that influence a products value to a consumer. This includes both negative attributes such as spoilage, contamination, adulteration, food safety hazards and positive attributes such as the origin, color, flavor, texture etc. Another term which is often used while talking about food safety is 'food hygiene'. Food hygiene refers to all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain.

After a comprehensive review of the different terms used in the context of food and its safety concerns, we will now focus on the importance of safe food and hazards which are a concern to food safety.

All of you are aware of the constituents of food and the fact that we need food for our survival. You may have also noticed that some of the foods are consumed as Food Microbiology and such while others require certain processing, before they are ready for consumption.

Safety Processing of certain foods develop constituents that might be toxic for human consumption. You might be wondering what these constituents are. The food processes that might lead to the development of potentially hazardous compounds in foods, or those that affect its nutritive value include use of agricultural and environmental chemicals, drugs, synthetic ingredients and fertilizers. The safety of foods, therefore, is of utmost significance and has gained a worldwide attention.

There are certain specific food safety concerns that differ markedly and include issues such as additives, drug residues, pesticides, irradiation, fertilizers and other growing aids, microbiological contamination, food toxicants, adulteration, misbranding etc. During recent years, newer challenges such as globalization of trade in food, urbanization, changes in life style, international travel and environmental pollution, all have further contributed to the concern for food safety. The new World Order and global environment for food trade places a considerable obligation on the part of both importing and exporting countries to ensure safety and quality of food.

Apart from all these, one of the major issues that require special focus is the consumer's attitude and knowledge about food safety. It is essential to acquire the know-how and skills necessary to understand and manage food safety hazards. Consumer confidence in the safety and quality of food supply is an important requirement and consumers are demand g protection for the whole food supply chain from the primary producer to the e consumer, often described as 'from farm or pond to the plate approach '. However, it is interesting to note that most of the consumers are not concerned about microbiological contamination and food safety issues. Many households have unsafe food storage and preparation practices. Consumers rarely consider their own food practices a hazard. However, food industry is most concerned about the microbiological safety of its products and many quality control checks are made to ensure that foods are safe. An elaborate system known as Hazard Analysis Critical Control Point (HACCP) is being employed in recent years by many food industries to minimize the chances of contamination during processing.

It is important to remember that an integrated approach on food safety and quality facilitates improved consumer protection, reduces incidence of food borne diseases, effectively stimulates the agriculture and the food processing industry and promotes domestic and international food trade and improves the economy.

Promoting good manufacturing practices, educating food retailers and consumers about appropriate food handling are essential for promoting good nutrition and better health.

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2.4 FACTORS AFFECTING FOOD SAFETY

There are various factors affecting food safety, the biggest one being 'food hazard'. Food hazards can be defined as a biological, chemical or physical agent in a food, or condition of a food, with the potential to cause an adverse health effect.

Physical	Biological	Chemical	
		Natural occurring poisons of biological origin	Chemicals or deleterious substances
Glass Hair Metal Stones Plastic Parts of pests Insulation material Bone Fruit pits	Microbiological Pathogenic Bacteria • Spore-forming • Non spore-forming Parasites and protozoa Viruses	Mycotoxins, Algal toxins	Veterinary residues, Antibiotics Growth stimulants Plasticisers and packaging material Chemical Residues Pesticides Cleaning fluids, Allergens Toxic metals, Lead and cadmium, Food chemicals, preservatives, processing aids, polychlorinated biphenyls (PCBs), printing inks, prohibited substances

Table 2.1: Hazards associated with food

2.4.1 Physical Hazards

Physical hazards include a variety of materials often referred to as extraneous materials. It may be defined as any foreign material not normally found in a food, which may cause illness or injury to the individuals consuming or using the product. They may cause injury, illness and others may never be noticed.

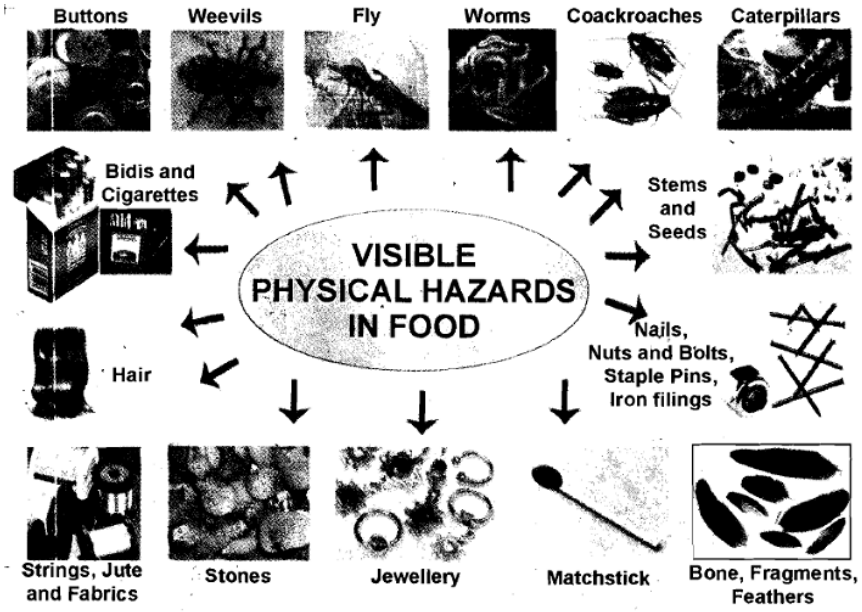

Figure 2.1: Examples of physical hazards

Food Microbiology and Physical hazards, as you would realize, include non-living things in foods, such as Safety stones, inedible stones, hair, glass, metal, wood,

plastic, insulation material etc. These materials can become a part of foods from the environment.

Now, how do these get into foods that we eat?

Well, there can be many ways. It could be from the environment in which the foods are grown or contamination could occur during processing and packaging e.g. iron fillings from worn out machinery, processing tea.

The use of electronic metal detector in many food processing operations can help in detecting and screening harmful metallic pieces. Inspite of availability of various mechanisms and technologies to prevent the risks caused due to physical contaminants, foreign / extraneous objects still represent one of the largest categories of complaints by consumers. Hence, it is the job of the government and industry to ensure that these risks are minimal and acceptable.

2.4.2 Biological Hazards

Among the biological hazards the major concern is from microorganisms. Few of the microbiological hazards are as:

Biological hazards, include bacterial, fungal, viral and parasitic organisms (protozoa and worms) and/or their toxins. There are many microorganisms, which are pathogenic to humans, but relatively few are associated with foods. These microorganisms that cause diseases are termed as 'food-borne pathogens'. There are three types of food-borne disease from microbial pathogens: infections, intoxications and toxic infections.

You would realize that diseases caused by these organisms are sometimes incorrectly called food Infections result from the ingestion of live pathogenic organisms which multiply within the body and produce disease. While intoxications occur when toxins produced by pathogens are ingested. You must remember that intoxications can occur even if no viable microorganisms are ingested. This often ensurs when foods are stored under conditions which allow the pathogens to grow and produce toxin. It is interesting to note that subsequent processing of food may destroy the microorganisms but not the toxin.

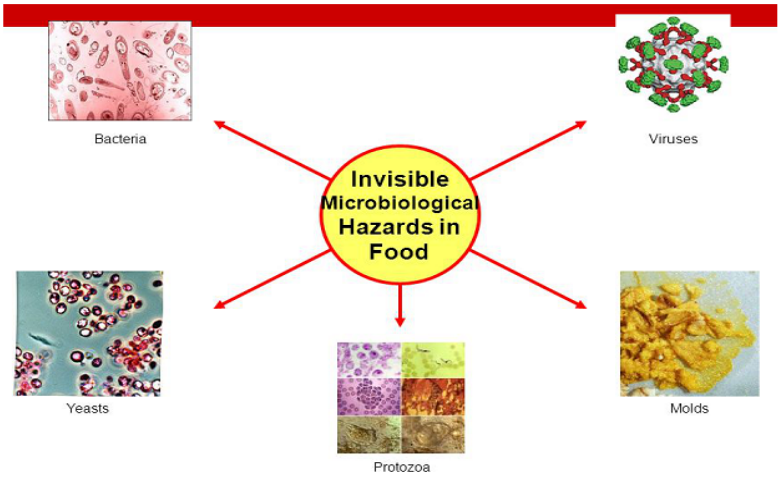

Figure 2.2:Biological hazards in foods

Hazardous microorganisms and parasites along with their commonly affected Food Organisms Foods Implicated

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S.No	Organisms	Foods Implicated
1.	*Clostridium botulinum* types A, B, E, and F	Meat, fish, low or medium acid canned foods, home canned products
2.	*Salmonella* spp. *(Salmonella typhi: Salmonella paratyphi)*	Eggs, meat and meat products, bakery products, dairy products (esp. ice-cream)
3.	*Shigella* spp.	Shellfish, fruits and vegetables, chicken salad
4.	*Clostridium perfringenes*	Raw meat, poultry and their products
5.	*Staphylococcus aureus*	Custard, cream, bakery foods, poultry, ham, dairy products(especially. khoa)
6.	*Bacillus cereus*	Cereal dishes, puddings, mashed potatoes, sauces, soups
7.	*Vibrio cholerae 01, non-01 Vibro vulnificus Vibrio parahaemolyticus Listeria monocytogenes*	Water, potatoes, eggs, asparagus, salads, seafood (shrimps, oysters, clams, crabs, lobsters and related shellfish), finfish, milk and milk products, raw meat and poultry products, fruit and vegetables, salads, seafood
8.	*Enterovirulent Escherichia coli* (EEC)	Cream pie, mashed potatoes, meat, poultry, dairy products like cheese
9.	*Campylobacter jejuni*	Dressed chicken, meat dishes, raw milk, raw poultry
10.	*Yersinia enterocolitica*	Dairy products, egg products, raw meat and poultry, raw vegetables
11.	*Brucella abortis; B suis*	Milk and milk products, raw meat
12.	*Viruses (Hepatitis A and E, Rotavirus, Norwalk virus group)*	Shellfish, raw fruits and vegetables, salads sandwiches, potatoes, lettuce, coleslaw
13.	*Entamoeba histolytica*	Water, raw fruits and vegetables
14.	*Diphyllobothrium latum*	Fish
15.	*Cryptosporidium paruum*	Raw fruits and vegetables, salads
16.	*Giardia lambea*	Water, lettuce, raw fruits and vegetables
17.	*Taenia saginata, Taenia solium*	Meat (beef and pork)
18.	*Trichinella spiralis*	Raw pork, meat products

2.4.3 Chemical Hazards

A chemical hazard is any chemical contaminant introduced in food system which may cause illness or injury to the individuals using the product.

Few of thechemical hazards includes pesticides and residues, veterinary

residues, colors, cleaning....etc

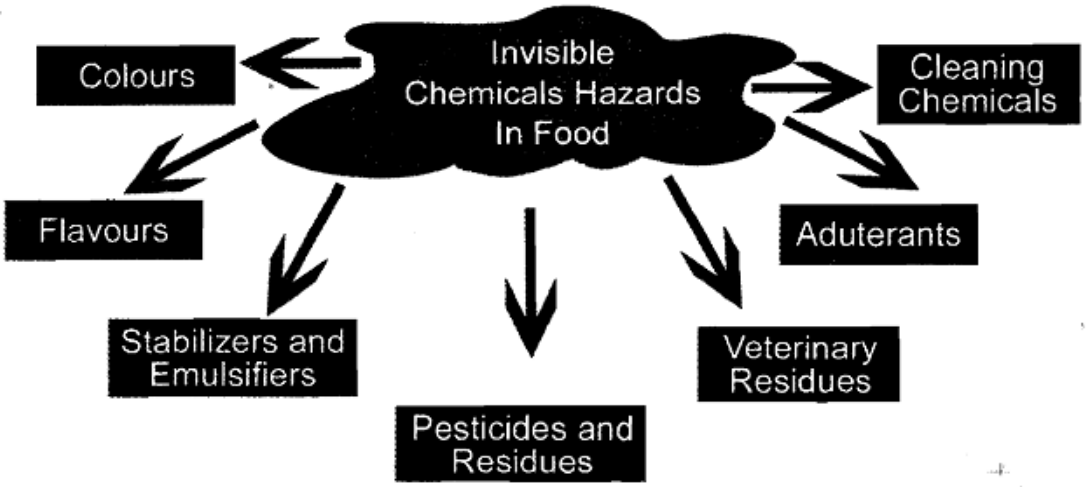

Figure 2.3: Examples of chemical hazards

Chemicals which cause a harmful response when consumed by animals or humans are said to be toxic. How do we know that a particular compound is toxic or not?

It might surprise you that almost everything can be considered a toxicant, without regard for the origin of the substance. The factors which determine the toxicity are the dosage or the amount of exposure and potency of the chemical.

The examples of the chemicals in each category are also indicated.

Food Borne Toxicants		
Naturally Occurring Chemicals	**Unintentional Chemicals**	**Intentional Chemicals**
Found in plants, microorganisms and animals e.g. mycotoxins, histamine, mushroom toxins, shellfish toxins etc.	Lead, Polychlorinated biphenyls (PCBs) and paralysis products etc.	Food additives, pesticides, drugs

Table 2.2: Types of chemical hazards

Food Borne Toxicants

Naturally Occurring Chemicals Unintentional Chemicals Intentional Chemicals Found in plants, microorganisms Lead, Polychlorinated Food additives, pesticides, and animals e.g. mycotoxins,biphenyls (PCBs) and drugs histamine, mushroom toxins, paralysis products etc. shellfish toxins etc.

STUDENTS ACTIVITY - 1

1) Define the following terms:
   a) Food Safety
   b) Food Hazards
2) How can you classify chemical hazards? Give examples.

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2.5 MICROORGANISMS IN FOODS

We shall now discuss the different types of biological hazards and the important microorganisms that can lead to food borne illnesses and eventually act as a major concern in food safety. Biological hazards include bacteria, viruses, moulds and fungi.

2.5.1 Bacteria

Bacteria are the organisms characterized by small size, approximately 0.5 to 2.5 gm in diameter and unicellular in nature. The major characteristics of bacterial cells are their size, shape, structure and arrangements. There are three distinct forms listed herewith:

- bacilli (singular, bacillus meaning little)
- cocci (singular coccus meaning berry) or cylindrical or rod-shaped cells; and.
- spiral forms, curved rods or spiral cells.

The most common of all the three forms is the bacillus i.e. the rod-shaped bacteria, which is cylindrical and may vary considerably in length and breadth according to the species. The rod-like cells may be straight or slightly curved.

Next, comes the coccus and the least common form is the spiral in which the cell is curved spirally. Although these three forms are well recognized, there are variations of these shapes. The shape of each of the species of bacteria also does not always maintain definite shape at all times. Some species even exhibit a variety of shapes.

The arrangement of bacterial cells The bacterial cells are arranged in a characteristic manner according to the species. The cocci exist either singly, or in pairs or in long chains depending upon the manner in which they divide and then adhere to each other after division, whereas, the bacilli can be seen as a single cell, in pairs or in short or long chains.

The length of cocci chains is an identifiable characteristic but in case of bacilli, it is not so. The spiral bacterial cells sometimes adhere together in S-shaped strands, (vibrios), spirilla (singular, spirillum) are actually like spirals and spirochetes, which are different from spirilla which possesses flexible cell walls.

The bacterial cell structure

Like other living cells, a bacterial cell essentially has an outer wall or a membrane, cytoplasm and nuclear material. The outer part of the bacterial cell is made up of cell wall, cytoplasmic membrane and slime layer.

The cell wall gives shape to the-cell and it is made up of proteins and complex carbohydrates or polysaccharides, large amounts of fat or lipid may also be present. Apart from giving protection to the cytoplasm, the cell w all also plays a role in cell division. It also regulates the passage of various materials between the external and internal environment.

The slime layer is like a jelly which surrounds the bacteria. In some bacteria, the slime becomes very thick and covers the bacteria. It is known as a capsule. The slime layer gives some protection to the bacteria against invasion.

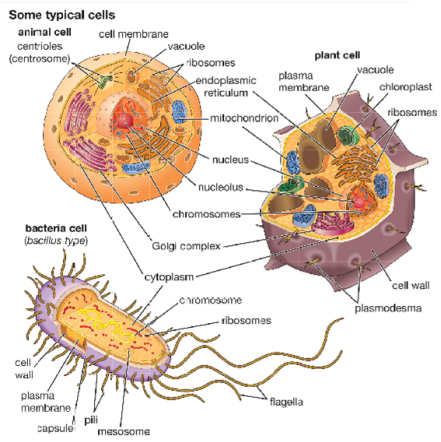

Figure 2.4: Bacterial Cells

The cytoplasmic membrane, which is inside the cell wall, initiates the cell division and also controls the entrance of food into cells and clearing the waste products. The cytoplasm is a complex substance containing the nuclear body, which is rich in deoxyribonucleic acid (DNA), ribosomes, which consists of ribonucleic acid (RNA), combined with protein and a fluid portion which contains various dissolved nutrients.

The nuclear body is involved in reproduction whilst ribosomes are involved in protein synthesis.

Many bacteria can swim by the means of small appendages called 'flagella' (flagellum, singular). In bacteria, this is the only means of locomotion. They are usually several times the length of the cell body but are extremely thin.

The flagella of the motile bacteria are distributed over the surface depending on the bacteria. In some cases, they may be found all over the surface of the cell or they may be restricted to one or both ends.

The growth of bacteria

The growth of bacteria can be defined as an increase in mass of bacteria per unit volume of medium. The bacteria divides by binary fission i.e. a division of cell produces two new cells, which are assumed to be nearly identical in all relevant properties.

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Under favorable conditions of moisture, pH, nutrition and temperature, the growth of bacteria takes place. There are several factors like exhaustion of food supply, accumulation of waste products etc. which can limit the growth of bacteria.

The growth of bacteria is generally expressed as a growth curve in which there are four principal stages viz.

(1) lag phase,

(2) logarithmic or exponential phase,

(3) the stationary phase, and

(4) the death phase.

A few viable cells from a culture incubated in a suitable medium at the optimum temperature generally go through these four phases. The growth/ increase in the number of bacteria is calculated as CFU/ml, i.e. Colony Forming Units or the total number of colonies formed per ml of the medium in which the bacterial cells were originally inoculated.

- **Lag phase:** During the initial lag phase i.e. in a period of one to few hours, there may be little or no increase in the cells. But when the growth begins, due to cell division, the cells may proliferate rapidly at regular intervals.
- **Logarithmic (Log phase)**: In this phase, the cells multiply logarithmically i.e. one cell dividing to 2 cells and then 2 cells to 4 cells etc. The average generation time is mostly constant for a given species under similar conditions.
- **Stationary (resting) phase**: In this phase, after rapid growth, the cell multiplication gets stagnant due to the exhaustion of nutrients or accumulation of waste products or any other facts. The stationary phase can be maintained for hours or days by the majority of the cells remaining viable without further growth or by balance between the death of some cells and the continued division of others.

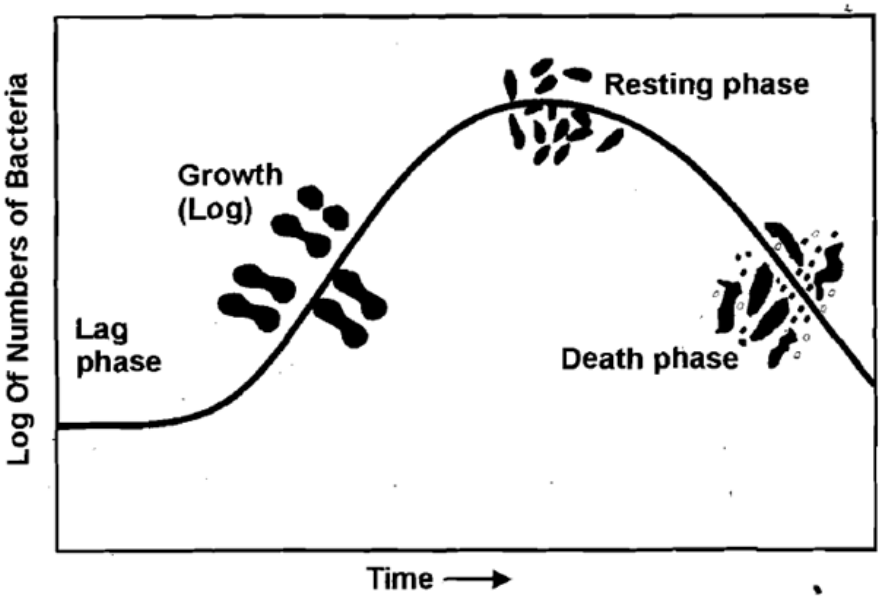

Figure 2.5: Four phases of bacterial growth

- **Stationary (resting) phase**: In this phase, after rapid growth, the cell multiplication gets stagnant due to the exhaustion of nutrients or accumulation of waste products or any other facts. The stationary phase can be maintained for hours or days by the majority of the cells remaining viable without further growth or by balance between the death of some cells and the continued division of others.
- **Decline or death phase**: In this phase, the cell death occurs due to buildup of toxic waste products, when the medium is not changed, as it has become incapable of supporting further growth. We have looked at the growth of bacteria above, while on the topic of bacteria, you may have also heard about endospores.

The endospore

Some bacteria like Bacillus or Clostridium produce resting structures known as endospores, which are produced within the cell, one spore is formed within a single bacterial cell. These are the highly resistant bodies. The endospore is physiologically dormant and it can resist extremely unfavorable conditions, both physical and chemical, like heat, UV light and chemicals.

When conditions are favorable, these spores will germinate and produce fresh vegetative cells. This process of sporulation is a mode of reproduction. Endospores can be quite harmful.

2.5.2 Fungi

Fungi exhibit a wide range of different forms, which includes moulds, yeasts and mushrooms. The important forms are yeasts, which are unicellular and the moulds, which are filamentous and multi-cellular. Mushrooms in addition to being filamentous and multi-cellular, have a definite fruiting body, which is quite prominent. .

2.5.3 yeasts

The yeast cells, in general, are round, egg-shaped, cylindrical or filamentous. The yeast cells are generally much larger than the bacterial cells, which range from 3-5 gm wide by 5-10 gm long and they exist as single cells. The reproductive processes in the case of yeast cells are by the process known as budding.

Although in certain yeasts, the process is by way of fission as in bacteria. The budding process involves the bulging of protoplasm outwardly and as the bulge grows in size, it separates from the parent cell after attaining maturity.

Some types of yeasts reproduce sexually also and are known as 'true yeasts' In this process, the cells serve as ascus (sac). Here the nucleus undergoes division without the participation of the cell wall forming spores within the ascus.

The spores of yeast are also resistant to some adverse conditions but get destroyed at temperatures above 600C, whereas, the bacterial spores you learnt earlier are quite resistant to higher temperature.

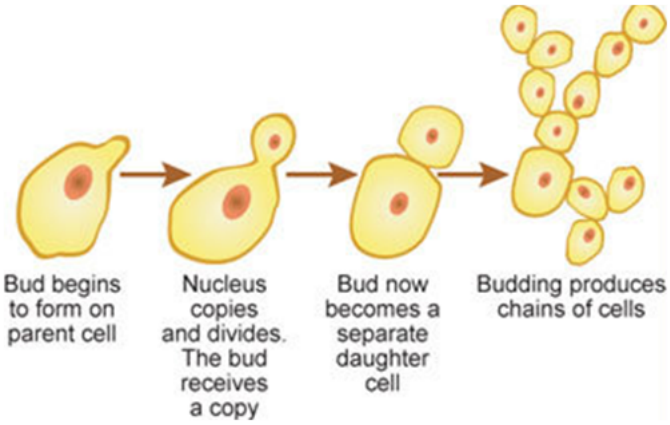

Figure 2.6 : The budding process of the yeast

Some types of yeasts reproduce sexually also and are known as 'true yeasts' In this process, the cells serve as ascus (sac). Here the nucleus undergoes division without the participation of the cell wall forming spores within the ascus. The spores of yeast are also resistant to some adverse conditions but get destroyed at temperatures above 600C, whereas, the bacterial spores you learnt earlier are quite resistant to higher temperature.

2.5.4 Moulds

The term mould is used to describe certain multi-cellular fungi consisting of a filamentous branching growth known as a mycelium, which is composed of individual filaments called 'hyphae' (singular, hypha) as illustrated in Figure 2.8. Depending on the location, the aerial mycelium carries fertile hyphae which acts as a reproductive organ while the remainder of the mycelium absorbs food and moisture necessary for growth.

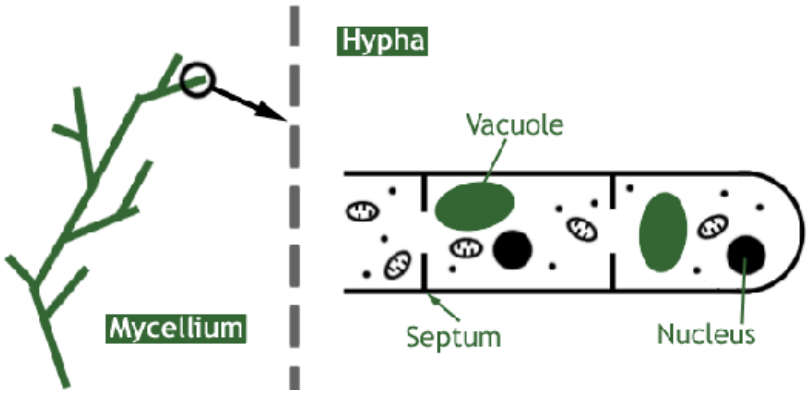

Figure 2.7: The hyphae

In moulds, reproduction is mainly by sexual spores. Based on the manner and type in which the spores are formed, moulds are classified as:

i) Phycomycetes

ii) Ascomycetes

iii) Basidiomycetes

iv) Fungi Imperfecti

A word about these moulds.

i) Phycomycetes

The moulds belonging to the group of phycomycetes contain several. genera. These moulds produce hyphae, which are not divided into typical uninucleate cells and thus have no cross walls (septa). These non-septate hyphae have nuclei scattered throughout their length.

Phycomycetes, which are commonly found on food, are members of the sub-class zygomycetes. The two most commonly found genera of this group are genus Mucor and genus Rhizopus. These moulds possess hyphae that although apparently alike, are able to conjugate and form a zygospore (sexual spores) Species of Mucor genus are present in soil, organic matter, fruits, vegetables, stored grains and other foods.

Mucor species plays a role in the fermentation of foods and have a commercial value.They sometimes cause spoilage of foods. Species of Rhizopus are commonly associated with the spoilage of stored foods. (e.g. spoilage of bread by R.stolonifer).

ii) Ascomycetes

These moulds have septate hyphae and multiply asexually by separation at the tips of fertile hyphae (conidiophores) to produce spores known as 'conidia', formed either singly, in chains or in irregular clusters on the condiophores. In the ascomycetes, the sexual spores are termed as 'ascopores'. These are formed following the union of two cells from the same mycelium or from two different mycelia.

A number of ascospores, usually eight, are subsequently formed within a sac known as 'ascus'. The organisms of importance which belong to this group of genus are Claviceps, Neurospora, Sclerotina and Byssochlamys,

iii) Basidiomycetes

This group also contains septate hyphae and forms spores, usually, four in numbers. Most of the edible mushrooms belong to this class and the spores are produced in a club-shaped structure known as 'basidium'. The spores are called basidiospores.

Most of the edible species of mushrooms are the members of the genus Agaricus. In America, the commercial production is dominated by the species Agaricus bisporus. In East Asia, especially in Japan, Lentinus eddoes, which is grown on tree tops, is popular. In India, the oyster mushrooms are increasingly accepted as a source of food and considered a delicacy.

iv) Fungi imperfecti

This group of fungi is known as the fungi imperfecti, as the sexual stage of reproduction of many strains are yet to be discovered. Fungi imperfecti produces

characteristic conidiophores and conidia. The organisms of importance of this class are Alternaria, Aspergillus, Fusarium, Penicillium, Botrytis. Cladosporium etc. The Aspergillus and Penicillium species are most commonly found and are the significant storage fungi responsible for the spoilage of foods.

2.5.5 Viruses

Till the presence of viruses was demonstrated by Iwanowski in 1892, bacteria were considered the lowest forms of life. Viruses are called as 'obligate intracellular parasites ', since they are unable to carry out any of the typical life functions until they are inside a host cell. Once inside the host cell, they thrive and direct the host cell to produce more viruses. As long as the virus is outside the host cell, it is known as vision

The viruses are inute when compared to bacteria. Except for a few, viruses like the cow pox virus, used in vaccination against small pox is 0.3 gm, whereas, the smallest type, like the foot and mouth disease virus is about 0.01 gm. Note, they are so small that they cannot be seen under an electron microscope.

The viruses consist of a protein layer, capsid, surrounding nucleic acid comprising either RNA or DNA. The important characteristic of viruses is that they are host- specific. Most viruses infect only one species, either animal or plant or else only very closely related species. The mammalian viruses do not affect any prant e.g. the polio virus infects humans and monkey and does not affect other animals, whereas, the tobacco mosaic virus, which attacks plants, does not affect humans.

Viruses are killed in a few minutes under pasteurization temperature i.e. 620C for 30 minutes. They are affected by general disinfectants like phenols, formaldehyde, halogens and cresols. To a certain extent, soaps and detergents inactivate them and UV light destroys all viruses. They are not affected by antibiotics unlike bacteria.

Viruses are known to cause illness although they do not grow on foods or produce toxins in foods. Food items merely act as a vehicle for their transfer. They are the intestinal or enteric type and are food borne. They spread from the hands of human carriers and from water to foods. The presence of viruses in foods, especially the shell fish grown in sewage polluted water, could be the significant route of illness in man. Other foods like fruits and vegetables contaminated by feces and salad preparations using contaminated vegetables have been implicated in several outbreaks of food borne diseases.

The hepatitis A virus, which causes jaundice, spreads through foods but the etiology is difficult to establish, as it has a long incubation period, ranging from 15-50 days.

Having looked at viruses, we move on to parasites, which are the last of the biological hazards discussed in this section.

2.5.6 Parasites

Parasite, as you may already know, is a plant or animal that at some stage of its existence obtains its nourishment from another living organism called the host. Several foods act as carriers of parasites, which may cause illness when. Ingested.

The parasitic infections of foods may occur due to contamination of food by a food handler directly or by polluted waters. In many parts of the world, the consumption of under-cooked meat and fish are popular. The problem of contamination with parasites can occur when the food preparation is made with polluted water and under-cooking prevents the parasites from destruction. Amoebic infection is the most important parasitic infection through contaminated food.

A) **Amoeba**: Entamoeba histolytica, a protozoan, is the cause of amoebiasis, which is very common in a tropical country like India. About 15% of the population suffers from this disease. The disease is transmitted at 60öC through infected cyst. It remains viable only in moist form and gets destroyed at 600C and at freezing conditions beyond 24 hours.

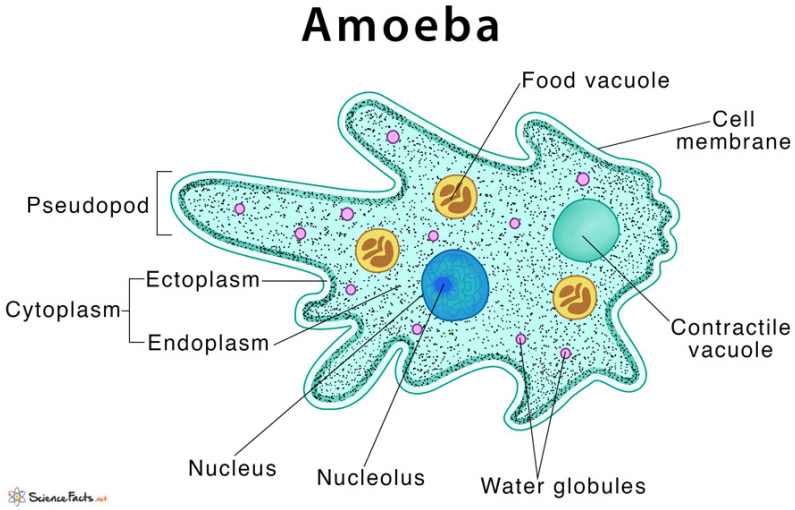

Figure 2.8: The Amoeba

The foods like vegetables from fields irrigated with sewage polluted water are the vehicles of transmission. They get contaminated with amoebic cysts through polluted water and infected handlers. Viable cysts have been foundon the hands and under the finger nails of the carriers. The common pests like flies, cockroaches and rodents may also harbor the cysts and contaminate food and drinks. The symptoms of diarrhea occur from several days to 4 weeks after ingestion of the contaminated food. The prevention of amoebiasis is by using food procured from reliable sources, preparing food in potable water and adequate cooking and proper storage after preparation.

Use of filtered / boiled water, disinfection of uncooked vegetables with an aqueous solution of iodine around 200 ppm or acetic acid (5-10%) or full strength are the recommended measures to minimize the problem.

B) **Giardia:** The disease giardiasis is caused by the 'flagellated protozoan Giardia lamblia. This disease occurs in the areas where poor sanitary conditions prevail and it affects mostly children. The cyst of this organism is absorbed through the intestinal walls and the affected person excretes Giardia cysts in feces.

The cysts get transferred to food when contaminated water is used for washing the vegetables. Consumption of such food containing the cysts leads to infection. The

incubation period ranges between 2-25 days and the symptoms include discomfort, nausea and diarrhea. Infected persons may simply be the carriers and may not always exhibit symptoms.

The disease can be prevented by adopting good personal habits and proper fecal disposal methods and protecting the water supplies from Fecal contamination.

C) **Trichinella**: The disease trichinosis is caused by the nematode, Trichinellaspiralis the nematode- It is one of the commonly found parasitic food borne infections in the populations consuming principally the undercooked pork.

The parasite enters the human host in the form of larvae, which are released and enter the duodenum, producing larvae which gain entry into the blood stream and encyst in the muscle. The symptoms appear normally 2 days to one week after ingestion of the contaminated food with the larvae. The symptoms include fever, abdominal pain, nausea, vomiting and diarrhea.

In some cases, edema of face and hands is also observed. The prevention of trichinosis is ensured when the food is thoroughly cooked to a temperature of 600C, which destroys the larvae. The meat has to be cooked till it imparts a grey color. The parasite is also destroyed when held at temperatures below —250C or lower, for 10 days.

2.6 CONCERNS FOR FOOD SAFETY

The rising worldwide human travel and global distribution of food is facilitating the introduction and flow of pathogens and other hazards into human and animal populations. Further, global sourcing can also move pathogens and toxins from areas in which they are indigenous to places in which they have not previously existed.

Food safety issues such as debate over organic foods, genetically modified foods, the incidence of bovine spongiform encephalopathy (BSE), dioxin-contaminated foods are causing heightened consumer concern about food safety worldwide today. What are these concerns all about? Let's find out.

2.6.1 Prions

In recent times, Bovine Spongiform Encephalopathy (BSE) and Creutzfeldt-Jakob Disease (CJD) have been the highly publicized food safety hazard. You may recall reading about the mad-cow disease and large number of diseased cattle being destroyed in the UK, or about the ban on British beef worldwide. Why was this action being taken? What was the hazard? The hazard was from the Prions. Prions entered the public's consciousness during the mad cow epidemic that hit England in 1986.

What are Prions?

Prions, the cause of BSE and CJD, are an entirely new source of food borne diseases. Prions, is the abbreviation of proteinaceous particles. The word 'Prion'

was coined by D" Stanley Prusiner to indicate that this disease was caused by a "proteinaceous infectious agent." Prions, in fact, are modified forms of a normal protein called as PrPC.

The protein that causes this and all other prion diseases is called PrPSC, which stands for prion protein of scrapie. Prions enter cells and apparently convert normal proteins found within the cells into prions just like themselves. The proteins accumulate in the brain causing holes or plaques and the subsequent clinical symptom leading to death. The medical term for the prion diseases is "spongiform encephalopathies," in acknowledgement that the sick brains are riddled with holes and have taken the form of sponges. Transmissible spongiform encephalopathy in animals and humans are caused by prions. Prions, therefore, can be infectious and can cause infectious diseases.

The second and potentially more troubling aspect is that, like other infectious agents, prions can jump species' barriers and cause deadly diseases in humans. Only time will tell how big a problem the prions will be both as the agents of dreadful diseases of the human nervous system and as vectors of diseases from other species.

BSE was first confirmed in cattle in 1986 in UK. It is commonly accepted that BSE was first caused in Britain when cattle were fed carcass meal from scrapie infected sheep. Since 1999, other countries in Europe e.g., Belgium, Denmark, France, Germany, Ireland, Italy, Netherland, Portugal etc. have reported confirmed cases of BSE. Humans contracted the non-classic form of CJD, called new variant CJD (vCJD) after consuming cattle meat, in particular, the nervous tissue.

Bovine Spongiform Encephalopathy (BSE)

Bovine spongiform encephalopathy (BSE), is commonly known as mad-cow disease. It is a progressive neurological disorder of cattle that results from an infection by an unconventional transmissible agent. BSE is one of a group of diseases that affect a number of different mammals. These diseases, known as Transmissible Spongiform Encephalopathies (TSEs), or Prion Diseases, result from the build-up of abnormal prion proteins in the brain and nervous system. BSE attacks the brain and central nervous system of the animal and eventually causes death. Research has shown that TSEs have two characteristics in common: they can be transmitted between animals, and they fuse the same spongy decay of brain tissues. A commonly occurring prion disease is scrapie. The symptoms commonly associated with it are disorientation, clumsiness and occasionally, aggressive behavior towards other animals and humans.

What caused the disease?

Most experts agree that the BSE was spread by cattle eating feed that contained meat-and-bone meal (MBM), which contained BSE infected parts of other grazing animals. MBM is produced in a process called rendering, this is where otherwise unused meat products are taken from the animal carcass and turned into cattle feed. Cattle can contract BSE if they are fed infected brain tissue. Thus, it is presumed that BSE was transmitted to cattle through their animal feed.

NOTES

Creutzfeldt-Jakob disease (CJD)

The most commonly known disease in prion diseases group among humans is Creutzfeldt-Jakob Disease (CJD). This is a rare and fatal form of dementia and mainly occurs in individuals between the ages of 40 and 80. In 1996, scientists discovered a new strain of CJD that occurs predominantly in younger people. More recent evidence has shown that the protein that accumulates in the brains of individuals with this new form of CJD is similar to the protein found in cattle infected with BSE, rather than that found in classical CJD. Because of this newly discovered difference, the new illness in humans is known as variant CJD or vCJD. The occurrence of a new form of CJD in the UK, where there is a high incidence of BSE, suggested that there might be a direct link between the two diseases. Some cases that have developed vCJD are known to have eaten BSE infected meat. Like BSE in cattle, vCJD is always fatal in people.

How does an individual get infected by vCJD? As discussed earlier, a victim of vCJD becomes infected through consumption of cattle products contaminated with thy BSE agent. What are the symptoms and consequences? Generally, vCJD patients, show atypical clinical features with prominent psychiatric or sensory symptoms, with delayed onset of neurological abnormalities, including ataxia within weeks or months, dementia and myoclonus late in the illness.

Next, who are the most at risk of this disease?

The risk to travelers (who visit the countries where outbreaks of BSE have taken place) and importers (who import beef and beef products from countries where vCJD cases have been reported) is the most. As far as travelers are concerned, the risk can be controlled by avoiding beef and beef products altogether or by selecting solid muscle pieces of beef with less chance of contamination and avoiding calf brains and burgers and sausages. Milk and milk products are reported to be safe, as these pose no risk for transmitting the BSE agent.

The countries that import beef and beef products from countries where cases of vCJD have been reported need to exercise control measures to ensure that the disease is not transmitted to the importing country. Severe restrictions need to be imposed on importation of live ruminants, such as cattle, sheep and goats and certain remnant products from countries where BSE is known to exist. Avoiding beef and beef products altogether by selecting solid muscle pieces of beef with less chances of contamination and avoiding calf brains and burgers and sausages can control entry of infected foods.

Having looked at the concern from prions, next let us critically analyze the use of genetically modified foods.

2.6.2 Concerns of Genetically Modified (GM) Foods

However, the context of genetically modified foods, concern from environmental, food safety and ethical angles have been raised. Further, concerns related to nutrient aspect of GM foods, elimination, loss, reduction or increase in micronutrients due to genetic modification and increase in anti-nutritional factors need to be addressed.

Issues of concern to environment include the capability of the GM organism to escape and introduce the engineered gene into wild population (cross breeding) through pollen drift leading to loss of biodiversity. The transgenic material from GM maize cultivated by a farmer could be transferred in non-GM maize cultivated in the neighboring farmer's field without his knowledge. There could be the possibility of development of resistance in the target organism. This is particularly true for cotton crop insects.

Concerns from the health angle include toxicity, allergenicity, nutritional imbalance, possible gene transfer such as antibiotic resistant gene to gut flora which could adversely affect the therapeutic efficacy of orally administered antibiotics, unintentional effects in the form of acquisition of new. traits or loss of existing traits and use of unapproved varieties like Star Link maize. Concerns of ethical nature have been raised from vegetarian groups on using animal genes in plants.

Thus, the risk and uncertainties surrounding the process of genetic engineering and the resulting GM product has resulted in considerable public debate and consumer groups have been vociferous in demanding labeling of GM products. In India, the Policy on GM foods is under active consideration by the Government at the highest level and is likely to emerge soon.

2.6.3 Concern of Dioxin-Contaminated Foods

Dioxin has been discovered in chickens. In 1998, unacceptable levels of dioxin were found in milk produced in the North of France. The source of this contamination was out of the incinerator plants settled on the grass. It then got chewed by the cows where it was concentrated mainly in their fat deposits and from there into their milk.

What are dioxins and why are they harmful and a concern for food safety? Dioxin and related compounds, i.e. polychlorinated dibenzo-p-dioxin (PCDDs), polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs), are halogenated aromatic compounds which are industrial pollutants that persist in the environment. In addition to cancer, dioxins have been linked to adverse human health effects such as developmental, immunologic and endocrine toxicity. The major environmental sources of dioxin and dioxin-like compounds (referred to simply as "dioxins") are emissions from combustion, incineration, any industrial processes using chlorine, paper mills, fireplaces, grass fires etc. The aerial transport of these emissions is the primary pathway dioxins enter the terrestrial environment and food chain.

How do dioxins enter the human diet?

Dioxins are lipophilic (fat-loving) compounds which accumulate in the fat of animals. Hence, the types of foods which tend to have the highest dioxin concentrations are dairy products, meat and poultry, eggs, fish and animal fats. Green vegetables, fruits and grains, on the other hand, are the types of foods with the lowest dioxin concentrations

How do foods and animals become contaminated with dioxin and related compounds?

Deposition of airborne dioxins onto plant and soil surfaces, and subsequent ingestion of this contaminated vegetation and soil by food animals, is considered the primary pathway by which dioxins enter the food chain. The levels produced in this way are considered background levels. Fish become contaminated due to airborne dioxin deposition into the water and also from contaminated soil or industrial waste washed into rivers and lakes, leading to high sediment concentrations.

Inhalation and water pathways are not considered significant sources of exposure for terrestrial animals. Contamination above background levels can occur if food animals are fed products which are adulterated, either by natural or unnatural means, with high concentrations of dioxins.

2.7 LET US SUM UP

In this unit, we looked at the concept of food safety and the importance of safe food and the hazards which are a concern to food safety. Then we studied about some of the important microorganisms, their structure, mode of reproduction and diseases spread by them. We also discussed about favorable and unfavorable conditions that affect the growth of these microorganisms.

The last part of the unit focused on recent concerns of food safety. Prions, dioxin- contaminated foods and concerns related to genetically modified foods were highlighted in this section.

2.8 GLOSSARY

- Budding : the asexual reproductive process of yeast involving the bulging of protoplasm outwards and its separation from the cell, on maturation.
- Endospore : resting structure of bacteria.
- Flagella : small appendages, which help the bacteria to swim.
- Infections : these occur on the ingestion of live pathogenic organisms which multiply within the body.
- Intoxications : these occur on ingestion of toxins that are produced by pathogens.
- Mycelium : filamentous branching growth of multicellular fungi.

2.9 CHECK YOUR PROGRESS

1) Differentiate between the terms 'toxicity' and 'hazard'? .
2) What is a physical hazard? How do harmful products enter food?
3) What are the health-related concerns of GM foods?
4) What are 'dioxins' and comment on their food safety risks
5) What are the common hazards to food safety?

UNIT

3

OCCURRENCE AND GROWTH OF MICROORGANISMS IN FOOD

STRUCTURE

3.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- enumerate the major reservoir or the support system for microbial growth,
- describe the sources of food contamination,
- discuss conditions conducive for the growth of microorganisms, and
- explain the methods to control or destroy the microorganisms in food.

3.2 INTRODUCTION

We already learnt about the various microorganisms in the nature — bacteria, moulds, yeasts and fungi — which are of interest to the food scientist. In this unit, we will try to understand what types of microorganisms are present in air, water and the food itself. How they enter the food and what are the factors responsible for their growth and proliferation. Finally, we will study about the methods which are used to control or destroy these microorganisms in food.

3.3 MICROBIOLOGY OF AIR, WATER AND SOIL

Have you ever wondered what are the major reservoirs or the support systems for

microbial growth? Well, these are the ones which we too require for our survival — air, water and food. Let us get to know about these support systems and the organisms they support. We begin our discussion by dealing with the microbiology of air.

A) Air

You would realize that air, by nature, does not contain a natural flora of microorganisms. All that comes into air is by accident and is usually present on the suspended solid materials or in moisture droplet. Microorganisms get into the air or dust or a lint or dry soil, droplets of moisture from coughing, sneezing or talking, sporutalins moulds on walls, ceilings, floors, foods and ingredients. Thus, the air of a dairy plant may contain bacteriophages or at least the bacterial cultures used in the plant. The microorganisms in air have no opportunity for growth, but they merely persist on air and the kinds which are most resistant to desiccation, will live the largest.

Mould spores, because of their small size, are resistant to drying and are usually present in the air. Cocci are more numerously found than rod shaped bacteria. Yeasts are also found more in air. It is obvious jut dust or sprays of various materials are carried up into the air, the microorganism's characteristic of those suspended materials will be present.

B) Water

Unlike air, natural waters contain their natural flora, as well as, microorganisms from soil and possibly from" animals and sewage. The kinds of bacteria in natural water are chiefly species of Pseudomonas, Chromobacterium, Proteus, Micrococcus, Bacillus, Streptococcus, Enterobacter and Escherichia.

The microbial load of any water depends upon, whether it is stream water, stored water or ground water. Stored water will have more number of microbes than ground water.

C) Soil

You would realize that the soil contains greatest varieties of microorganisms. It actually serves as a medium for growth and development of various microorganisms. In fact, if microbiologists want to search for new kinds of microorganism, they usually turn to soil. The soil is the most important source of heat-resistant spore forming bacteria.

Important microorganisms associated with soil include Bacillus, Clostridium, Enterobacter, Escherichia, Micrococcus, Alcaligenes, Flavobacterium, Chromobacterium, Pseudomonas, Proteus. Streptococcus, Leuconostoc, Acetobacteria and Actinomycetes.

3.4 SOURCES OF FOOD CONTAMINATION

All plants and animals have a natural microflora associated with them. For example, the plants have a natural microflora associated with the surface of roots, stems, leaves etc. The animals have a natural microflora associated with the skin, the gut content and external openings e.g. the mouth. These microflora are one of the sources of microorganisms associated with spoilage.

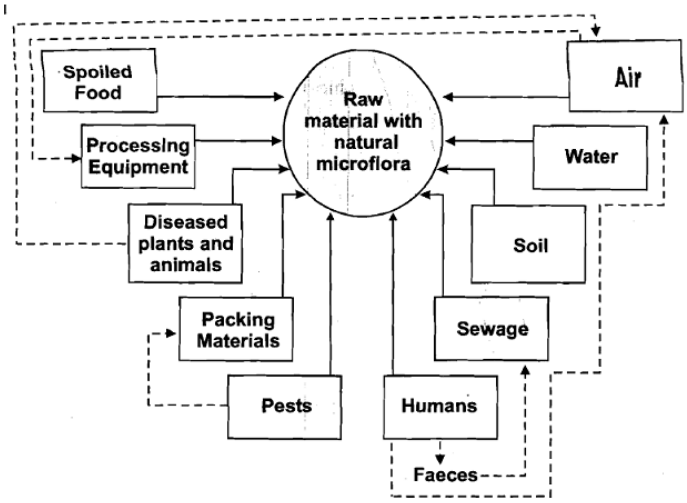

Figure 3.1: Sources of contamination of food

Equipment can be a source of contamination. It can be contaminated during production and also while it is not being used and most important, if not cleaned regularly and thoroughly. Other than the foreign objects, the most common source of microbial contamination in food are the employees i.e. the humans. The hand, hair, nose and mouth carry microorganisms that can be transferred to the food during processing, preparation, packaging and service by touching, breathing coughing etc. Further, water used for cleaning and as an ingredient in many processed food, if not clean/ pure can contaminate food. Microorganisms in air can also contaminate food during processing, preparation etc. Insects and rodents such as mice, cockroaches etc. carry dirt and disease with their feet, fur and feces. They transfer dirt from garbage dumps and sewers to food or food processing and food service area, thus being a source of contamination.

Finally, raw untreated sewage carries high microbial load and may contaminate water, food or equipment through faulty plumbing or otherwise. So we have learnt about the various sources of contamination. For your information, the type of microorganisms found in each food depends upon the microbial ecology (relationship between microbes and their surrounds), water activity (measure of 'free' water in a food sample, as opposed to 'bound' water) and composition. We will learn more about water activity and other factors affecting microbial growth later in this unit.

First, let us look at the type of microorganisms found in selected foods. We shall with milk, which you also know is one of the foods which is considered to be wholesome and a highly perishable commodity. of milk for the growth of microorganisms.

Do you know why?

Yes, rater, protein and sugar content, it becomes an ideal organisms. Escherichia coli, Bacillus subtilis, Alkaligenes are the commonly found bacteria and in milk are Cospora lactis and other organisms found in milk also depends upon the cleanliness of udder, utensils in which the milk is collected, the sanitary conditions of the dairy farm and the personal hygiene of food handlers.

A) Microbiology of meat

Like milk, meat is also an ideal medium for microbial growth. Being an animal tissue, it harbors various microorganisms. Though originally, it was thought that the tissues of healthy animals do not contain any microorganism. But analysis of many samples indicated the presence of various types of bacteria.

Micrococci are normally present and Salmonella and Escherichia coli are often found. Besides these microorganisms, meat can carry bacteria like Anthrax, Bacillus tuberculis and parasites like Cylicercus bovis, Cylicercus cellulosi and Trichinella spiralis.

B) Microbiology of vegetables and their products

All of us are well aware that vegetables are grown in soil, which, we already know, are a major support system for the microbial growth. Vegetables being near and in the ground may carry heterogeneous flora of microorganisms. Microorganisms are transmitted to vegetables if the soil or water is contaminated.

Clostridium, Bacillus and Escherichia coli are the common organisms found in vegetables. Their presence is mostly superficial and not internalised. Salmonella paratyphi, Shigella dysenteries, microspine chlorae are also found in vegetables.

C) Microbiology of fruits

Fresh fruits, like vegetables, are in a close vicinity of ground and hence may have varied flora of microorganisms. Nature has given the protective covering to the fruit, but if they are -injured, microorganisms enter the fruits. Presence of acid and sugar makes them ideal medium for yeasts and moulds. Common moulds responsible for rotting of fruits include Aspergillus and Penicillium.

3.5 FACTORS AFFECTING THE GROWTH OF MICROORGANISMS IN FOOD

In this section, we will focus on the several important factors which have a bearing on the growth of bacteria.

The principal influencing factors include nutrition, oxygen, temperature, hydrogen ion concentration (pH), moisture, osmotic pressure, light and the presence of inhibitory substances like chemicals. Although each of the factors mentioned limits the growth of bacteria, the growth depends more on the combined effects

of these factors. Let us get to know about these factors starting with the most important one i.e. nutrition.

3.5.1 Nutrition

Food is food to humans and microbes — be it carbohydrates, proteins or fats. The nutritional requirements of bacteria, however, differ from species to species. The nutrition is required by bacteria not only as a source of energy but also for manufacturing cellular components. The majority of the bacterial species use naturally- occurring organic materials viz., carbohydrates, proteins and fats . as a source of energy and the essential elements like carbon, hydrogen, oxygen, nitrogen, sulphur and phosphorus. Other elements like iron, magnesium, potassium are required in minute quantities.

Generally, based on the nutritional requirements, the bacteria can be divided into two groups, namely, autotrophic and heterotrophic bacteria. The autotrophic bacteria's requirements of carbon are derived from carbon dioxide or from carbonates and the requirement for nitrogen from gaseous nitrogen or nitrites and nitrates. They have the ability to synthesize its other essential requirements from inorganic substances like sodium chloride (NaCl), dipotassium hydrogen phosphate (K_2HP0_4) etc. for and survival. From these simple substances they synthesize complex structures like carbohydrates, proteins, vitamins, enzymes etc. The heterotrophic bacteria require one or several preformed organic compounds which are readily available for their growth. These requirements range from a single vitamin to several complex organic compounds. By far, the heterotrophic bacteria are the most commonly found type of bacteria and are widely distributed.

Even the autotrophic and heterotrophic bacteria are sub-divided further depending on the mode of deriving the energy source. They are chemosynthetic and photosynthetic. The chemosynthetic bacteria get their energy from the oxidation of inorganic chemical reactions, whereas, the photosynthetic bacteria have the ability to get their energy requirement from the sunlight.

So we have seen how microorganisms can differ based on the nutritional requirement they can utilize for energy and also vary in their need for vitamins or accessory food substances. Some like Staphylococcus aureus can synthesize a part of the food they need, others like Pseudomonas or Escherichia coli synthesize all of the factors needed and still others (the lactics and many pathogens) must have them all furnished. Like nutrition, oxygen is also basic for the growth of microorganisms? Let's read the next sub-section and find out.

3.5.2 Oxygen

The presence of oxygen in the atmosphere is essential for the survival of human beings. Contrary to this, you would realize that there are many microorganisms including bacteria, which have the ability to thrive in the absence of oxygen or free air. Microorganisms have been classified as aerobic when they require free oxygen, anaerobic when they grow best in the absence of free oxygen, and facultative when they grow well either aerobically or anaerobically.

Moulds are aerobic, most yeast grows best aerobically, and bacteria of different kinds may be aerobic, anaerobic or facultative. The bacteria which have the ability to thrive in the absence of oxygen or free air are known as 'strict' or 'obligate anaerobes '.

These organisms die when exposed to air or oxygen. But there are only few obligate anaerobes. Many bacteria are referred thus, because they tolerate extremely low levels of oxygen. There is another category of bacteria, which can survive either in the presence or absence of oxygen. They are known as 'facultative anaerobes The other kinds of bacteria which cannot survive in the absence of oxygen are called 'obligate aerobes'. There is yet another category of bacteria known as 'micro- aerophiles', which requires oxygen for survival albeit at low concentrations than present in air.

The oxygen tension or partial pressure of oxygen about a food and the oxidation-reduction potential (O-R) i.e. the reducing and oxidizing power of the food itself, influences the growth of microorganism. The organisms obtain energy from chemical reactions involving either inorganic or organic compounds. This takes place as an oxidation or reduction reaction through a loss or gain of electrons. The compound losing the electrons is known to be 'oxidized' while the compound accepting the electrons is 'reduced'. The compounds vary in their O-R potential i.e., the tendency to give up electrons. The presence or absence of oxygen and the O-R potential of the food itself has a bearing on the type of organism which grows on a particular food. The O-R potential oaf system is usually Eh and measured and expressed in terms of millivolts (mV). A high (oxidizing) potential favors aerobes but will permit the growth of facultative organisms and a low (reducing) potential favors anaerobic or facultative organisms.

3.5.3 Temperature

Temperature is one of the important factors affecting the process of growth in bacteria, as it has a bearing on chemical reactions. The temperature at which the maximum growth occurs is known as the optimum temperature. Based on the temperature at which the maximum growth occurs, the bacteria are divided into three main categories:

1) **Thermophiles**: The species of bacteria which grows rapidly between 45-650C, although they may grow anywhere between 45-750C.
2) **Mesophiles**: The species of bacteria which grows rapidly between 20-450C, where the optimum temperature range is 30-400C.
3) **Psychrophiles**: The bacterial species which grows rapidly at OOC (and even below), and have an optimum temperature range of 10-200C.

Although bacteria have been grouped into three categories based on temperature, there is no certainty that there is no overlapping between the bacterial groups. The division is based on a broad range of species. To illustrate, raw milk held at different temperatures support the initial growth of different bacteria. At temperature near freezing, cold tolerant bacteria, e.g. species of Pseudomonas will grow and Alcaligenes are favored at room temperature. Streptococcus lactis and coliform bacteria usually predominate at 400 to 450C. At 550C, thermophilic

bacteria like Lactobacillus thermophillus will grow.

Moulds and yeasts, for the most part, do not grow well above 350 to 37 and therefore, would not be important in foods held at high temperatures. On the other hand, moulds and yeasts grow well at ordinary room temperature and many of them grow fairly well at low temperatures, some even at freezing or slightly below. Therefore, moulds often grow on refrigerated foods.

3.5.4 Moisture Requirement

The Concept of Water Activity We already know that moisture is one of the important factors for the survival of living species. As such, it has a great influence on them, including microorganisms like bacteria. Water accounts for 80 90% of the total weight of cells. The water requirement of bacteria varies from species to species. Although water is required by bacteria, the growth largely depends upon the available water, which can be utilized for the growth of microorganisms. This is expressed as water activity which is defined as the percent equilibrium relative humidity (%ERH) divided by 100. ERH is an expression of the amount of free water vapor present on a product, both at its surface and within its structure. Numerically, ERH of a food divided by 100 equals "Water Activity". This can be represented by the following equation: Equilibrium Relative Humidity

$$\textit{Water Activity } (a_w) = \frac{\textit{Equilibrium related humidity}}{100}$$

In definition, water activity, expressed as the percent equilibrium relative humidity (%ERH) divided by 100 is unexciting. In practice, water activity is really a measure of free' water in a food sample, as opposed to 'bound' water.

Besides water activity, you may come across another concept 'water content' while talking about moisture. You must understand that water activity is different than the water content in foods. Water content, when referring to a solid material, is an expression of the percentage of the materials weight which is water, usually referred to as 'percent moisture content The reason why water activity merits closer attention is that it influences the shelf life of a food product. Water activity affects microorganism survival and reproduction, enzyme and chemical reaction. While temperature, pH and several other factors can influence if and how fast organisms will grow in a product, water activity may be the most important factor in controlling spoilage. We will learn more about this concept later in Unit 11, while talking about food packaging.

The nutrition and temperature have been found to have a bearing on moisture. With an increase in temperature, the available water will be reduced and then the availability of nutrition determines the growth. Most bacteria have been shown to grow well in media with water activity (aw) between 0.990-0.998. Water activity is an important factor in the control of growth of microorganisms.

3.5.5 Osmotic Pressure

Another important characteristic of a cell is 'osmosis'. You would recall reading

about osmosis in the Applied Physiology Course in Unit 8. In this section, let us learn more about cell and how it behaves when placed in water or any other solution. Do you remember the structure of bacteria? Yes, bacterial cell is contained by a cell membrane, which allows water to pass in and out of the cell. Active bacteria contain an excess of 80% water. When bacteria is placed in a heavy sugar syrup or salt brine, water in the cells move out through the membrane and into the concentrated syrup or brine containing 30-40% water. This is known as 'osmosis '. In the Figure 1.2, you can see a simple representation of the process of osmosis, where a membrane separates the solute molecules. Transfer of a liquid solvent through a semipermeable membrane that does not allow dissolved solids (solutes) to pass is osmosis.

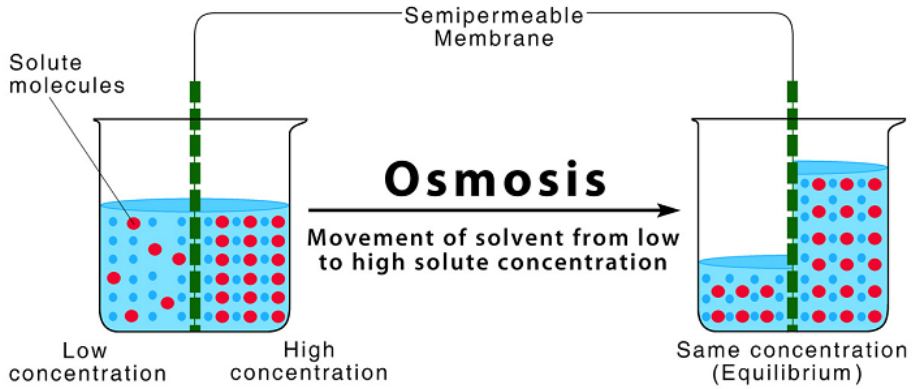

Figure 3.2: Osmosis

The tendency to equalize water concentration inside and outside the cell in this case causes partial dehydration, where the cell shrinks and is called 'plasmolysis Instead, If the bacterial cell is placed in distilled water, the water enters the cell and causes it to burst. This is known as 'plasmoptysis '. The tendency of cell membrane to allow water to pass from inside to outside or vice versa, is there to maintain an equilibrium between the cell contents and its fluid surroundings. As the hydrostatic pressure causes osmosis, it is known as osmotic pressure.

The osmotic pressure is related to the water activity of solutions and foods, solutions high in solute concentrations have a high osmotic pressure and a lower water activity. Dilute solutions are lower in osmotic pressure and have a high water activity.

3.5.6 Hydrogen Ion Concentration — pH

The hydrogen ion concentration has a significant role to play in the growth of bacteria, as every microorganism has a minimal, maximal and an optimum pH at which it can exist and thrive.

The pH, as you may already know, is defined as the negative logarithm of the reciprocal of the hydrogen ion concentration, expressed as

$$pH = -\log \frac{1}{H^+}$$

The pure water when ionized contains 10^{-7} moles each of H^+ and OH^-.As there is a balance between H^+ and OH^- ions, the solution (water) is neutral (pH 7). A pH scale has been devised to indicate the pH of various foods. The pH of water being neutral (pH 7), it is the midpoint of the scale. The pH scale extends from 0-14. Any substance is known to be alkaline if the pH is above 7. Most of the bacteria prefer a pH near 7 (neutrality), whereas, there are some bacteria which prefer alkaline or acidic medium.

In general, yeasts and moulds are more acid tolerant than bacteria. Finally, let us look at the role of light in the growth of microorganisms.

3.5.7 Light

Although visible light is beneficial to the photosynthetic bacteria, the ultraviolet light (U V) is however harmful to the bacteria. The UV light is absorbed by the nucleic acid present in the cells, which gets denatured and may result in the death of cells. Due to this property, UV light is used in the sterilization of air, water etc. We will learn more about this later in this unit under methods to control bacteria. With this, we come to an end on our discussion on factors affecting the growth of microorganisms. These factors are important and you will learn more about their relevance and implication while discussing food safety or food preservation later in this course.

STUDENT ACTIVITY - 1

1) Fill in the blanks:
   a) and do not grow well above 350C to 37 oc and therefore are not important for foods held at high temperature.
   b) Based on the nutritional requirement, bacteria can be divided into and
   c) Chemosynthetic bacteria derive their energy from of inorganic chemical reaction while photosynthetic bacteria get energy from ....
   d) The temperature at which maximum bacterial growth occurs is temperatures.
   e) Based on temperature, bacteria are divided into..... ..., and

Earlier we learrnt about the factors influencing the growth and multiplication of Occurrence and Growth of microorganisms. Just like the way these factors favor growth, they can also be Microorganisms In Food manipulated to control the growth or cause destruction of the microorganisms.

3.6 CONTROL AND DESTRUCTION OF MICROORGANISMS

Destruction or control of growth of microorganisms is the basis of food preservation. To 'preserve' actually means to keep safe, retain quality and prevent decomposition. Food preservation, as you would realize, is a process by which certain foods can be preserved from getting spoiled and kept safe for a longer period of time. The color, taste and nutritive value of the food are also preserved.

Microorganisms can be destroyed or controlled by the manipulation of the few factors like PH. temperature and water activity, which affect the growth of the microorganisms, using physical or chemical methods. This is the principle behind food preservation. Let us learn about these methods of food preservation by describing the physical methods first.

A) Physical Methods

Physical methods include various methods to control and destroy growth of microorganisms such as pic:kling, fermentation, dehydration, pasteurization, sterilization, canning, irradiation, freezing etc. Here an overview of these methods is; presented for you to understand the mechanism and how and which factor(s) is manipulated for the control of microorganisms. The methods include:

Pickling: Pickling is the process of preparing a food by soaking and storing it in a brine (salt) or vinegar solution. Pickling vegetables and fruits with vinegar helps in the prevention of microbial growth. This is due to the food being placed in a low pH solution in which microorganisms cannot grow.

Addition of Sugar or Salt: The addition of large quantities of sugar or salt inhibits the growth of microorganisms by making the water unavailable involving osmosis. Jams, marmalades, jellies and pickles employ this principle. Salted foods and foods with added sugar are also effectively preserved using the same technique, since the water they contain is unavailable for microbial growth. Indeed, cells of microorganisms become plasmolysed when they come in contact with the surface of these foods.

Fermentation: Fermentation is a process by which the living cell is able to obtain energy through the breakdown of glucose and other simple sugar molecules without requiring oxygen. Fermentation, acts as a preservation method by producing an acid, which lowers the pH of the product, converting a perishable food into the one that has a longer shelf life, e.g. fresh milk to cheese. The basis of the fermentation process is the conversion of glucose (sugar) to alcohol or to lactic acid by enzymes and we learnt earlier that at low pH microorganisms cannot grow.

Drying: Control of microorganisms by drying is based on the fact that microorganisms and enzymes need water in order to be active. When the moisture content is reduced in foods, microorganism's growth is retarded. Drying reduces aw level, weight and bulk of the food and helps in food preservation. The main

principle of drying, therefore, is to prevent microorganism activity by reduction of water. Although some microorganisms are destroyed in drying, it is not per Safety se lethal. The earliest method of drying was by simply exposing fresh foods to sunlight until drying is achieved. Fruits such as raisins, prunes, figs and others are dried by this method. The commercial drying methods consist of spray drying, drum drying, tunnel drying, freeze drying etc. You shall learn more about these methods in the Course Principles of Food Science, in Unit II.

A few food products that are preserved using commercial drying methods are briefly highlighted herewith:

Milk: It is dried as either whole milk or non-fat skim milk. Dehydration is accomplished by either drum-drying or spray-drying.

Eggs: It may be dried as whole egg, yolk or white.

Vegetables: These are generally preserved by freeze drying.

Meat: It is usually cooked before being dehydrated.

In freeze drying, the sample is freezed and water present in the form of ice is removed by sublimation.

Temperature: You have already studied in this unit about temperature as one of the important factors affecting the growth of microorganisms. Here we shall see how an increase or decrease in temperature could help us in controlling and destroying the growth of microbes. We begin with high temperature.

a) **High Temperature** :High temperature means any and all temperatures above ambient (room) temperature. In high temperature, there are three categories which are used in controlling or destroying microorganisms:

(1) Pasteurization,

(2) Canning, and

(3) Sterilization.

1) Pasteurization: Pasteurization means destruction of all pathogenic organisms in food (e.g., milk) or reduction of spoilage organisms in certain foods (e.g., vinegar) using mild heat.

You might have seen, as well as, consumed a variety of pasteurized products. Do you know what it is and how is it done? Well, when foods are heated in containers or by other methods to a temperature below 1000C for a definite period, the process is called 'pasteurization'. Generally, the pasteurization process involves heating of the food to temperatures between 600C and 850C for a few seconds up to an hour. The food is cooled promptly after the heat treatment.

There are two general types of pasteurization:

(l) temporary, the purpose being either to destroy some pathogenic organism or to control any spoilage organism, and

(2) permanent, in which the food material is subjected to a low temperature for the necessary length of time to ensure the keeping quality. The containers in this method are generally hermetically sealed.

The shelf-life of food products increases by several days and are usually stored in refrigerated conditions. This method is used to preserve fruit juices such as grape juice and fresh milk. It is also safely used in preserving most soft fruits.

The process of pasteurization originated primarily when the French scientist Louis Pasteur (1822 1895) employed this technique for controlling the contamination of wild yeasts and bacteria, which are responsible for spoiling wine, which was later extended to beer. In the later years, the pasteurization was applied to the preservation of fruit juices. Under the acid conditions prevailing in juices, the organisms are destroyed. Hence, preservation is usually permanent.

Milk is pasteurized to destroy pathogenic organisms, reduce total bacterial numbers, extend the storage life and also to inactivate enzymes which can affect milk flavors adversely. Prior to pasteurization of milk, diseases like typhoid, scarlet fever, diphtheria, tuberculosis and brucellosis were common due to the consumption of contaminated milk.

Traditionally, the pasteurization of milk is carried out by Low Temperature Long Time (LTLT) process i.e., holding the milk heated between 63 to 650C for 30 minutes. In the High Temperature Short Time (HTST) process, the milk is heated rapidly to 71.70C and held for 15 seconds and immediately cooled to 40C. The other temperature ranges at different holding period are also adopted. In the Ultra High Temperature (UHT) pasteurization, milk and other dairy products are heated at 1320C for at least 2 seconds. By adopting this process, Coxiella burnetii, the organism responsible for "Q" fever, is eliminated. The heat treatment has to be elevated for the dairy products like cheese. The ice cream mix may be heated at 71. IOC for 30 minutes or at 82.20C for 16 to 20 seconds.

2) Canning: The term canning is generally applied to foods, more specifically, to the foods preserved by heat processing. It aim* to destroy microorganisms and their spores through the application of heat. The term "canning industry" is therefore primarily meant to include; the entire range of foods preserved by heat treatment whether packed in tin or aluminium cans or glass or thermostable plastic pouches. The process of canning is also known as "appertization" named after a French scientist Nicolas Appert, who published the directions for canning process and he is known as "father of canning". Now how to successfully accomplish or carry out the canning process? Apart from this, are there any factors which influence the canning process? If yes, which are these? Let us find out. In the process of canning, the temperature used for heat processing varies from 1000C for high acid foods to 1230C for low acid foods. For HTST process, temperatures in the range of 1200 to 150?C or higher may have to be used. The process normally gives a better quality :product when compared to a product subjected to longer time at lower temperatures.

The heat processing for canning depends on a few essential factors such as pH, initial bacterial load, salt and sugar concentration in the product. The pH of a food to be canned is one of the important factors which determine the temperatures to be used. The pH affects the quality and stability of the food product. The critical pH on which most- processes are based is pH 4.5, which is the lowest pH at which C. botulinum can grow under normal conditions. With a few exceptions, the heat resistance of the bacteria is more when it is near to the neutral point i.e., pH 7. If the product is acidic in nature, the bacterial spores die.

What are the conditions where the spores can still survive in spite of the process of canning? Pathogenic and thermo-resistant spore formers, that may be associated with the raw materials or ingredients like spices as an initial bacterial load, pose a hazard for canning. So, proper care prior tocanning, can eliminate this danger to a great extent.

Conditions for various bacteria differ with regard to salt and sugar concentrations in the product. The bacterial spores display heat resistance up to a salt concentration of 4%. But as the concentration increases, the. Resistance drops. As far as sugar concentration is concerned, an increase of sugar greatly reduces the heat susceptibility.

3) **Sterilization**: The process involves the use of a combination of high temperatures and time to destroy nearly all microorganisms in food. This process is more severe than pasteurization and can sometimes affect the taste and appearance of the food. Then why is this method used? This method is important as some microorganisms (like Clostridium botulinum) can form spores, which have the ability to survive at high temperatures. If the correct temperature is not reached, there is the possibility that the spores will germinate and grow and food poisoning could result. Food products that have been sterilized have a very long shelf period at ambient temperature, e.g. canned ham or long life milk. These types of products would have a 'best before' date mark on the label, which means that the product should be consumed before that date.

4) **Irradiation:** It is the process of exposing food to carefully controlled amount of ionizing energy to destroy and control microorganisms in food. In fact, food irradiation can produce a wide variety of beneficial effects including delay in the ripening of fruits and vegetables, inhibition of post-harvest sprouting of tubers and bulb crops besides destruction of insects, parasites, bacteria, yeasts and moulds which can cause food spoilage or poisoning. There are three types of treatments that are given to food, which vary in terms of dosage level of radiation. These are:

   a) **Radappertization**: It is the treatment of a food with a dose of irradiation, usually 25 to 45 kg rad to produce a commercially sterile product, similar to canning. This high dose food application is generally used for foods, is meant for immuno-compromised people and astronauts etc.

   b) **Radicidation**: It is the treatment of a food with a dose of irradiation sufficient to reduce the number of viable, non-spore forming, pathogenic bacteria to undetectable levels which is equivalent to pasteurization with heat and the dose is generally less than 10 kg rad.

c) **Radurization:** It is the treatment of a food with a dose of radiation (<10 kgrad) in sufficient quantities to reduce the number of spoilage microorganisms and to enhance the keeping quality of the foods.

Next, let us learn about use of low temperature as a preservation technique.

b) **Low Temperature:** Like in high temperature, lowering the temperature of a food product too helps to control, as well as, destroy the growth and survival of microorganisms. Let us briefly look at the major low temperature techniques of bacterial control. We shall begin with chilling.

i) **Chilling**: You may have noticed that the refrigerated storage is the most widely practiced methods of controlling microorganisms in perishable foods. When temperatures are lowered below the optimum for growth of a particular organism, it is seen that the log time and generation time increases and growth rate decreases until the temperature approaches the minimum for growth, the cell division ceases.

ii) **Freezing**: Besides chilling, freezing is another method of control of microorganisms. It was mentioned earlier that decreasing the temperature decreases the metabolic activity in organisms and freezing totally arrests the growth of microorganisms. Freezing, hence, is based on the following two principles: 1) Very low temperatures, which inhibits growth of microorganisms and retards the enzymic and chemical activity, and 2) Formation of ice crystals, which draws available water away from food, therefore, prevents the growth of microorganisms. There are certain methods of freezing that have been developed in the food industry to speed up the freezing time, as well as, reduce the risk of microbial growth. These are:

Blast freezing: Batches of food are subjected to a constant, steady stream of cold air (— 400C or lower) in a tunnel or a cabinet.

Scraped heat exchange: In this, the product such as ice-cream is scraped against a cooled surface. This is to reduce the formation of large ice crystals.

Cryogenic freezing: Liquid nitrogen/ C02 is sprayed directly onto small food items (prawns, soft fruits). Due to the liquid's extemely low temperatures (—1960C and —780C respectively), freezing is almost instant. Fish and fish products, beef and their products, vegetables and ready meals are some of the foods where freezing is used.

Modified Atmospheric Packaging: Modified atmospheric packaging is the enclosure of food in a package in which the atmosphere has been changed by altering the proportion of carbon-dioxide, oxygen, nitrogen, water vapor and trace gases. The process retards microbial and biochemical activity.

B) Use of Chemicals to Control and Destruct Microorganisms in Foods

The use of chemicals, as a process of food preservation, has been used since long, ever since man found them by trial and error to be beneficial to him. Sodium chloride or the common salt has been the oldest compound which has been serving the purpose since several centuries. Apart from sodium chloride, other chemicals which were being used include salt peter, slaked lime etc. The salt peter (sodium and potassium nitrate) in combination with common salt was used to impart flavor and keeping quality of meats. All these compounds can be termed as a preservative.

Now, then, how would you define a chemical preservative? Let us find out.

A chemical preservative is a substance which is capable of either inhibiting, retarding or arresting decomposition of foods. The use of chemicals as preservative has been subjected to criticism due to their indiscriminate use and the likely hazard they pose to the human health. The process of preservation by the addition of chemicals to foods has to be undertaken, keeping in mind the usefulness and limitations in affecting human health.

International organizations, such as the Food and Agriculture Organization (FAO) and World Health Organization (WHO), have defined limits for each chemical to be used as a preservative. The Government of India regulates the use of various additives in foods. The use of chemicals has to be employed, if it is an economical means of preservation and only when other physical means like pasteurization etc. are not possible or other methods of preservation are not available. The preservative should extend the storage life of the product and at the same time, not affect the quality and be an antimicrobial agent. It also should not be converted to other toxic compounds on reaction with the food commodity.

But here we must understand how do these preservatives extend the storage life of the product. Remember, the chemical preservatives serve as antimicrobial agents by acting as growth inhibiting or growth retarding agents or by killing the microorganisms.

The action of most chemical agents on microbes include their effectiveness either by their effect on their genetic functions by:

(a) interacting with the DNA molecules

(b) acting upon the cell wall

(c) inhibiting the microbial cell enzymes, and

(d) making the essential nutrient unavailable to the microorganisms.

What are the types of chemical preservatives commonly used?

Let's find out.

There are several food preservatives which have been 'Generally Recognized As Safe' (GRAS) in the USA and for which Acceptable Daily Intake (ADI) have been specified by the FAO/WHO. These are widely used in many countries of the world to help prevent the bacterial and fungal contamination of foods. Such chemicals include: Benzoates, sorbates, propionates, acetates, nitrates and nitrites, sulphur dioxide and sulphites, and antibiotics. A word on each of these preservatives follows:

a) Benzoates

Benzoic acid, sodium benzoate and the parahydroxy esters (parabens) are used as preservatives. Benzoic acid and its sodium salt, sodium benzoate, is the widely used preservative when compared to other preservatives. Sodium benzoate is more soluble in water, as such, it is the preferred form.

The antimicrobial activity of benzoate is greater at the lower pH values. Its optimum pH range is between 2.5 to 4.0. Only the undissociated benzoic acid molecules are active. Due to this, the benzoic acid and its salts are effective in high acid food products. These compounds act as inhibiting agents for some moulds and yeasts in acid fruit products like jams, jellies, fruit juices etc. The two esters, methyl paraben and propyl paraben are also used extensively, as they are effective at a higher pH level when compared to benzoates. This is due to the esterification of carboxyl group, which makes the undissociated molecule being available over a wider pH range.

b) Sorbates

Sorbic acid is an unsaturated carboxylic acid whose salts as sodium, calcium or potassium are used in foods up to 0.2%. As in the case of benzoates, the salts of sorbic acid are fungal inhibitors and are effective below pH 6.0 and comparatively act better between pH 4.0 to 6.0. Sorbic acid is widely used in bakery products, fruit juices, jams, pickles and especially cheese and cheese products. It effectively controls the cheese spoilage bacteria and being non-toxic, it does not impart off-flavors. It is effective at the entire pH range of cheese and does not affect the bacterial ripening process. It is also applied to the bread wrapper, which eliminates the mouldy appearance in bread.

c) Propionates

Propionic acid is formed from lactic acid or lactates, as a result of the bacterial action during the manufacture of Swiss cheese. The characteristic 'eye' formation in Swiss cheese is due to the gas formation by the bacteria. It serves as a developed preservative up to 1% and prevents the growth of moulds. 'The calcium and sodium propionates are extensively used in the bakery products to prevent the 'rop' by B. mesentericus. They do not have much effect on yeasts and bacteria. The inhibition of moulds is best between the pH 3.5 to 4.5.

d) Acetates

Acetic acid is an approved GRAS food preservative. This is a widely used preservative due to being freely available and cheap, when compared to other products. It is effective against bacteria. As a principal component of vinegar, it is used in many foods. The derivatives of acetic acid, dehydroacetic acid and sodium diacetate are being used as preservatives. Among them, dehydroacetic acid is used to impregnate wrappers for cheese in inhibiting growth of moulds and sodium diacetate is used for inhibiting moulds in bread. These two are also GRAS preservatives. The action, like in benzoates, propionates and sorbates, increases with a decrease in PH.

e) Nitrates and Nitrites

The use of nitrates and nitrites has been widely used in the curing of meat. The reduction of nitrates by bacteria produces nitrites under acid conditions created by meat. Recent research has pointed out that nitrites can react with secondary and tertiary amines to form nitrosoamines which have been known to be carcinogenic to humans. This is alarming. The use of nitrites as an inhibitory agentagainst Clostridium botulinum in meat products is well established.

f) Sulphur dioxide and sulphites

Sulphur dioxide as a preservative in wine preparation has been in use since ancient times. It is also used in other foods, like fruits and vegetables, for preventing the microbial growth. Sulphur dioxide is effective in inhibiting bacterial and mould growth when compared to yeasts. It is also used in combination with sodium benzoates in fruit preparations. Apart from sulphur dioxide, other sulphites, sodium sulphite, potassium sulphide and sodium metabisulphite etc. are also used as preservatives, as they act more or less similarly in inhibiting microbial growth. The inhibition of microbial is through the inhibition of certain enzyme systems and other biochemical reactions and is also pH dependent. The sulphur dioxide forms sulphurous acid (H2S03) when it combines with water and is effective at the lower pH values.

You must have heard about antibiotics and its role in diseases. What are these and how are these produced? Let's find out.

g) Antibiotics

The antibiotics are the chemicals produced by microorganisms which are able to destroy or inhibit the growth of other microorganisms. The therapeutic use of antibiotics in bacterial diseases is well established. This led to the thought of using antibiotics for the prevention of microbial spoilage of foods. Several antibiotics were tested as preservatives but their use has been discouraged, since it was observed that antibiotic resistant microorganisms were developing due to regular use. Only nisin produced by certain strains of milk souring organism, Yreptococcus lactis is permitted to be used as a preservative in foods in several countries, including India. With this, we come to an end to our discussion on methods used to control microbial growth. We hope this information equipped you in understanding the role of different factors influencing both the growth and survival of microorganisms in food.

3.7 LET US SUM UP

In this unit we studied the microbiology of air, water and soil which act as physical sources of a variety of microbes. The various sources of food contamination were also discussed in this unit. The major focus of the unit was on the factors affecting the growth of microorganisms which included pH, water activity, nutrition, OR potential etc.

Further, the methods to control and destroy and growth and development of microorganisms in foods were dealt with. These involved among the physical methods, the use of altered temperatures (high and low), drying, fermentation and chemical preservatives such as sorbates; propionates, benzoates etc. The use of antibiotics to prevent microbial spoilage of foods was also highlighted.

3.8 GLOSSARY

- Antibiotics : the chemicals produced by microorganisms which are able to destroy or inhibit the growth of other microorganisms.
- Facultative anaerobes : bacteria which can survive either in the presence or absence of oxygen.
- Heterotrophic bacteria : these require one or several preformed organic.
- Micro-aerophiles : bacteria which require oxygen for survival.
- Microbial ecology : the study of relationship between microbes and their surrounds (environments).

3.9 CHECK YOUR PROGRESS

1) What are the factors affecting the growth of microorganisms?
2) What are the common sources of food contamination ? List the different physical methods of preservation.
3) Explain the following terms:
   a) Facultative anaerobes
   b) Plasmolysis
   c) Osmosis
   d) pH
   e) Water Activity
4) Explain how chemical preservatives act as antimicrobial agents.
5) Explain the main principle behind food preservation. What are the two methods used for food preservation?

UNIT

4

FOOD SPOILAGE

STRUCTURE

4.1 LEARNING OBJECTIVE

Objectives

After studying this unit, you will be able to:

- explain what is spoilage and the factors that lead to spoilage,
- describe various chemical changes that occur in foods due to spoilage, and
- discuss, in detail, about spoilage of different foods.

4.2 INTRODUCTION

We already learnt about the various organisms causing food spoilage and the factors influencing their growth. In this unit, we will fry to understand What is meant by food spoilage, what factors are responsible for food spoilage, changes that are brought aboui by spoilage and how it differs from food to food.

4.3 FACTORS RESPONSIBLE FOR FOOD SPOILAGE

When do we consider a food to be spoiled? A food is considered to be spoiled when it becomes unacceptable for consumption as perceived by the individual, based on the organoleptic characteristics like smell, taste etc. The normal process of spoilage of foods by microorganisms has caused a greater concern than any other form. The microbial deterioration ofa food is usually manifested by a change in

the appearance, texture, odour, flavour or by slime formation. The appearance includes colour changes formation of packets of gas or swelling and microbial growth, especially of that of moulds.

Microorganisms can cause a change in the character of food, which may be classified as positive or negative. Products of "positive" microbial transformations include cheese, yoghurt and wine, which can be seen as increasing the nutritional value or keepin quality of products with a short shelf life. "Negative" aspects of microbial growth include food deterioration and spoilage by decay and foodpoisoning, mainly caused by different and less widespread bacteria. As they grow, microorganiöms release their own enzymes into the liquid surrounding them and absorb the products of external digestion. This is the main basis of microbial food spoilage, which lowers its nutritional value. Bacteria and moulds may also produce waste products which act as poisons or toxins, thus causing the renowned ill-effects.

Spoilage, as you would realize, is quite a natural phenomenon. All foods undergo varying degrees ofdeterioration or spoilage that may be physical, chemical or biological. Spoilage results in losses in the organoleptic desirability; nutritional value, safety and aesthetic appeal.. What are the factors which lead to food spoilage? Can we avoid them or slow them to a certain extent?. These are the issues with which we are going to deal with,, Let us begin with the factors that make a food unacceptable. These include:

a) Growth and activities of microorganisms, principally bacteria, yeasts and moulds

b) Activities of food enzymes, for instance, enzymatic browning

c) Infestation by insects, parasites and rodents

d) Chemical changes in a food, for instance, chemical oxidation of fats causing rancidity and non enzymatic browning reaction.

e) Physical changes, or the damages caused by freezing or drying etc.

f) Presence of foreign bodies, and

g) Physical abuse i.e. contamination with chemical agents.

You have now got a fairly good idea of the factors leading to spoilage. In the last unit we studied about the factors influencing the growth of microorganisms. All these factors too are important in the context of food spoilage.

But what is the criterion for classifying a food as unacceptable? How do we decide whether a food is spoiled or not?

Well, you would notice that the concept of spoiled food is quite subjective and is closely associated with an individual's taste preference or ethnic origin and family background. The extent of chemical and bacteriological changes is associated with the decision about a food's acceptability. A food which might be unacceptable for some due to the above mentioned changes could be a delicacy for others. For instance, bananas that have become brown and sugary are considered overripe and therefore spoiled to many consumers but are perfectlyacceptable to some.

You would have noticed that some food items deteriorate or spoil easily within a day or two as compared to others. In fact, based on the ease or quickness with which

a food item gets spoiled, all foods can be categorized into the following three groups:

- **Non-perishable foods**: As the name suggests, these are the foods which do not spoil unless handled and stored carelessly and that can be stored at least for several months. Examples of non-perishable foods include cereals, pulses, sugar etc.
- **Semi-perishable foods:** Like the non-perishable foods, semi-perishable foods can survive without any perceptible sign of spoilage for a couple of weeks or for a few months. Here, of course, temperature and humidity of the environment makes a big difference. Examples in this category include cereal and pulse products like wheat flour, refined wheat flour, semolina, vermicelli, broken wheat, bengal gram flour (besan), potatoes, garlic, some fruits like apples, citrus fruits, fats and oils.
- Perishable Foods: These are the foods which spoil easily within a day or two unless special methods are used to prevent such spoilage. Yes, all animal foods such as milk and milk products, meat and meat products, fish, poultry and eggs are included in this category. Most fruits and vegetables too fall in this category.

The classification presented above is practical, however, it is important to understandFood Spoilage that there is nothing which would not spoil unless special care is taken. Even sugar and salt can absorb water and become soggy during conditions of high humidity like in rainy season. In a hot tropical country, like India, with the diverse environmental conditions — extreme temperatures and varying levels of humidity — there can be no absolute classification of food. The classification presented above is just a basic guide.

We have talked about food spoilage in this section. Are you aware of the changes taking place in food items, which render them as spoilt?

The next section presents a detailed discussion on the chemical changes occurring during food spoilage and highlights the changes in specific foods and the organisms causing the spoilage. You will find this information very useful, not only from academic point of view, but also in terms of practical application in the day to day life. Read it carefully

4.4 CHEMICAL CHANGES DUE TO SPOILAGE

A food item may have apparently looked safe and wholesome for you to eat, but the rumbling and grumbling in your stomach at night may have made you think, was the food really safe?

Yes, very often the spoilage is not apparent on the surface of the food. It is the changes undergoing inside the food, not apparent to the naked eye, which might cause ill health. The chemical changes that occur in a food due to spoilage depend primarily upon the composition of food. The changes vary depending upon the source of the food i.e plant foods are primarily carbohydrate-rich, while animal foods are rich in proteins and fats, hence the changes will differ. Let us see what changes takes place wit respect to the nutrients present in the food when bacteria

NOTES

Degradation of Carbohydrates

The carbohydrates that are naturally present in foods, you may already know, can be divided into monosaccharides, disaccharides, oligosaccharides and polysaccharides. Most commonly occurring carbohydrates are disaccharides and polysaccharides. Bacteria breakdown these carbohydrates to monosaccharides. This results in softening or liquefaction of the food.

Degradation of Fats

Fats are the esters of glycerol and fatty acids and are called as 'glycerides'. Fats are susceptable to hydrolysis, oxidation and other chemical changes that produce both desirable and undesirable flavour changes in foods. The pure fat cannot be attacked by microorganisms. They need an aqueous phase to grow in foods like butter, creams and margarine. Microorganisms degrade fats into glycerol, free fatty acids, ketones and alcohols.

Degradation of Proteins

Proteins are composed of amino acids combined by peptide linkages. The native proteins are resiStant to attack by microorganisms. The.other compounds like dipeptides and free amino acids in fresh meat, fish and poultry are readily used by microorganisms. Spoilage of the protein-rich foods may be evident before any significant amount of protein is degraded. The degradation of amino acids is of primary importance in the spoilage of protein foods. The products that are formed depend upon the followingfactors: (i) the type of microorganism (ii) amino acid composition of the material (iii) available oxygen, and (iv) type of inhibitors present. The anaerobic degradation of amino acids by microorganisms produces foul smell which is called as 'putrefaction Aerobic degradation is called decay.

So far we have looked at the changes, in general context We know each food varies Safetyin its nutriefit content and hence the changes will vary. Milk, for example, is composed of carbohydrates, proteins and fat as compared tp chapatti, which contains predominantly carbohydrates. Not only the nature of spoilage will differ but also the organisms causing the spoilage will vary.

4.5 SPOILAGE OF DIFFERENT FOODS

Earlier in the unit, we did present a general classification of foods based on the perishability. Let us now look at the consequences of spoilage of these foods, starting with a highly perishable food that is, 'meat', which owing to its ideal composition, is susceptible to microbial attack.

4.5.1 Spoilage of Meat

Meat is primarily the muscular tissue which is the edible portion of the carcass

of animals. It contains all the essential nutrients in the ready form for microbial growth and also it has a high water content (a_w = 0.99), which is ideal, for most of the microorganisms, particularly bacteria. What are the changes that occur in meat and lead to its spoilage? Well, it is surprising to note that the spoilage of meat depends mostly on the initial contamination of the animal. We had emphasized earlier that plants and animals have a natural microflora.

In case of animals, except for the external surface and the gastrointestinal and respiratory tracts, ahealthy animal does not contain any microorganismS. But the animal is slaüghtered, the situation changes, as the body's defense mechanism is withdrawn and the slaughtered meat is subjected to biochemical changes. The enzymes present in the meat act upon the meat protein which makes the nitrogen compounds available for microorganisms. Immediately after the slaughter, the meat becomes stiff and rigid, which is known as rigor mortis (stiffening). Actually, the action of enzymes in tenderizing the meat is desired by many and is kn8wn as 'ripening'. If this autolysis (action of enzymes) is not stopped, the meat goes on to become sour. What are the factors which influence the spoilage of meat? Can you list a few? Sure enough, you should be able to enumerate these having learnt about them earlier on. These important factors which lead to the growth of microorganisms in meat are highlighted next:

Initial microflora

The initial microbial load on an animal clearly determines the keeping time under good preservation conditions. As such, the hygienic conditions of an animal are important for the reduction in the proliferation of microorganisms in the stored meat. The general sanitation of the abattoir also helps in reducing the contamination of fresh meat.

pH

After the animal is slaughtered, the pH of the carcass drops from around 7.0 to 5.6, as the glycogen reserve in the muscles is used up slowly and lactic acid is formed. Ifthe condition of the animal at the time of slaughter is abnormal due to excitement, stress etc., the available glycogen is used up rapidly thereby the desired reduction in pH does not occurs and the pH remains around 7.0. This helps in the growth of microorganisms and the spoilage of meat results.

Oxidation-reduction potential

You leamt earlier that the presence or absence of oxygen and the O-R potential of the food itself has a bearing on the Wpe of organism which grows on a particular food. In the case of meat, after slaughter, the oxygen stored in the muscle gets reduced bringing down the oxidation reduction potential, while at the same time, it is higher at the surface of the meat. This condition is favourable to aerobic bacteria, yeasts and moulds while the internal conditions still being anaerobic, favours the growth of anaerobic bacteria. Under the anaerobic conditions, both the anaerobes and facultative anaerobes cause putrefaction. Putrefaction, as you know already, refers to the decomposition of foods due to microbial action. This is

generally due to the growth of Clostridium spp. within the tissue, with the release of decomposition products like mercaptans, hydrogen sulphides, ammonia etc. The organism which is predominant in the decomposition of protein under anaerobic conditions is the Clostridium perfringens, which incidentally is a food borne disease causing organism. Under the aerobic conditions, apart from bacteria, yeasts and moulds also grow on meat. The growth of a particular microorganism depends on temperature, moisture and other conditions. The organisms principally responsible for the spoilage of meat are bacteria of the genera Pseudomonas, Bacillus and Micrococcus. The other commonl bacteria include Cornybacterium, Escherichia and Aerobacter.

Temperature

Temperature has a profound impact on the spoilage of meat. The carcass meat held at temperatures above 200C is subjected to the spoilage of anaerobic bacteria. Once the meat is minced, the aerobic and facultative anaerobic bacteria also grow, with an increase in the availability of oxygen, thereby increasing the oxidation-reduction potential. The spoilage is rapid at this stage Normally, the fresh meat is stored in refrigerators at chilling and freezing temperature to enhance the shelf life. The danger to meat stored under refrigerated conditions is from the psychrotrophs like. Pseudombnas spp.

The Pseudomonas which is the predominant microflora, is limited to; the surface and up to 3-4 mm underneath the exposed tissue, due to its strong aerobic characteristic. Apart from bacteria, fungi can also grow on meat. Over an increased period of storage, the meat humidity on the surface layers gets dried and it will be susceptible to fungal attack due to a drop in water activity. Fungus growth is indicated by characteristic colours present on the surface.

Features	Moulds involved
Whiskers	*Thamnidium chaetocladioides Telegans, Mucor mucedo, M. insitanicus*
White spots	*Sporotrichum carnis*
Black spots	*Cladosporium herbarum*
Green patches	*Penicillium expansum, P. asperulum*

Table 4.1: Spoilage of meat by moulds

4.5.2 Spoilage of Poultry and Poultry Products

Poultry meat is the muscle tissue of chicken, ducks, turkey etc. The reference to poultry meat generally is the 'dressed chicken'. It is similarly considered along with the other meats. The spoilage organisms involved also follow more or less the same pattern. After processing, like evisceration (removal of the parts), the meat is general stored under chill conditions. Under this storage temperature,

the bacterial growth in poultry meat takes place on the surface. Once the spoilage takes place, off-odours are initially noticed and then followed by slime formation. Species belonging to Pseudomonas are the primary spoilage organisms in the meat held at 100°C or less Above 100°C, Micrococci, Alcaligenes and Flavobacterium also grow.

Eggs

Most of the freshly laid eggs are sterile, although it may get contaminated through cracks in the shell. Washing also aids in the spoilage of eggs due to increased moisture on the surface • of the shell. The bacteria which cause spoilage of eggs include species of Pseudomonas, Micrococcus, Bacillus, Proteus, Alcaligenes, Flavobacterium and Salmonella. The most predominant among them is Pseudomonas. Moulds found on eggs include Penicillium, Aspergillus, Cladosporium, Mucor and Rhizopus. But the spoilage is generally caused by bacteria than mould.

Once the bacteria invade the inside of an egg, they develop characteristic odours and appearance. The common form of spoilage is known as rotting. How do we know whether an egg is rotten? Whether an egg is defective or not, could. Be identified by subjecting the egg to 'candling', which is a technique which involves rotating the egg in front of the candle light. This helps in identifying the cracks, rots etc. There are different types of rots characteristic to egg spoilage. The types of rotswhich are frequently encountered include:

- ***Black rots***

The black rots are caused by bacterial species of Proteus, Aeromonas and Pseudomonas. The species of Proteus usually causes the black rot. The egg under this condition, when broken, gives a muddy dark brown appearance with putrid odour due to hydrogen sulphide.

- ***Red rots***

This rot is caused by Serratia marcescens and is distinguished by a red colour.

- ***Pink rots***

This is caused by the species of Pseudomonas.

- ***Green rots***

Pseudomonas fluorescens is the causative organism of this rot, which fluorescens under the UV light.

- ***Colourless rots***

Acinetobacter, Alcaligenes and Pseudomonas are responsible for this rot.

Of all the rots, the important ones are the green, colourless and black rots. Pink rotsFood Spoilage are not frequently encountered.

4.5.3 Spoilage of Fish and other Sea Foods

Fish and other marine foods are second only to nieat and poultry as a staple animal food around the world. India is one of the important fish producing countries due

to its vast sea coast and several inland water sources. Fish is a regular diet in populations residing in the coastal districts of various States in India. The demand for inland fish is greater when compared to marine fish, which is generally exported. Most of the fish is consumed fresh in India, although dried and salted fish is also used widely.

Spoilage of Fish

The spoilage of fish depends on several factors which include:

i) **The type of fish**: Different types of fish are susceptible to spoilage due to shape and size. A fat fish is susceptible to spoilage due to the oxidation of unsaturated fats of their oils, whereas, the thin variety may get spoilt due to the rapid settin of rigor mortis (stiffening)

ii) **The initial microflora**: The flesh and internal organs of fish are normally sterile at the time of catching but the external skin, gills and the intestine may contain bacteria depending on the environment it has been caught. If they are caught in polluted waters, the microbial load will be higher.

iii) **The temperature of air and water source**: The type of microorganism on the fish depends greatly on the location. The fish from warm seas are contaminated with the mesophilic strains while the fish caught in cold regions contain psychrotrophs.

iv) **Handling of the fish after being caught**: The handling process after catching the fish is also important to its spoilage. The fish after catching are held either as whole, beheaded or gutted (the intestines are removed). The spoilage pattern differs for each, the gutted fish keeping longer. The immediate storage pattern also plays a role. Sometimes, the fishes are piled, creating pressure on the lower layers of fish. If ice is used in preserving the fish, it also contributes to the microbial load, as ice is generally manufactured with unpotable water. The crosscontamination from earlier catches, the nets used, boats, baskets or other containers used and their sanitary conditions also play a role.

v) **Chemical changes in fish**: Similar to meat and poultry, the autolytic enzymes do play an active role in the deterioration of fish apart from the microorganisms. As lipids in fish contain high levels of polyunsaturated fatty acids (PUFA), the oxidative rancidity is more pronounced in fish than in the other animal products. In fish, the trimethylamine oxide (TMAO) is reduced to trimethyl. Amine (TMA) due to the action of fish enzymes and bacterial action. The presence of TMA is considered as a test in assessing the spoilage of fish. This is also evident from the stale fishy odour.

So you have seen that normally the spoi lage of fish is caused by the natural microflora of its habitat followed by the storage condition. In case of fish, the storage is by the cold process. The microorganisms causing spoilage of the fish are the Pseudomonas which is the predominant type of bacteria under condition, followed by Acinetobacter,

Moraxella and Flavobacterium.Are these organisms also responsible for spoilage of other sea foods? Let's find out.

Spoilage of Other Sea Foods

The widely consumed sea foods are shrimps, oysters, crabs etc. The shrimps are commonly stored in chill conditions where the predominant organisms responsible for spoilage are the species of Acinetobacter, Moraxella, Vibrio, Altermonas and Pseudomonas. The oysters are spoiled at near freezing temperatures by Pseudomonas and Moraxella species. The oysters contain high levels of carbohydrate as glycogen, as such they are subject to different spoilage patterns. The crab meat is spoiled by Pseudomonas, Acinetobacter and when held at chilled temperatures. V. parahaemolyticus is the predominant pathogen in fish and sea foods.

Type of sea foods	Microorganisms	Spoilage effects
Fresh fish	*Pseudomonas* *Acinetobacter* *Moraxella*	Off-odour
	Pseudomonas	Hydrogen sulphide odour, Fruity odour
Salted fish	*Halobacterium*	Pink colour
Shrimps	*Pseudomonas*	Off-odour
Oysters	*Rhodotorula*	Pink colour

Table 4.2 : Types of spoilage of fish and other sea foods

STUDENTS ACTIVITY - 1.

1) Mention 'rots' that are frequently encountered on eggs as a consequence of spoilage, along with the name of organism responsible for spoilage.
2) Briefly describe chemical changes occurring in fish.

From animal foods, we now move on to the plant foods and here we shall leam about the nature and organisms responsible for their spoilage. We start with fruits and vegetables.

4.5.4 Spoilage of Fruits and Vegetables

Fruits and vegetables are an integral part of daily diets of man all over the world. The spoilage of fruits and vegetables normally occurs after harvest. However, some plant pathogens cause spoilage even before harvesting. The post-harvest spoilage of fruits and vegetables occur mostly during packing, transport and storage, before being processed or consumed. Unlike other food products, the fruits and vegetables will be undergoing physiological changes for quite some time even after harvesting due to the process of ripening. During the ripening process, the autolytic enzymes are active, breaking dovvn the carbohydrates.

Apart from the enzymes, the microorganisms are also involved in causing the spoilage of the fruits and vegetables from pre-harvest to post-harvest stage. These are the fungi and bacteria. Let us get to know them.

NOTES

Spoilage by fungi and bacteria

The dominant spoilage organisms in fruits are fungi, as their pH is low (normally 5), whereas the pH of vegetables is from 5.0 to 7.0, which makes them susceptible to both fungi and bacteria. The spoilage is affected through the formation of rot, which is due to the ability of fimgi and bacteria to secrete pectolytic enzymes. The rot is characterized by the softening of the tissue due to the action of pectolytic enzymes. Most important moulds involved in the spoilage of fruits and vegetables are Penicillium and Rhizopus.

Although bacterial spoilage of fruits and vegetables is less when compared to moulds, nevertheless, certain strains of bacteri still cause spoilage. The important organisms belong to Erwinia Spp. and Pseudomonas Spp. Among them, Erwinia motovora is important.

Fruits and vegetables	Genus	Spoilage Effects
Majority of fruits and some vegetables	*Penicillium*	Blue rot
Several fruits and vegetables	*Rhizopus*	Soft rot
Several fruits and vegetables	*Sclerotinia*	Watery soft rot in vegetables, brown rot in fruits
Potato, tomato, citrus fruits and many vegetables	*Geotrichum*	Sour rot
Cabbage, cauliflower, potato, lemon, orange, apple and pear	*Alternaria*	Black rot

Table 4.3: Fungi responsible for the spoilage of fruits and vegetables

4.5.5 Spoilage of Cereals and Cereal Products

Cereals are the main source of energy to human beings. There are several varieties of cereals, of which wheat and rice are the major crops and staple food for the majority of people in India. In the preparation of different snacks and other varieties of foods, the cereals are the major ingredients. The cereal products, especially wheat, are extensively used in the food preparations like chapati, bread and other bakery products. Cereals, cereal flour etc., are generally stable due to their low water activity (a_w), hence, are considered as semi-perishable foods. You may recall reading about this earlier also.

The spoilage of these commodities can take place only when they are stored in humid conditions or the product prepared contains high moisture The spoilage organisms, in the case of cereals are usually moulds and followed by yeasts and bacteria as the moisture percentage increases. Occasionally, unseasonal rains occur at the time of harvest and standing of harvested grains of wheat, maize and sorghum are infected by moulds like Aspergillus and Fusarium.

Let us next discuss the spoilage of cereal products, starting with the most popular cereal product i.e. the bread, which we all perhaps consume almost everyday.

Bread

Among the cereal products, bread assumes a prime position. It is a Widely prepared cereal byproduct which is consumed all over the world. The spoilage of bread is mainly by moulds. The common spoilage moulds include Rhizopus nigricans, which produces the characteristic black spots. The Penicillium expansum or Aspergillus niger develops the green spots while the Monilia sitophila imparts the pink colour. The red or blood bread is caused. by Serratia marcescens. The important spoilage problem in bread is the 'ropiness' is caused by Bacillus subtilis or Bacillus licheniformis.

Figure 4.1: A mouldy loaf of bread

This occurs as the flour protein and starch in bread gets hydrolyzed which leads to stringiness in the bread. The spoilage ofcommercial bread has come down drasticall due to the usage of preservatives like propionic acid. It has been found that chapati, which is the most common form of wheat preparation in India, when held in a polythene cover, keeps for nearly seven days inspite of the relative humidity being up to 90 to 95%. The Aspergillus spp. spoils chapati after this period.

Cakes, pastries and other bakery items.

Moulds are generally responsible for the spoilage of cakes and other bakery items. But the addition of several ingredients, like cream filling in pastries and other dairy products, eggs etc., can add up several spoilage organisms, as the water activity Of these products is quite high. Staphylococcus aureus has been found frequently in pastries due to the addition of milk products. Due to the addition of high sugar icing, low pH topping like fruits, spoilage bacteria do not gain entry but ultimately yeasts or moulds can grow. The storage under refrigeration conditions below 50C can help in reducing the risk of spoilage of pastries and cakes.

Having studied about fruits and vegetables above, which are classified as perishable foods, we move on to yet another perishable food i.e. milk and get to

know about its spoilage and that of its products namely cheese, butter etc.

4.5.6 Spoilage of Milk and Milk Products

NOTES

Milk is a wholesome food and so it is generally consumed in its basic form or with the addition of a beverage supplement. Milk is a basic food commodity for several milk-based preparations. It is important to know that the raw milk obtained from a healthy buffalo or cow is generally free from organisms. How then does the milk get spoiled? There are many factors that lead to spoilage of milk. Can you suggest few?

Consider the following situation. The milk is normally procured from small farmers, collected in refrigerated containers and transported to the processing plants. Much before the milk is procured, the process of milking the cattle takes place. Now, can you suggest how milk can get spoiled at each of these stages? The first and foremost exposure is the milk obtained from an infested udder which can carry microorganisms, as cows and buffaloes generally suffer from mastitis. Apart from the udder, the othe sources of spoilage organisms in milk could be through the handler, utensils, storage vessels and other process equipments etc.

Several microorganisms are encountered in raw milk, which includes the species SafetyPseudomonas, Flavobacterium, Streptococcus and Lactobacillus. The impart several undesirable organoleptic changes in raw milk, the predominant ones being souring of milk and ropiness. Ihe Streptococcus lactis is responsible for souring while the ropiness is caused by Alcaligenes viscolactis. The milk is normally procured from small fanners, collected in refrigerated containers and transported to the processing plants. As such, the spoilage organisms encountered in refrigerated milk are the psychrotrophs. The psychrotrophic bacteri& enter the milk through soil, water, containers etc. If there is any delay in cooling, the bacterial load increases. The psychrotrophic bacteria produce enzymes such as proteases, lipases and other enzymes.

The proteases while hydrolyzing the milk proteins, impart a bitter flavour. The lipases are responsible for the rancid off-flavour. Due to further processing like pasteurization, the organisms may die but the enzymes may remain unaffected. So can the pasteurized milk also get spoiled? Let us see how.

The spoilage of pasteurized milk

You would recall that pasteurization is one of the techniques to control and destroy the pathogenic, as well as, -spoilage bacteria in milk and milk products. There are certain bacteria which can withstand pasteurization temperatures. They are 'thermoduric bacteria' which are heat-resistant. Streptococcus thermophilis, Streptococcus faecalis, Cornyebacterium lacticum and. Micrococcus luteus are some of the commonly found thermodurics.

The spores of B. cereus are also foun in pasteurized milk and they are also responsible for spoilage when held at normal temperatures. The spore formers especially Bacillus subtilis are responsible for the spoilage of Ultra High Temperature (UHT) processed milk. But generally the spoilage also results due to the enzyme activities. Next, a word about the spoilage of milk products.

Spoilage of milk products

Butter, cheese, condensed etc. are some of the milk products commpnly used in day to day life. What are the organisms which are responsible for their spoiläge?

Let's find out.

Butter

Butter, which has a high content of fat, is subject to rancidity and microbial spoilage due to contaminated cream from which it has been prepared. The dominant microorganisms responsible for spoilage are the psychrotrophie bacteria due to the fact that butter is usually stored under refrigeration conditions. The putrid, proteolytic fruity flavours in butter are caused by the psychrotrophic bacteria. Pseudomonas fluorescens and Pseudomonas fragi are associated with the fruity odour in butter. They are both proteolytic and lipolytic i.e., they decompose proteins and fats. The presence of these organisms is due to the post pasteurization contamination through water and processing equipment. The surface taints and putrid flavours are caused by Altermonas putrefaciens and Pseudomonas putrefaciens which grows on the surface of butter.

Cheese

Cheese is manufactured by souring or ripening of milk. The cheese is susceptible to abnormal fermentation which causes spoilage and abnormal physical appearance. In cheese, spoilage due to mould growth is encountered and especially species of Penicillium, Cladosporium, Candida and Mucor appear on the surface of cheese. 'The bacteria responsible for the spoilage of cheese are encountered during the ripening stage of production. The spoilage due toFood Spoila Pseudomonas impart the slimy nature and the coliform bacteria are involved in the gas formation, the Clostridium spp and Bacillus spp are the chief gas forming bacteria. Yeasts also sometimes cause spoilage, Rhodotorula produces the pink colouration.

Figure 4.2: Cheddar cheese with aspirations to become blue cheese -various species of Penicillium, which can grow even in the refrigerator.

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Sweetened condensed milk

The sweetened condensed milk contains about 8% milk fat, 23% total milk solids and sweetened with the addition of a sweetener, usually sucrose, to prevent spoilage due to the lowered water activity (a_w). A high a favours microbial growth in foods The condensed milk is normally packed in small sealed cans. The cans keep for long periods without refrigeration. The spoilage of the canned condensed milk is due to the presence of osmophillic yeasts like Torulopsis spp or moulds, if the can is under-filled. The spoilage is evident by the swelling of the cans due to gas formation. The spoilage could be due to the entry of spoilage organisms via the canning equipment.

Spray-dried milk powder

The milk which is concentrated by the process of spray drying contains about 40-45% total solids. Do you know how the dried milk powder is prepared? The milk is repasteurized and then atomized into å drying chamber of hot air where the hot ai is made to flow, depending on the design, in the same, opposite or a combination of directions relative to the flow of the atomized milk particles. The drying air is heated to temperatures up to 150-2600C.

The moisture is removed as particles move through the hot air and collects at the base of drying chamber. The dried powder is cooled to 38-400C as .it moves from the drier. The large clumps are separated in a 'sifter' and then packed.

The spoilage of dried milk depends upon the type of organisms present initially in the raw milk and the cönditions of sanitation in the processing. Micrococcus flavus and Bacillus subtilis are the common thermOduric organisms found in raw milk which can withstand drying temperatures.

Frozen dairy desserts

The frozen dairy desserts include ice crearn, sherbet, ices and custards etc. The ingredients used in the preparation of Rhese prpducts_are.milk. cream, fruits, nuts, eggs and' egg products and various additives like emulsifiers, stabilizers, colouring substances etc. The spoilage of various frozen preparations could be due to microorganisms present in any of the ingredients used. The pasteurization process normally eliminates the microorganisms. The survivors will be only the spore formers. The spoilage is avoided if the pasteurized product is frozen promptly. The spoilage is usually due to the contamination or delay at the stage of freeze storage.

Ice creams are the most important frozen dairy products. The pathogens gain entry into ice creams due to faulty practices by way of using raw unpastuerized milk, eggs containing Salmonella spp. Insanitary handling while processing and improper storage practices etc. are other factors contributing to spoilage.

The presence of Staphylococcus aureus enterotoxin, which withstands higher temperatures, has been found to be the principal reason for outbreaks involving ice creams.

STUDENTS ACTIVITY - 2

1) List the sources of spoilage of raw milk.
2) Name a few thermoduric organisms.

4.5.7 Spoilage of Soft Drinks, Fruit Juices, Fruit Preserves

We all consume soft drinks, fruit juices, as well as, preserves, which normally are available in the market as tetrapacks, cans, bottles etc. What microorganisms lead to their spoilage? Let us try to leam about them.

Soft drinks, fruit juices and fruit preserves are {he unique products, as they are acidic by nature, to which antimicrobial ingredients are added. The soft drinks are of two types. One, carbonated, and the other one is non-carbonated. The carbonated soft drinks are manufactured by the absorption of carbon dioxide in the potable water containing flavours and colours. Other ingredients like sweeteners, foaming, emulsifring and stabilizing agents may also be added. The non-carbonated drinks, apart from th above ingredients, may contain fruit juices and vitamin C.

Do.you know how these are prepared and what additives are used to preserve them? The fruit juices are liquids, extracted from mature fruits. The bottled commercial fruit juices are diluted and blended with additives to give the required taste. The fruit preserves or jams are viscous or semi-solid products containing single fruit or mixed fruits. Other ingredients like jellying agents, pectin, gums etc., are added. The concentrated drinks are both with and without fruits. They have to be diluted appropriately before consumption, to suit the taste.

The above mentioned types of beverages contain either natural antimicrobial properties like the low pH, low water activity or added preservatives to enhance the shelf life. But the spoilage of these products still takes place. Yeasts and moulds are the principal organisms that can grow in soft drinks, juices and fruit preserves. Certain lactic and acetic acid organisms among bacteria also can grow. Let us see how these yeasts, moulds or bacteria can cause spoilage.

Spoilage by yeasts

Yeasts dominate in the spoilage of fruit products which contain high acid content due to their ability to tolerate high acid environment. Yeasts are osmophiles but they can tolerate only high sugar environment but not salt. They also have the ability to gro anaerobically and have low nutritional requirements coupled with the ability to synthesize the nutrients required for growth and survival.

Among the types of yeasts, the ascospore-forming and heat-resistant organisms like Saccharomyces cerevisiae and S. chevalieri are found responsible for the spoilage in canned fruit products. The growth of yeast in a product results in the formation of $C0_2$, development of turbidity, clumping and flocculation (forming wooly cloudlike aggregations).

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Spoilage by moulds

Like yeasts, moulds also can tolerate high acid environment, sustain low water activity and grow with minimum nutrients. But majority of the moulds are strict aerobes which restrict their growth in fruit containing products due to low redox potential prevailing in them. The moulds which have been found responsible for the spoilage of fruit products are Penicillium notatum, Penicillium roquefortii, Cladosporium spp or Byssochlamys spp. Moulds can also tolerate high temperatures, when compared to yeasts and as such they are found in pasteurized fruit products. The organisms include Byssochlamys fulva, Thermoascus aurantiacum etc.

Spoilage by bacteria

The Lactobacillus and Leuconostoc species have been reported in spoiled fruits and soft drinks. Gluconobacter species is also responsible for the spoilage of fruitproducts. The spoilage of fruit products due to lactic acid bacteria causes opalescence in soft drinks, gas bubbles and bursting of containers.

In the end, let us look at the spoilage of miscellaneous products.

4.5.8 Miscellaneous Products

Confectionery products namely sweetened products, fats and oils, spices are included under miscellaneous products here in this section. The spoilage of these products is described herewith.

a) **Confectioner product**s: The confectionery products are sugar-based sweetened products to which cocoa, chocolate, fruits and milk products are added. The spoilage of confectionery products depends largely on the ingredients which are used in the preparation of a particular product. The main ingredients of confectionery apart from sugar are vegetable oil, milk and milk products, egg, edible gums, nuts, fruits, flavours, stabilizing agents etc. The major spoilage organisms include osmophilic yeasts like Saccharomyeces cerevisiae and gas producing Clostridium spp. The main pathogen which can enter the confectionery products is various confectionery ingredients like coconut, chocolate, milk, egg albumin, spices etc. are susceptible to contamination by Salmonella.

b) **Fats and oils**: Fats and oils form an integral part of several food preparations. The fats and oils are subjected to chemical changes. The chemical changes induced by auloxidation are generally referred to as 'rancidity'. It is a manifest with an accompaniment of off-flavours. Nevertheless, oils and fats are also spoiled by lipolytic microorganisms which also develop rancidity. The microbial enzymes hydrolyze fats to yield free fatw acids (FFA) and glycerol. The products like butter, margarine, vegetable oils, mayonnaise etc., are the chief vehicles for seéeral food preparations. The bacteria which can spoil the oils and fats include Pseudomonas, Bacillus, Achromobacter and Micrococcus. The moulds which can affect them belong to the species of Geotrichum, Penicillium and Aspergillus etc.

c) **Spices and condiments**: Spices and condiments are used in the preparation

of several foods. Spices are pungent and are natural additives used to impart flavours. They are substances obtained from plants. The principal spices include pepper, ginger, cloves, cinnamon, chillies etc. The spices are generally spoiled by moulds. Mycotoxins, like aflatoxins are found in pepper and chillies. Spices can act as vehicles of spores of microorganisms which can spoil the foods. This is due to the fact that spices are added to certain food preparations after the cooking process is over. The spore forming Clostrüium perfringens, Bacillus cereus and Salmonella are implicated in various food borne diseases.

STUDENTS ACTIVITY - 3

1) Fill in the blanks:

   a) Ascospore forming ..... are responsible.for spoilage of canned fruit products.

   b) Principal organisms that grow in fruit juices are.....and .....

   c) Moulds can tolerate high .....environment, sustain low ..... and grow with minimum .....

   d) Moulds found in pasteurized fruit products are ..... and .....

2) Define 'Rancidity'.

3) Name three microorganisms that lead to the spoilage of:

   a) Confectionery Products

   b) Fats and oils

   c) Spices

4.6 LET US SUM UP

In this unit, we studied about food spoilage and the chemical changes that occur in major nutrient i.e., carbohydrates, fats and proteins, as a consequence to microbial spoilage. Next, we focused on various factors that lead to microbial grovth and spoilage in a variety of foods groups such as meat, poultry, milk and its products cereals, fruits, and vegetables etc. Also we discussed a few characteristic signs and the chemical changes occurring in these food items because of the growth of microorganisms.

4.7 GLOSSARY

- Candling : A technique which involves rotating the .egg in front of a candle light; helps in identi&ing the cracks, rots ete.

- Decay : aerobic degradation of amino acids.
- Mastitis : refers to the inflamation of breast.
- Putrefaction : the anaerobic degradation of amino acids by microorganisms to produce foul smell.
- Rancidity : the chemical changes occurring in fats and oils induced by autoxidation.
- Rigor mortis : stiffening of the meat, immediately after the slaughter.
- Ripening : tenderizing the meat by the action of enzymes. It is a desirable process.
- Rotting : the decomposition of food by the action of spoilage bacteria, fungi or viruses. When microbes eat food, they break down the proteins into smaller parts, generate acids, and poison the food with toxins that keep other microbes from growing in competition."Rotten" food is waste and partially digested result from microbes.

4.8 CHECK YOUR PROGRESS

1) What do you understand by the positive and negative aspects of microbial growth?
2) List a few factors that make a food unacceptable.
3) Define the following terms:
   a) Rigor mortis
   b) Ripening
4) List four important factors that are involved in meat spoilage.
5) What causes the spoilage of canned condensed milk?

UNIT

5

FOOD HAZARDS - MICROBIAL

STRUCTURE

5.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- classify and describe the food borne diseases,
- enumerate the various food borne infections, intoxications and toxic infections, discuss about the causative agents and methods to cohtrol them, and
- report and investigate the food borne diseases.

5.2 INTRODUCTION

Food is liable for contamination during the various stages of production to consumption cycle i.e. growth, harvesting, procuring, transporting or even during storage and distribution. The contaminant can be a physical agent, a chemical agent or a biological agent. The consumption of such contaminated foods is likely to cause adverse health effect' to the consumers and hence referred to "food hazards". It is found that most of the food borne diseases are due to microbiological contamination of the food. In recent years, a number of bacteria, viruses and parasites have emerged as food borne pathogens which have resulted in numerous food borne disease outbreaks. Thése outbreaks have had a major impact in terms

of loss of human lives and economic costs. In this unit, we will try to understand about the food borne diseases and their causative agents, how to control them and how to investigate and report a food borne disease.

NOTES

5.3 FOOD BORNE DISEASES

Food borne diseases are caused by the ingestion of foods containing toxic or infectious agents. In India, the diseases transmitted by food are commonly referred to as food poisoning. Food poisoning, in other words, is the term used to refer to the harmful effects of consuming food contaminated by microorganisms.

Food borne disease outbreaks in the community .are of common occurrence, both in the developed and developing countries. A food borne disease outbreak is defined as an incident in which two or more persons experience a similar illness, usually, gastrointestinal, after the ingestion of a common food which is identified as the source of food borne illness. You would be interested to know that more than 250 different food borne diseases have been described. Most of these diseases are infections, Caused by a variety of bacteria, viruses and parasites that can be food borne. Other diseases are poisonings, caused by harmful toxins or chemicals that have contaminated the food, for example, poisonous mushrooms. Certain moulds also produce toxins, called mycotoxins, in the food they attack. All these can lead to illness. Food borne disease has been termed as the most widespread health problem in the contemporary world and an important cause of reduced economic prosperity. It is said that occurrence of a number of food borne diseases is next only to common cold. In developing countries, the exact magnitude of the problem of food borne diseases is not frilly recognized. It is estimated by the World Health Organization (WHO) that the ratio of actual to reported cases of food borne diseases varies from 25:1 to 100:1.

In India, the food borne diseases are rarely recorded and when recorded, most often they are categorized under gastroenteritis (inflainmation of the stomach and small and large intestines). As the effects of food borne diseases are mild and relatively of short duration, the affected persons ignore them and are not aware of the linkage of their illness to the foods consumed. On most occasions, they do not take medical help. Even if they seek medical aid, it will be on an individual basis, except in rare where a large number of people are affected simultaneously. How then can we recognize a food borne disease? What are its usual symptoms?

Food borne diseases, generally involves. a disturbance of the gastrointestinal tract, with abdominal pain, diarrhoea and sometimes vomiting. Symptoms of food borne illness range from mild gastroenteritis to life-threatening neurologic, hepatic and renal syndromes.

5.3.1 Types of Food Borne Diseases

You already know that food borne diseases or food poisoning is a condition resulting from eating contaminated food. The disease causing culprits are the microorganisms or pathogens including fungi, bacteria, parasite or virus. You would realize that

some fetypathogens produce toxins in food which when consumed can cause illness. On the other hand, pathogens may be present in food, which when consumed, may produce a toxin in the gut or invade and destroy the healthy tissues. Accordingly, food borne diseases are classified into three categories, namely:

i) food intoxications

ii) food infections, and

iii) food borne toxic infections.

Food infection generally involves microorganisms present in the food at the time it is consumed. Once inside the human body, they begin to grow and cause disease. Salmonellosis, caused by the bacteria Salmonella, commonly associated with chicken or egg, is an example of food borne infection. Food intoxication, on the other hand, involves toxic substances produced in the food by microorganisms, before it is consumed. The toxin present in the food makes the person feel sick. Staphylococcus aureus food borne disease is an example of illness that results from the consumption of toxins in food. The third category i.e. food borne toxic infections are caused by the ingestion of a large number of enterotoxigenic strains of bacteria which, while multiplying in the intestine produce and release enterotoxins in the intestines.

Apart from the three categories given herewith, you would come across certai moulds and fungus which produce toxins in the food they attack. The toxins produced by the moulds are called mycotoxins. Poisoning caused by ingestion of a food or feed that contains a mycotoxin is called mycotoxicosis. Examples include aflatoxins found in peanuts and sometimes in maize, rice and sorghum. Ergot fungus is associated with bajra, jowar and rye. This fungus produces toxins which result in ergotism. In addition, there are a few naturally occurring toxins in food which can cause illness. We shall study in details about these food borne diseases in the next section/sub-sections, starting with food intoxicants.

5.4 FOOD BORNE INTOXICATIONS

Food borne intoxications or poisonings are caused by either the:

i) ingestion of toxicants that are found in the tissues of certain plants or animals, or

ii) toxins formed and excreted by bacteria and fungi while they multiply on or in foods, as well as toxins formed and excreted by algae and ingested and concentrated by shell fish during their growth in sea water, or

iii) poisonous substances that may be intentionally or incidentally added to foods during producing, processing, transporting or storing.

The most important bacterial food borne intoxications are:

(a) Staphylococcal poisoning

(b) Bacillus cereus poisoning, and

(c) Botulism.

5.4.1 Staphylococcal Poisoning

Staplylococcal food poisoning is one of the most frequently reported food borne diseases, which is common throughout the world. The disease is caused by the ingestion of the enterotoxin formed in food, during the growth of certain strains of Staphylococcus aureus, as they muhiply in protein-rich foods. The toxin is referred to as enterotoxin, becausé it is a toxin produced by bacteria that is specific for intestinal cells and causes gastroenteritis i.e., inflammation of the lining of the intestinal tract.

Staphylococcus aureus is a small, 0.5-1.0 mm in diameter, gram-positive, non-motile, non-spore forming, coccus or a spherical cell, which divides to form irregular clusters of cells resembling bunches of grapes. It is aerobic and facultative anaerobic, with an optimum growth temperature around 350C- 37 oc and is capable of growing within the temperature range of 70°C-480°C.

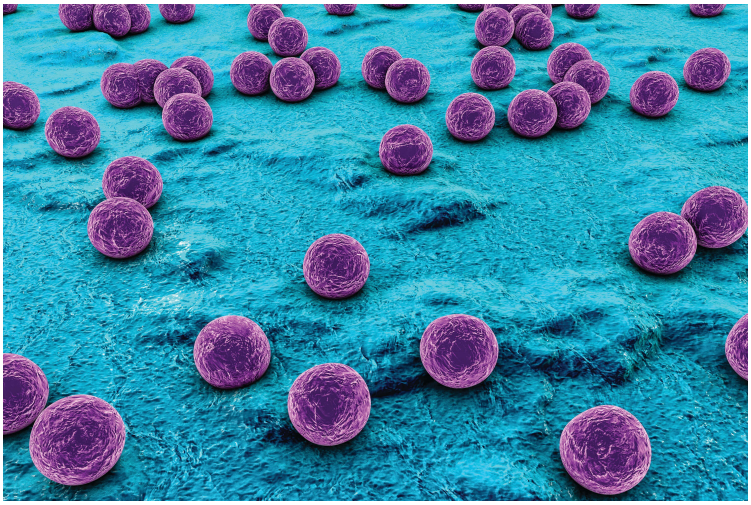

Figure 5.1: Staphylococcus aureus

Under optimal conditions, the organism doubles every 20 minutes after one hour lag. Staphylococcus aureus can tolerate foods containing 15% - 20% salt, as it has a low water activity (Av) level (0.86). Enterotoxin produced by it are designated as A, B, Cl, C2, D and E, the commonly identified toxins involved in the outbreaks are A and D. The toxins can be detected only during the late exponential or stationary phase Of growth. Small amounts of toxin, about 1 gm, can cause the illness in sensitive persons.

The toxins are heat stable in their crude form. They are able to withstand boiling temperatures in a food for several minutes upto 30 minutes. A number of commercial sterilization processes such as normal cooling process, spray-drying and pasteurization have found not to inactivate the toxin. The organism itself is not heat-resistant and will be destroyed by pasteurization. After the ingestion of a contaminated food, the symptoms appear within 1 to 6 hours and in most cases, between 2 to 4 hours. The period is deperyient on the dose ingested, greater the enterotoxin ingested, shorter is the time for appearance of the symptoms. Onset is

heralded by nausea followed by vomiting and abdominal cramping.

Other gymptoms may include fever and Chills, weakness and headache, but do not last for long, usually from less than one day to two days. Mortality in the case of Staphylococcus aureus toxin is low, but a few fatal cases have been recorded in the children and elderly. The treatment for poisoning is usually symptomatic, which includes oral or intravenous administration of fluids.

The most important source of Staphylococcus aureus is man. The principal reservoir is the nose, followed by hair. It is harboured on human skin especially on cuts, burns, boils etc. which can cause contamination of foods. So its presence in cooked or processed foods can serve to indicate poor hygiene among food handlers. The foods involved in S. aureus food poisoning are typically those that have been handled and then temperature-abused prior to consumption. The common foods implicated in the outbreaks are raw milk;raw meat, custard, cream, bakery foods, poultry and ham, egg foods, fermented meat and dairy products. In India, the dairy product "khoa", the major sweet base, has been involved in several outbreaks. Animals can also act as a source of S. aureus. The udder and teat canal in cows and buffaloes are the common sites of the organism.

It is not possible to totally eliminate the Staphylococci out of foods, as they are Safetypresent almost everywhere. Therefore, only preventive measures have to be undertaken to minimize the risk by inhibition of Staphylococci from multiplying and producing the toxin. Some strains of S. aureus are capable of producing heat stable toxins in food. It is this toxin that causes the typical symptoms associated with food poisoning, which we had studied earlier. So let us now look at some of the which could decrease the risk of infection. These are:

1) Keep the handling of cooked foods to a minimum.
2) Once the food is prepared, it should be held at temperatures above 56°C.
3) Cooling of foods rapidly and storing chilled foods in shallow containers at temperatures below 7°C.
4) Processing of foods within a time span of 1 to 2 hours, in which Staphylococci are in the lag phase.
5) Minimizing the cross-contamination from raw to cooked foods and also by taking precautions to avoid contamination from working surfaces, equipments and utensils.
6) The personnel handling the foods have to take good personal care adopting hygienic practices. They should wear dispösable gloves, wherever possible.

5.3.2 Bacillus Cereus Poisoning

Bacillus cereus poisoning is caused by the organism which is a large (3-5 μm long and 1-4 μm wide), gram positive, motile and spore-forming rod.. B. cereus is an aerobic organism but is also capable of growing under anaerobic conditions. Mesophilic strains of B. cereus grow between temperatures of 10-45°C, with an optimum growth temperature range being 20-35°C. The psychrotrophic strains, however, grow and produce toxins at temperatures as low as 4°C.

Further, since it is a spore-former, the heat resistant spores can survive the cooking

NOTES

process. Hence, it requires a severe heat process to destroy the spores.

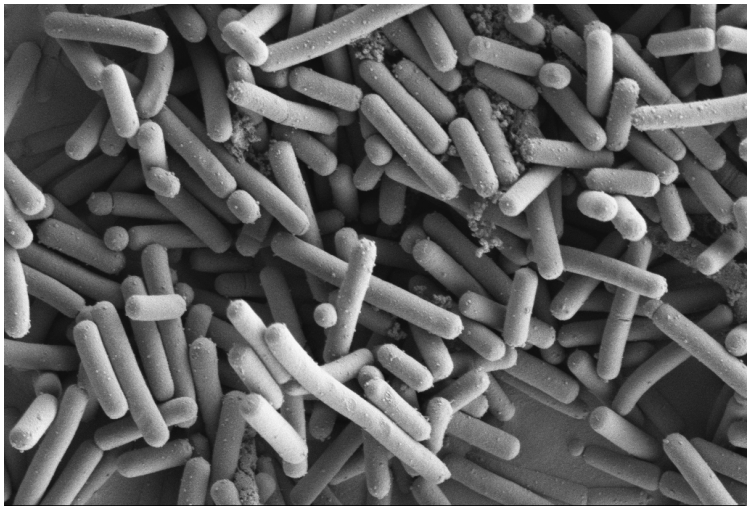

Figure 5.2: Bacillus cereus

Bacillus cereus

Bacillus cereus can cause two distinctive forms of food poisoning, which differ both in their incubation time and the symptoms they elicit in the victim. Some of the strains produce and release a toxin which causes diarrhoea, while some other strains produce an emetic toxin in the intestine which causes nausea and vomiting in the Person consuming food containing the toxin, 2-5 hours after food ingestion.

The diarrhoeagenic toxin is relatively heat-sensitive and is destroyed in 30 minutes at 56°C and in 20 minutes at 60°C. The emetic toxin, however, is capable of tolerating high temperature; (126°C) for 90 minutes. The vomiting (emetic) type, of illness exhibits the symptoms in a shorter time, usually between 1-5 hours and occasionally anywhere between 15 minutes to 11 hours. The symptoms observed are general malaise, acute attåck of nausea and vomiting. Diarrhoea is also observed in some cases. The other form of illness is characterized by acute abdominal pain, profuse watery diarrhoea, nausea, vomiting, fever, chills and body aches. The incubation period is anywhere between 8-16 hours and lasts for less than 24 hours. The treatment for the B. cereus food poisoning is symptomatic.

Being ubiquitous in nature, B. cereus is commonly found in soil and in vegetables and grains. The prepared foods, which are the vehicles of diarrhoeal form of illness, include cereal dishes, puddings, milk and dairy products, mashed potatoes, sauces, vegetable and chicken soups and meat and rice dishes. The usage of spices in preparation of meat dishes adds the B. cereus spores to the dishes, as spices harbor spore-bearing bacilli. If the preparations like mutton and chicken biryani are not adequately heated, it allows the spores to germinate during the subsequent holding of the prepared food at room temperature for longer periods. This leads to a heavy growth of the vegetative cells. The other type of illness, the vomiting (emetic) type, results from the consumption of fried rice. The rice is usually prepared in large quantities and allowed to cool at the room temperature, which

is an ideal condition for the germination of surviving spores. The rice is fried just before serving. Th heating process generally reduces the bacteria but depending on the microbial load, the person consuming the food may get affected.

B. cereus is normally found on or in the foods. There is a possibility that the spores produced by the psyghrotrophic strains, survive the cooking temperatures and germinate at room temperatureg. Therefore, prevention of illness through foods can be minimized by following certain precautionary measures, which include:

1) The rice cooked for preparation of fried rice should be boiled in small quantities whenever required, depending on the customer inflow, which helps in reducing the holding period of cooked ricer
2) If the rice has to be cooked in large portions, care should be taken to ensure that the hot rice is held at temperature not less than 63°C. For any reason, if this is not possible, the cooled food should be divided into small portions, cooled quickly in shallow containers and transferred to the refrigerator and held at temperature less than 7°C This should be carried out within 2 hours of
3) Always avoid holding the cooked rice at room temperature. This is highly essential in avoiding B. cereus food poisoning.

Having studied about Bacillus cereus poisoning' finally we move in to the third food borne intoxication i.e. Botulism.

5.4.3 Botulism

Botulism is an extremely serious neurological illness. It is caused by the ingestion of improperly preserved carmed foods, containing a neurotoxin produced by Clostridium botulinum. This is generally a fatal disease and carries a high risk of mortality (35- 40%), although its occurrence is rare in India.

- **The Clostridium botulinum** is an obligate, anaerobic, mesophilic, motile and gram-positive rod (4-8 μm by 0.9-1.2 μm), which produces a heat stable spore. Some strains of C. botulinum are psychrotrophic which are capable of slow growth and produce toxin at low temperatures (3.3°C).

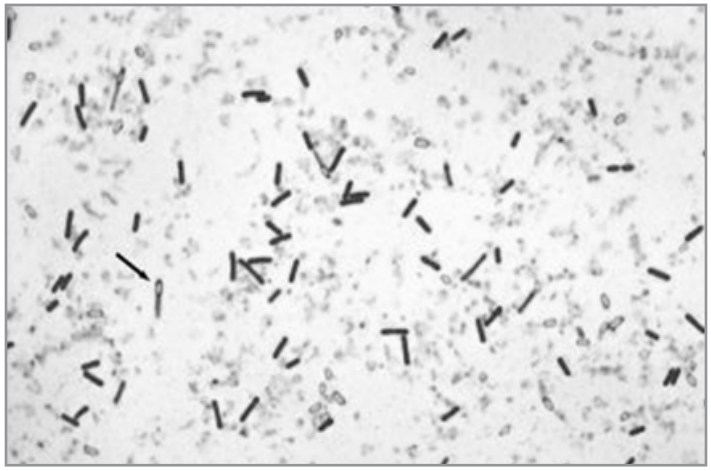

Figure 5.3 : Clostridium botulinum

Clostridium botulinum

There are eight types of toxins produced by it and are designated as A, B, C_1 C_2 D, E, F and G. All the strains do not produce single toxins, as some produce mixed toxins like C_1, which produces C_2 toxin but also some D toxins. Most human cases of botulism have been reported to be caused by A, B and E toxins.The toxins are called 'neurotoxins', as they act upon peripheral nerves of the involuntary muscles of the body. The toxins A and B can be inactivated by heat treaünent at 80°C for 10 minutes while the E-toxin can be destroyed by heating for 5 minutes at 60°C. The incubation period of the disease ranges from 2 hours to 14 days after the ingestion of contaminated food. The first symptoms appear between 18-36 hours and the signs and symptoms depend upon the type of toxin. Generally, the symptoms are nausea and vomiting, occasionally, diarrhoea, headache, dizziness and persistent constipation followed by blurred vision.

Clostriduim botulinum is widely distributed in soil and marine sediments throughout the world. It is also found in the intestinal tract of animals, including fish. Most of the outbreaks of botulism have been associated with the products offish or marine animals, meat, fruits and vegetables, including mushrooms. Insufficiently heated canned and bottled foods are at a high risk as these provide the anaerobic (without air) environment required by the organism to grow. The types of foods which have acted as vehicles of infection differ from country to country. Generally, the toxins A and B have been implicated in improperly home canned foods. The type E outbreaks have occurred by the ingestion of fermented or smoked marine products, fruits and vegetables-including mushrooms. Home cured ham and other meat products have been implicated in the outbreaks reported from Western Europe. The organism can be isolated occasionally from many foods because of its widespread occurrence in the environment. However, it is interesting to note that because of their non-proteolyti characteristics; their growth in foods cannot be detected by off-odours and off- flavours.

Botulinum produces preformed toxins. Remember, it is the ingestion of the preformed toxin, which is the most potent natural toxin known to man that causes the illness known as botulism. Ingestion of live organisms of C. botulinum is not the cause for foodborne botulism. The toxin cambe destroyed by heat treatment (800°C or above) for only a few seconds.

The botulism can be prevented by killing C. botulinum spores in foods through following these steps:-

(i) processing

(ii) eliminating the recontamination of processed foods

(iii) destroying the toxin by proper heating of the processed food before serving

(iv) proper storage

(v) discarding the product that hasdeveloped signs of spoilage (e.g., off-odour, bulging cans and gas bubbles on opening the can), and

(vi) avoiding tasting of suspected food unless it is heated to 100°C. A heat process called 'Botulinum Cook' is commonly recommended for low – acid canned products.

In conclusion, botulism is an extremely serious food bome disease, and unless recognized food and treated promptly, it carries a high risk of mortality (35-40%). It is the most severe form of food poisoning.

STUDENTS ACTIVITY - 1

1) Fill in the blanks:
   a) Moulds produce toxin called .....
   b) Food borne diseases are classified as food ..... ,food .... and .....infections.
   c) The most frequently reported food borne disease is..... food poisoning.
   d) Strains of Bacillus cereus produces two types of toxins, namely..... and .....
   e) Botulism is caused by the ingestion of .....
2) List five common foods implicated in the outbreak of staphylococcal poisoning.

5.5 FOOD BORNE INFECTIONS

Food borne infections, as you may recall reading earlier, are caused by the ingestion of pathogenic microorganisms that penetrate the intestinal mucosa and multiply or migrate into other tissues where they multiply. Common food borne infections include Salmonellosis, Shigellosis, Vibrio parahaemolyticus gastroenteritis, E. coli diarrhoea, infective hepatitis etc. Let us study about a few of these infections.

5.5.1 Salmonellosis

Salmonellosis is a common food borne disease all over the world. There are approximately 1600 different strains (sero types) of Salmonella. The most common of the species is Salmonella typhimurium which causes typhoid.. The members of the genus Salmonella are short (1-2 μm), motile, gram-negative and non-sporing rods. They are aerobic and facultative anaerobic.

Several of the serotypes have been named after the place from where they were first isolated like S. newport etc. These organisms grow best at around 38°C, however, the growth is slow at temperatures below 10°C. They are heat sensitive and are destroyed by pasteurization and heat treatments at 60°C in 15-20 minutes.

Salmonellosis occurs following the ingestion of viable cells of the organisms and is the most common type of food borne illness. The occurrence of the disease is largely dependent on the resistance of the individual, the strain involved and the number of bacteria ingested, which varies. S. enteritides and S. typhimurium are the frequently implicated organisms in cases of salmonellosis, other serotypes have also been involved in food poisoning from strain to strain. The incubation period varies from 6 hours to 3 days but is normally between 12 to 36 hours. The symptoms are nausea, diarrhoea, abdominal pain, vomiting and fever. In some

cases, this may be preceded by chills and headache. Although death from the disease is rare, it can occur in 'at-risk' groups e.g. infants, elderly and the immuno-compromised. The illness usually lasts for several days.

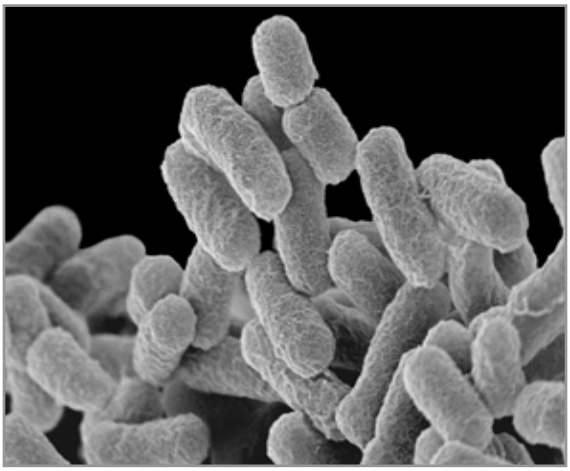

Figure 5.4 : Salmonella typhi

The prime source for Salmonella is the animal but human beings are also indirectly the source after once becoming infested and are known as carriers. The domestic animal food sources like chicken, pigs, turkey etc. are the main reservoirs of the organisms. The organisms spread from carcass to carcass at the slaughter house. The types of foods involved in food borne salmonellosis have been wide-ranging and involve mainly cereal and grain products, desiccated coconut, chocolate and dairy products. The egg and egg products which have not been pasteurized were implicated in several outbreaks. Meat and meat products also are the vehicles of food born disease outbreaks. Milk and milk products like fermented milks, ice cream, cheese etc., have also been responsible for diseases. Foods such as desiccated coconut, chocolate and dairy products are also involved in food borne diseases. In kitchen, the foods may get cross contaminated by the equipments and utensils.

The prevention of salmonellosis involves adopting several precautionary steps which include:

i) Checking of the animal to be free from contamination.

ii) Avoiding cross-contamination from raw to cooked foods.

iii) Destruction of Salmonella by proper cooking.

iv) Cooling the prepared foods rapidly to below 7 oc and storing within the refrigerators or freezers or held at a temperature above 600C

v) Removing food handlers who are carriers from the food preparation area, and

vi) Improving general sanitary conditions of the premises and ensuring better pest control.

5.5.2 Shigellosis (Bacillary dysentry)

Shigellosis is caused by the genus Shigella and is a common enteric (intestinal) infection. The genus has four serological groups, of which S. sonnei (Subgroup

D) and S. flexneri (sub-group B) are the important ones. The Shiaellae are non-motile, aerobic and facultative anaerobic, non-sporulating gram-negative rods in the family.

Enterobacteriaceae. Figure 5.5 illustrates the Shigella organism. The optimum temperature for the growth is 37°C with a temperature range of 10 to 40°C. They can withstand salt concentrations of up to 6% and are heat-sensitive. They utilize glucose and other carbohydrates and are inhibited by potassium cyanide.

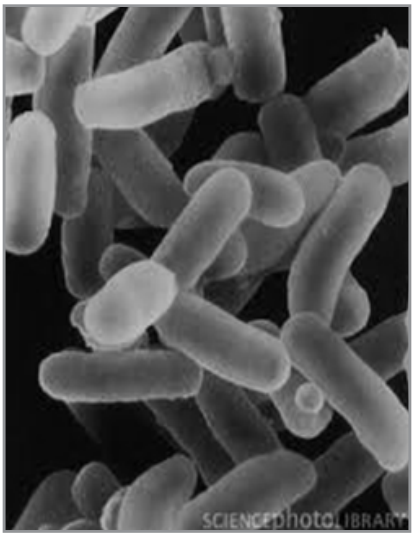

Figure 5.5: Shigella

The number of organisms to cause illness is low and the main mode of transmission is from human to human. The incubation period depends upon the organism, the affected person's age and the health status. The incubation period is usually short, ranging from 1-7 days (usually 1-3 days). The symptoms are diarrhoea, accompanied by juver, nausea and sometimes vomiting and cramps.

The stools of the affected person may contain blood, mucus and pus. Although shigellosis is usually transmitted by contaminated water, where food has been involved, the vehicles of infection are milk, shellfish, raw vegetables, Mexican dishes and various salad preparations. The infection is transmitted by the food handler with poor personal hygiene and acts as a carrier.

The food handlers contaminate the food or food preparation surfaces. The following measures help to minimize the problem.

i) The food handler who is the primary carrier, has to be educated regarding safe handling of foods and made to follow strict personal hygiene practices, like washing hands after visiting the toilet.

ii) The left-over foods have to be chilled rapidly or held at temperatures at which Shigella cannot grow (above 40°C).

iii) Cooking and reheating of foods to safe temperatures is also essential for preventing shigellosis.

5.5.3 Vibrio Parahaemolyticus Gastroenteritis

Outbreaks of illness associated with Vibrio parahaemolyticus are frequently reported from Japan. V. parahaemolyticus— associated gastroenteritis is the name of the infection caused by this organism. The organism is a facultative anaerobe, straight or slightly curved, motile, gram-negative rod with a single polar flagellum. It is also slightly halophilic (salt-lover) and can grow in 8% NaCl but grows ideally between 2-4%. The optimum temperature at which it can grow is 35-37°C but exhibits growthtrends over a wide range of temperatures from 8°C-44°C.

Figure 5.6: Vibrio parahaemolyticus

In the V. parahaemolyticus gastroenteritis, the symptoms are severe abdominal pain, vomiting and diarrhoea, leading to dehydration and fever. The incubation period is usually from 12 to 24 hours and the illness may last from 1 to 7 days.

V.parahaemolyticus is found in marine environment. The organism is found abundant during the warm months and it colonizes the water and marine life. Fish and shellfish are the two major sources of contamination and are generally implicated in th outbreaks. The important cause of the outbreaks in Japan is the habit of consuming raw fish, as such, hence there is a high prevalence of the disease in the country. In India, the disease has been reported from Kolkata. The major reservoirs of the pathogenic bacteria are crabs, shrimps and certain fresh water fish commonly consumed in West Bengal. Normally, the recovery after illness takes place anywhere between a few hours to 10 days. The organism is easily destroyed by heat. The best way to, however, prevent the illness due to V. parahaemolyticus is by:

i) thorough cooking of the sea foods,

ii) avoiding cross-contamination of cooked food from raw foods, and

iii) proper refrigeration of raw sea foods.

5.5.4 Enteropathogenic Escherichia Coli Diarrhoea

Escherichia coli (E. coli) is an important organism, as it is, regarded as a part of normal intestinal flora of humans and animals. Its presence in food has been used as an indicator for faecal contamination. The E. coli is a short, non-spore forming, facultative anaerobe, motile and gram negative rod. Some strains of E.

coli can cause acute gastroenteritis affecting children. Such strains are designated as enteropathogenic E. coli (EPEC).

Figure 5.7: Escherichia coli

Diarrhoeal disease due to EPEC is age-related, usually occuring in infants. Outbreaks involving babies, even foetuses have been reported from hospitals and nurseries. There are certain serotypes of E. coli, known as Vero Toxigenic E. coli (VTEC), which may cause diarrhoeal disease or more serious forms of illness, such as acute renal failure or long-term kidney problems. VTEC produces toxins referred to as verotoxins because they affect vero cells (a tissue culture line of monkey's kidney cells). The main serotype of verotoxin producing E. coli is E. coli 0157. This strain of E. Coli produces a powerful toxin and can cause severe illness. The optimal temperature for the growth of E. Coli is 37°C but it can grow between 7 to 43°C.

The organism is heat-sensitive.The pasteurization and normal cooking temperatures are effective in destroying the organism. The organism survives well at low temperatures with the incubation period between 12-72 hours. The symptoms include abdominal pain, diarrhoea, vomiting and fever. Blood and mucus in stools may also be observed.

EPEC may be present in poultry, beef products, pork, lamb, apple cider, meat and dairy products, like cheese, which has been implicated in some outbreaks reported from USA and UK. It is spread through faecal contamination of food, water an from person-to person transmission. Diagnosis of its outbreak is only possible through culture and identification of the germ using biochemistry and serology. The prevention of EPEC-induced gastroenteritis is to adopt strict personal hygiene and good sanitary practices.

5.4.5 Hepatitis A

Infective hepatitis, which is caused by hepatitis A, is a viral disease which spreads through food. How does the hepatitis A virus look like? Hepatitis A virus is

presumed to replicate initially in the gastrointestinal tract and then it spreads primarily to liver, where it infects hepatocytes (liver cells) and kupffer cells.

Infective hepatitis is a major public health problem all over the world. The major source of the virus has been man. The disease is transmitted through the oral-faecal route. The sources of outbreaks involving food have been reported but the long incubation period of 15-50 days (normally between 28-30 days) makes it difficult to investigate. However, foods such as ice, water, ice cream, milk, pastries, salads, sandwiches, shellfish, raw foods or foods subjected to additional handling after cooking are the major food vehicles for virus transmission.

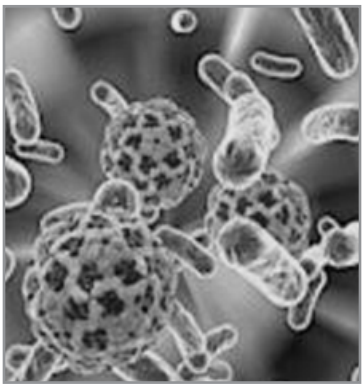

Figure 5.8: Hepatitis A virus

The typical symptom of the disease is jaundice accompanied by abdominal pain, headache, fatigue, fever etc. Jaundice, as you may already know, is the symptom characterized by yellowish discolouration of the whites of the eyes, skin and mucous membranes caused by the deposition of bile salts in these tissues. Shellfish from polluted waters, fruits and vegetables contaminated by faeces and various salads prepared under unhygienic conditions were responsible for several outbreaks. The best way for the prevention f infective hepatitis is to ensure good personal hygiene of food handlers, like proper i and washing etc. The other approach is to avoid food known to have been procured from polluted water sources.

Finally, let us get to know about shell fish poisoning.

5.4.6 Shellfish Poisoning

Shellfish like oysters, mussels and clams are generally bred in the sewage polluted beds or brackish water. The shellfish poisoning in humans is caused due to the consumption of oysters, mussels and clams etc. which accumulate the toxins produced by dinoflagellate algae Gonyaulax catenella.

The mussels and clams concentrate the dinoflagellates by filtering them as food from the surrounding water. Ifthe concentration exceeds 200 cells per ml in the surrounding water during a "bloom", they will contain sufficient toxin to cause illness to those consuming the shellfish. The shell fish poisoning assumes importance due to the fact that they are consumed undercooked or uncooked. They also harbor other pathogenic microorganisms. In India, shellfish poisoning has

been reported from the coastal areas of Tamil Nadu and Karnataka.

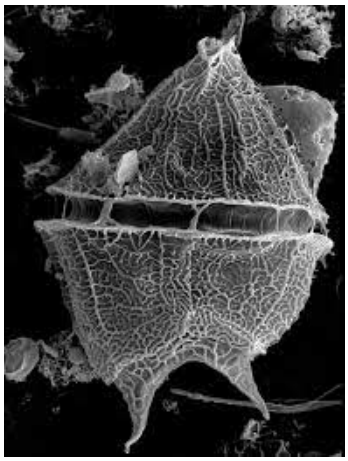

Figure 5.9: Gonyaulax catenella

5.6 FOOD BORNE TOXIC INFECTIONS

The food borne toxic infections, you may recall reading earlier, are caused by the ingestion of a large numbers of enterotoxigenic strains of bacteria which, while multiplying in the intestine produce and release enterotoxins in the intestines. Few of the foodborne toxic infections include Clostridium perfringens gastroenteritis, enterotoxigenic Escherichia coli gastroenteritis, cholera, listeriosis etc. Now we will focus on these major food borne infections and study about the characteristic features of the organism responsible for these infections.

5.6.1 Clostridium Perfringens Gastroenteritis

Clostridium perfringens-associated gastroenteritis is a food borne disease which is frequently reported and is a common cause of illness. The organism Clostridium perfringens is a large (2-8 μm long; 1 μm wide), non-motile, gram positive, obligate anaerobe and spore-forming rod. The organism does not produce spores while growing in the food but it forms spores when it reaches the intestinal tract.

Clostridium perfringens The spores of C. perfringens can withstand boiling temperatures for up to 6 hours. The optimum temperature for growth is between 43°C to 45°C, whereas, the maximal temperature at which it can grow is 55°C. Its growth gets restricted at the temperatures of about 15-20°C. The vegetative cells of the organism are usually destroyed at the temperatures of 60°C and above.

The strains of C. perfringens are classified into 5 types—A to E, depending on the type of toxin produced. The strains of C. perfringens type A, the spores of which are heat resistant survive at temperatures from 95-1000C for periods of upto one hour. These are responsible for several outbreaks in the United Kingdom. The incubation period for the disease ranges between 8 to 22 hours, but normally the symptoms occur between 8 to 12 hours after the ingestion of contaminated food. The important symptoms are severe abdominal cramps and watery diarrhoea, vomiting

is rare. The recovery is usually within 1 or 2 days. The C. perfringens is the most common of all pathogenic bacteria, as it is widely distributed and usually can be isolated from soil, dust, marine sediments, human faeces and animal manure. They are also found in raw meat and poultry. The usual vehicles of infection are the dishes prepared from meat and poultry. The outbreaks have been reported from places where a large number of people eat, like the restaurants, institutional canteens, hospitals etc. The major reason for the cause of outbreaks I the time temperature abuse after the preparation of the dishes. The slow cooling process which sets in while the cooked food is held at room temperature, aids in the growth of spore germination and a large number of vegetative cells may develop within a few hours.

C. perfringens causes a mild but common type of food poisoning. Its spores are heat resistant, surviving normal cooking. The organism usually forms the toxin, once it is in the human intestine and has started to sporulate. The toxin formed in food is not very heat resistant (destroyed by heating at 60°C for 10 minutes).

C. perfringens food poisoning causes severe abdominal pain and prolific diarrhoea. Sometimes fever, nausea and even vomiting may occur. Normally, a large number of cells need to beFood Flazards of Microbial ingested to cause illness and the recovery is usually rapid (24 48 hours).Origin The C. perfringens being widely distributed in nature and due to the danger of the presence of spores in raw and cooked foods due to contamination, the preventive approach should aim to restrict the germination of spores and inhibiting the multiplication of the vegetative cells.

To achieve this, the cooled foods have to be:

(i) consumed as early as possible

(ii) held at temperature above 560C or higher, if there is a delay in consuming

(iii) cooled rapidly (within I hour) and held below 7°C, and

(iv) if the food is prepared far in advance, heating thoroughly above 74°C before serving.

5.6.2 Enterotoxigenic Escherichia Coli Gastroenteritis

E.coli, you learnt, is a bacterium that normally lives in the intestines of humans and other animals. Most types of E. coli are harmless, but some can cause disease. Disease- causing E. coli are grouped according to the different ways by which they cause illness. Enterotoxigenic Escherichia coli, or ETEC, is the name given to a group of E. coli that produce special toxins which stimulate the lining of the intestines causing them to secrete excessive fluid, thus producing diarrhoea. You must make a note of the fact that the toxins and the diseases that ETEC causes are not related toEnteropathogenic Escherichia coli (EPEC) i.e. E. coli 0157.

Enterotoxigenic Escherichia coli gastroenteritis is one of the most common forms of food borne illness. Gastroenteritis is the common name of the illness caused by ETEC, although it is also referred to as traveler's diarrhoea. Infants and people travelling in developing countries are most at-risk of infection. ETEC produces two toxins, a heat-stable toxin (known as ST) and a heat-labile toxin (LT). The E. coli causes illness between 8 to 44 hours but generally around 26 hours. Large number of cells (1010) have to be ingested for the infection to set in.

What illness does the ETEC cause? Infection with ETEC can cause profuse watery diarrhea and abdominal cramping. Symptoms such as fever, nausea with or without vomiting, chills, loss of appetite, headache, muscle ache and bloating can also occur but are less common. Illness develops 1-3 days after exposure and usually lasts 3-4 days.

How does one get infected by ETEC? Infection occurs when a person eats food or drinks water or ice contaminated with E TEC bacteria. Human or animal wastes i.e. faeces are the ultimate source of ETEC contamination. Contamination may occur through the hands of food handlers to the cooked foods.

What can be done to prevent infection of ETEC? Well, the preventive approach in this form of illness is to adopt proper personal habits, like washing hands frequently. The foods must be thoroughly cooked and held before consumption at elevated temperatures or low temperatures. It is essential that potable water supply is ensured to reduce the illness due to contamination of foods by E. coli.

5.6.3 Listeriosis

Listeriosis is a food bome illness caused by a pathogenic bacterium called Listeria monocytogenes, which is food borne. Listeria monocytogenes is a gram-positive, motile, non-sporing and short rod organism. It is aerobic and facultatively anaerobic in nature. This is a psychrotrophic organism i.e., potentially capable of growing at refrigeration temperatures as low as O°C. It is the most heat- resistant organism among all the non-spore forming, vegetative food pathogens.

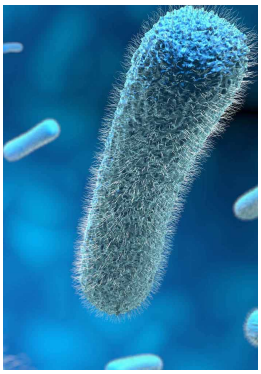

Figure 5.10 : Listeria monocytogenes

The comparatively rare disease, which is known as 'listeriosis', is spread through contamination of a variety of foodstuffs. Several major food commodities including milk and dairy products have been implicated in the transmission of disease. The disease spreads through milk from the infected cattle. Other food products include the raw meat and poultry products, fermented sausage, raw and pre cooked chicken. Jt also spreads through the consumption of vegetables, salads and sea foods.

The human listeriosis occurs in pregnant women, foetuses and new born children. In people whose immune system is compromised, the disease could be fatal. It is ubiquitous in the environment and so can be transferred to foods from a wide variety of sources. Its incubation period is between one and several weeks. The organism persists in soil and the faeces of affected animals could be a major

route when used as a manure in growing vegetables or fruits, as they are normally used as salad or eaten raw.

Foods can become contaminated with Listeria at any stage in the food chain, from the farm, through the processing and distribution, to the consumer' kitchen What are the symptoms of the illness? Its symptoms are typically meningitis or septicemia and in pregnant women, it can cause a flu-like illness, which can result in miscarriage, still birth or birth ofa severely-ill infant. Unlike other bacteria, due to its psychrotropic nature, the microorganism, L. monocytogenes is able to grow even at the refrigeration temperatures of 4-6°C. It can be prevented by treatment with pasteurization, proper cooking and also by adopting hygienic practices.

5.6.4 Yersinia Enterocolitica Gastroenteritis

Yersiniosis is an infectious disease caused by a bacterium of the genus Yersinia. Most human illness is caused by one species, Y enterocolitica. It is a gram-negative, rod-shaped bacterium. Although normally its optimum growth temperature is about 32°C, it can grow even at temperatures below 4°C.

Figure 5.11: Yersinia enterocolitica

Yersinia enterocolitica The organism produces an enterotoxin that survives at 100°C for 20 minutes. The symptoms of the disease include severe abdominal pain, fever and diarrhoea which occur after 24 hours due to the consumption of the incriminated food. The abdominal pain in this case resembles that of 'appendicitis'. The organism is found in the intestinal tract of several animals including pigs, cattle and dogs. Y enterocolitica has been isolated from dairy products, egg products, raw meats, poultry and vegetables.

5.6.5 Campylobacter Jejuni Diarrhoea

Campylobacter jejuni is responsible for 80-90% of Campylobacter infections in most parts of the world. Campylobacter jejuni is a small, spiral or curved, motile, gram-negative, rod-shaped bacteria.They grow under reduced oxygen levels, being 'micro-aerophiles'. The organism grows well at 42°C and is inactivated above 45 to

50°C. They do not grow below 25°C and are sensitive to drying.

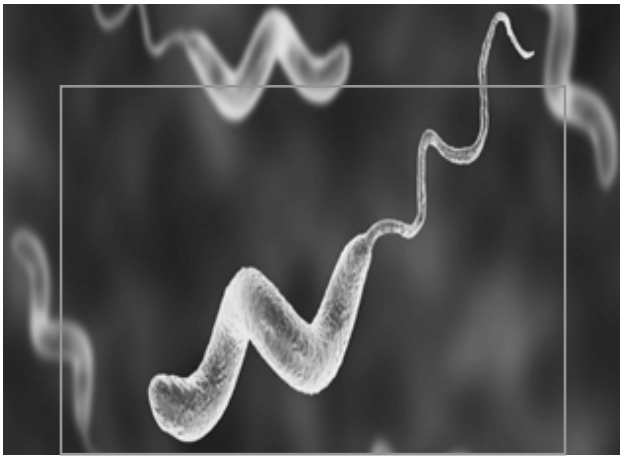

Figure 5.12 : Campylobacter jejuni

Campylobacter occurs widely as a part of the normal intestinal flora of many warm- blooded animals including chickens and turkeys. In addition, the organism occurs in raw water and raw milk. It enters the human food chain at the time of slaughter of the animals and this is believed to be the main source of infection for man.

C. jejuni has gained importance in recent years as several outbreaks are reported. The incubation period ranges from 1 to 10 days but is usually between 3 to 5 days. The onset of symptoms may be sudden, with abdominal cramps and diarrhoea. The diarrhoea may persist for 1-4 days and preceded by a period of fever of a few hours to several days. The major source of infection is the dressed chicken, raw milk and raw seafood. The food handler is another source of infection. The prevention of C. jejuni contamination can be achieved by proper cooking and pasteurization of milk.

5.7 MYCOTOXINS

What are mycotoxins? How are these produced and where are these found? Are these naturally occurring or produced? What is their significance?.Here, in this section, we shall focus on these aspects.

First what are mycotoxins? The term mycotoxin comes from a Greek word, "Mykes ", meaning fungus and the Latin word, "Toxicunl ", meaning poison or toxin i.e. fungus toxin or poison. Mycotoxins are the substances (metabolites by-products) produced by moulds like Aspergillus flavus etc. produced in agricultural commodities either during pre or post-hanest stages, which may be toxic or produce adverse effects in living organisnas, especially animals and/or humans. They are found in agncultural commodities like cereals (e.g., maize, wheat), oilseeds (e.g. groundnuts) and spices (e.g., chillies) etc. They are both important from the domestic, as well as, export market considerations. Poisoning caused by ingestion of a food or feed that contains a mycotoxin is called 'mycotoxicosis '. Let us learn about a few important

mycotoxins that affect both humans and animals.

We shall begin with aflatoxicosis.

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5.7.1 Aflatoxicosis

During 1974, an unknown disease resulting in over 100 deaths among tribals in Western India occurred. Epidemiological and laboratory investigations carried out revealed it to be the first authentic outbreak of aflatoxicosis in the world, caused by the consumption of maize contaminated with aflatoxins produced by the fungus.

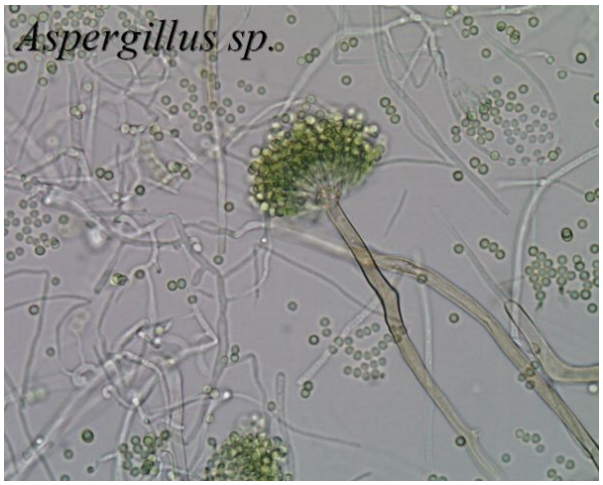

Figure 5.13 : Aspergillus flavus

The important characteristic features of aflatoxicosis are jaundice, cirrhosis. Long term exposure to aflatoxins could lead to chronic hepatitis and primary liver cancer. Besides maize, other foods in which this toxin or its metabolite can occur, are the raw food commodities including cereals, nuts, spices, figs, dried fruits, dairy products such as milk and cheese and also animal feed ingredients like groundnut and cottonseed cake. Aflatoxins are quite stable in many foods and are fairly resistant to degradation. Prevention measures include drying the agriculture commodities well, keeping commodities dry and decontamination. Detoxification using ammonia is also useful in case of animalfeed ingredients like groundnut cake. The complete elimination of aflatoxins in human and animal food, while desirable, is extremely unlikely as the climatic conditions determine the occurrence of aflatoxins during preharvest, harvest and post-harvest stages.

Aflatoxins, you should know, are both acutely and chronically toxic. Aflatoxins are quite stable in many foods and are fairly resistant to degradation. The complete elimination of aflatoxins in human and animal food, while desirable, is extremely unlikely as they have the potential to arise in a wide range of agricultural products. Besides maize, other foods in which this toxin can occur, are the raw food commodities including cereals, nuts, spices, figs, dried fruits, dairy products such as cheese and yogurt. The important characteristic features of aflatoxicosis are jaundice, primary liver cancer, chronic hepatitis, cirrhosis, rapidly developing ascites (accumulation of fluids in the abdominal cavity) and portal hypertension.

Recognizing the debilitating effects of the illness, various regulations, as well as, the maximum permissible limits for aflatoxins have been established for a range of commodities by the government.

5.7.2 Deoxynivalenol Mycotoxicosis

During 1987, an outbreak estimated to have affected over 50,000 people in the State of Jammu and Kashmir, was traced to the consumption of preparations made out of wheat products like wheat flour and refined wheat flour, barley, oats, rye, maize, sorghum and rice. The disease symptoms included pain in the stomach 10-15 minutes after consuming food and vomiting. The problem was diagnosed as deoxynivalenol mycotoxicosis.

Figure 5.14 : Fusarium,

What caused the illness? It was found that unseasonal rains at the time of harvest of wheat had resulted in the damage to wheat by fungi like Fusarium and the production of deoxynivalenol and other mycotoxins, knol,vn as 'tricothecenes' caused the outbreak. The mycotoxins can have effects on the immune system as well. It is thermally stable partially, so once formed, it is likely to persist through storage and food chain. The Origin only good thing is that as the toxin is water-soluble, a significant proportion can be removed by washing grain. Hence, preventive measures rest on advocating washingof grains before use.

5.7.3 Ergotism

Ergot is a disease of cereal crops like rye, wheat, millet, sorghum and grasses. Ergot of rye is a plant disease caused by the fungus Claviceps purpurea The infected flower, instead of developing into a normal grain, develops to a dark black mass, often refered to as 'ergot'. The ergot grain gets harvested along with good grains and contaminate the rye crop. Poisoning attributed to ergot of rye is, therefore, referred to as ergotism.

This disease was common in Europe in middle ages. In India, ergotism is caused by the consumption of bajra. Contaminated ergot was caused by the fungus Claviceps fusiformis. The ergotism found in India was manifested as nausea, vomiting, giddiness and prolonged sleepiness and is termed as enteroergotism while the European classical ergotism was characterized by convulsions and gangrene.

In India, several outbreaks due to the consumption of ergoty bajra were reported from Maharashtra, Gujarat and Rajasthan.

Figure 5.15 : Fungus Claviceps

With our discussion on ergotism, we come to an end of our study on mycotoxins. So far we have studied about food borne hazards of microbial origin. We learnt that microorganisms — bacteria, fimgus — themselves or the toxins produced by them in the food or in the human body can lead to food borne diseases. You would be interested to know that other than microorganisms and their toxins, certain naturally occurring toxins in foods, can also cause food poisoning.

5.8 FOOD BORNE DISEASES DUE TO NATURALLY OCCURRING TOXICANTS

A variety of naturally occurring food toxins have been linked to human ill-health and death. Among them, the principal toxicants that have been responsible to cause disease outbreaks in humans in India include the following:

i) Lathyrism111

ii) Veno-occlusive disease

iii) Epidemic dropsy

5.8.1 Lathyrism

Human lathyrism is endemic in some parts of the country specially certain areas of Madhya Pradesh. Cases of lathyrism have also been known to occur in Uttar Pradesh, Karnataka, Maharashtra and Andhra Pradesh. Several reports of human lathyrismhave been recorded in the past.

The disease has been attributed to the consumption of Lathyrus sativus, popularly known as 'Kesari Dal', as a staple diet. Why should consumption of kesari dal lead to lathyrism? A neurotoxic amino acid, "-oxalyl amino alanine (BOAA) has been identified as the constituent of the kesari dal responsible for the disease. Kesari dal or Lnthyrus sativus is a drought tolerant legume. It actually flourishes in conditions of the most devastating flood and drought, when no other

food crop survives. The grains contain 20 to 32 per cent protein, but they also contain a numbe of antinutritional compounds known as lathyrogens

Figure 5.16 : Lathyrus sativus

Lathyrogens are the neurotoxi amino acids that act as metabolic antagonists of glutamic acid, a neurotransmitter in brain. BOAA, found in kesari dal, is a neurotoxic amino acid. Consumed in large amounts during times of drought, a toxic syndrome — lathyrism — develops resulting in a crippling paralysis of the lower limbs is highlighted in Figure 5.19 and may result in death. The symptoms at the time of the onset include heaviness and stiffness of the limbs, muscle cramps, tremors and involuntary movement of the upper extremity.

Figure 5.17 : Lathyrism — Crippling of' lower limbs

However, it is encouraging to note that a declining trend of lathyrism has been observed in our country. This trend is attributed to the fact that the consumption ofOrigin L. sativus in the endemic areas has come down during recent years mainly because of availability of alternative grains like wheat. Further, increased cost of L sativus and the ban on sale of L sativus under the PFA Act has contributed to

the declining trend of lathyrism.

5.8.2 Veno-occlusive Disease (VOD)

Veno-occlusive disease (VOD) of the liver is a well-recognized form of toxic liver injury produced by pyrrolizidine group of alkaloids. The VOD outbreak was observed in the tribal areas of Sarguja district of Madhya Pradesh and was characterized by ascites, pain in the epigastrium and death. This incident occurred due to the consumption of minor millet, gondhli — Panicum milliare — contaminated with toxic weed seeds of Crotalaria nanabum. The seeds of Crotalaria contain monocrotaline and other toxic alkaloids belonging to the pyrrolizidine group.

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5.8.3 Epidemic Dropsy

There are several reports about outbreaks of epidemic dropsy in the last three decades in the country. Epidemic dropsy was first reported from Kolkata in 1877 and the most recent outbreak in Shivapuri district in Madhya Pradesh. The disease results from the ingestion of mustard oil or other vegetable oils contaminated with Argemon Mexicana seed oil, whose seeds closely resemble the mustard seeds.

The disease is characterized by oedema over ankles, gastrointestinal disturbances, vascular changes, ocular changes and cardiac insufficiency. Argemone toxicity presumably is due to the toxic alkaloid, sanguinarine which interferes with the oxidation of pyruvic acid, accumulates in blood resulting in signs and symptoms. Mortality is variable but it disables the victim for a long time. Epidemic dropsy has been a recurrent problem in those areas where mustard oil is used as a cooking medium.

In other parts of the country, the disease is confined to the communities using mustard oil or deliberate. adulteration of other vegetable oils with argemone seed oil by traders.

5.9 REPORTING AND INVESTIGATIONS OF FOOD BORNE DISEASES

We have already seen earlier in this unit that the reporting of food borne diseases is very little due to various lapses. You would now realize how crucial it is to record such instances for further investigations. Reporting an outbreak incidence could help in identifying the mode of transmission, the causative organism and in facilitating necessary action to be undertaken.

Further, it helps in formulating preventive strategies for the future so as to avoid or minimize the chances of occurrence of an outbreak. Hence, it can be said that the epidemiological surveillance of food borne disease is fundamental to the planning and management of food safety programme in a country. One of the important components of the surveillance is the reporting of a disease as it occurs which would enable the public health personnel to take the necessary actions. It is very difficult to have information on every food borne disease that

occurs in a country. In the Indian context, the information on the occurrence of a food borne disease is mostly through the newspaper reports and especially in vemacular press. Inspite of the best communication and networking facilities, the ratio between actual to reported cases is 25:1 in developed countries, whereas, it may be as low as 100:1 in developing countries like India.

We have seen earlier also that in India, the food borne diseases are rarely recorded and when recorded, most often they are categorized under gastroenteritis. Under Indian Food Regulations, all the physicians working in an area have to inform the occurrence of a food borne disease to the Medical Officer designated by the Government. However, this rule is rarely implemented and the food borne diseases are not recorded systematically.

What is the process of recording or investigation of an outbreak? Are you aware of the process? Let us learn about the procedure in the next section.

Investigation of an outbreak

Once a suspected outbreak of a food borne disease has been reported, the basic reporting of an outbreak investigation include:

1) Receipt of an initial data
2) Determination of whether an outbreak has occurred
3) Description of cases in terms of time, place and person
4) Epidemiological investigation
5) Formulation of hypothesis
6) Laboratory studies, and
7) Synthesis of findings with conclusions and recommendations.

You would realize that these elements are a part of an exercise of outbreak investigation and these steps are discussed herewith.

A) Receipt an initial data and assessment

How does an outbreak gets noticed? Food borne diseases are often brought to the attention by admission of patients with symptoms of vomiting and diarrhoea. The initial step, therefore, in any investigation is to verify the diagnosis or to confirm tnal illness has occürred. This is followed by an assessment of whether there is a outbreak and if so, its potential magnitude and importance. The major factor to be considered in food borne disease is that a true cluster of cases of the same illness is present. Certain additional factors which need to be considered include:

1) the number of people possibly affected
2) the severity of the suspected disease
3) time for which illness occurred, and
4) the potential for continued disease transmission.

The clinical symptoms will suggest the type of agent involved and initial laboratory specifications may have already identified the agent. Initial cases also may provide important clues to identiW a common source, groups or cohorts of people exposed and the areas to target.

NOTES

In the early stages of an outbreak investigation, it may be useful to survey the major providers of acute or emergency medical care serving the likely where the ill person are located. Geared with this knowledge, we are ready for planning the investigation.

B) Planning the investigation

Now, how to go about planning the investigation procedure? First of all, the method of investigation needs to be decided early in the investigation. The cohort method is often used in food borne outbreak investigation in which the whole group of exposed individuals is known, for example, all persons attending a wedding party at which a food borne outbreak occurs constitute. the cohort of persons at risk of illness. The investigation will be carried out by questioning all cohort members about illness and food consumption. In case a cohort is too large, a random sample can be interviewed.

We have talked about one of the methods of investigation i.e., Questionnarie. Let us have a look at what this method is and how it is used.

As you may already know, questionnaire is a set of questions, both open-ended and close-ended, used to elicit information about any topic. It can be administered over a large sample which should be literate or semi-literate.

What kind of informationcan be collected through the questionnaire? Can you suggest? Well, the information that needs to be collected can be listed as:

1) **Demographic information:** This includes narne, address, age, sex of the both affected and normal individuals.
2) **Symptoms:** These include diarrhoea, fever, abdominal pain, nausea, vomiting, time of onset and Sequence of onset of symptoms.
3) **Food history:** The standard practice in food borne outbreaks is to take a detailed history of foods consumed by affected persons over the 72 hours prior to the onset of symptoms. It is important to include water or other liquids consumed, as they also can be the vehicles for infection. It is also important to quantitate the intake i.e., number of servings, glasses etc.
4) **Data screening:** Filled up questionnaires Heed to be verified for the discrepancies, if any, while filling up of the information.

As can be seen, depending on the information required, the type of questionnaire will vary. Also the type of questionnaire used will depend on the population and the method of administration. Once the data has been collected, the next step is 'analysis'.

C) Epidemiological Analysis Food

Once the questionnaire has been checked, data needs to be analyzed, to describe the outbreak in terms of time, place, persons, symptoms and the likely causative agent. This is how it is to be done.

Time

The typical way the time course of an outbreak is to be known, is to use date/time of onset of symptoms and draw a histogram of number of cases by time of onset of the symptoms. The pattern displayed by the histogram will indicate whether an outbreak occurred from a single point or is it a propagation. A sharp peak in the histogram suggests that the incubation period is very short.

Place

Examining the attack rates i.e., number of persons affected/total group in various geographical sub groups of the outbreak can help to concentrate on a particular area where the investigations need to be done.

Persons

The personal characteristics of cases like age and sex will help in identifying the source of an outbreak. For example, if the affected persons are children, it may provide a clue to suspect a certain food.

Other important information

Additional information such as place, time, group ofpeople involved, involvement of animals which might have consumed the incriminating food etc. will also need to be collected.

After the simple analysis, it is time to determine association between different factors investigated in the outbreak. Let us see how this is done.

D) Analytical Epidemiological Analysis

Analytical epidemiological studies seek to determine associations between certain food items and illness. The selection of a control group is a vital step in the analytical epidemiological studies. In an investigation of a food borne disease among a cohort, the food consumption histories of all persons in attendance are collected and examined for association of eating certain food items with illness. Let us see how this is done

We will briefly go through one of the methods used to identify implicated food item by analytical epidemiological analysis. This method is traditional approach.

Traditional approach

Questionnaire responses from the affected and unaffected persons are used to generate a food specific attack rate table. For example, if 100 people attended a marriage party and 55 became ill after 4 hours, Staphylococus aureus was detected in the stool samples of several people who attended the marriage party.

The per cent of illness among persons eating and not eating each food item is calculated and compared. The kheer has the highest attack rate among consumers and lowest among non-consumers. Highly significant correlation ($P < 0.001$) is found with kheer. Same data can be analyzed by another method called “Relative risk”. Relative risk is calculated by dividing the rate of illness in food consumers by the rate of illness in persons not consuming the food. Similarly, there are many methods to analyze the data like case-control analysis and stratified analysis.

After the epidemiological analysis, it is imperative to carry out the laboratory analysis to identi$' the etiological agent causing the disease. We will learn about this aspect next under the heading 'collection of samples'.

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E) Collection of Samples

Most important aspect of food borne disease would be to collect the right sample.

Now, what procedure to follow while collecting the specimen? Let us try to understand a few steps involved in the collection of the food specimen.

Collect the specimens of all left-over foods. It is often observed that once a food borne disease occurs, all the suspected food is discarded deliberately or in the natural course. Efforts should be made to trace the sample. Normally, in the Indian context, in case of food borne disease outbreaks, the first to investigate are Police under section IPC 304A. Often, the incriminating sample is destroyed to erase any trace of evidence. If foods from commercial sources are suspect, carefully record the label information. If the food handler's role is suspected, the hand washings or swabs of infected wounds should be collected. All the samples should be collected in sterile containers (sterile jar, beakers or plastic jug) and should be transported to the laboratory in an ice-bucket and analyzed at the earliest. Collection of biological samples of affected persons such as urine/blood is also necessary. After sample collection, the next step is analysis.

F) Laboratory Analysis

Laboratory analysis is the next crucial step in determining the agent which led to the outbreak of a disease. The most important consideration here is that the laboratory should be informed in advance, so that all the. necessary arrangements are made for analysis as soon as the samples are brought to the laboratory. Appropriate analysis should be carried out to find out the etiological agent. Whenever positive results are found, the cultures and specimens should be preserved for further confirmation..

G) Preparation of the Final Report

Synthesis of epidemiological and laboratory analysis data leads to identification of the causative agent, vehicle of transmission and circumstances under which a food borne disease occurred. A final report has to be written meticulously, documenting all the compartments of epidemiological and laboratory analysis data, with conclusions and recommendations. So you see, this is how we report and investigate a food borne outbreak. We hope, you would use this information too while reporting and investigating an outbreak in your region.

STUDENTS ACTIVITY - 2

1) Why should the food borne diseases be systematically reported?
2) List the basic elements of an outbreak investigation.

5.10 LET US SUM UP

In this unit, we studied about food borne diseases, categorized as food infections, intoxications and toxic infections. We learnt in details about important food diseases caused by bacteria, viruses, parasites, mycotoxins and naturally occurring toxins in food. The main focus here was on the characteristics of the disease, its occurrence, etiology, incubation symptoms, mode of transmission and preventive measures.

Finally, methods of reporting and field investigation of food borne disease outbreaks were also dealt with.

5.11 GLOSSARY

- Aflatoxicosis : a major food borne disease outbreak involving aflatoxins, a metabolite of the fungus Aspergillus belonging to a variety of species.
- Ascites : an abnormal accumulation of fluid within the abdominal cavity. It develops most frequently as a result of liver disease.
- Botulism : an extremely serious neurological illness caused by the ingestion of improperly preserved canned foods, containing a neurotoxin produced by C. botulinum.
- Emetic : Toxinan agent/toxin that causes emesis i.e. nausea, vomiting, upchucking, regurgitation.
- Enteric : relating to or inside the intestines.
- Enterotoxin : a toxin produced by bacteria that is specific for intestinal cells and causes the vomiting and diarrhea associated with food poisoning. It is the toxin which causes gastroenteritis i.e. inflammation of the lining of gastro-intestinal tract.
- Food hazard : consumption of a contaminated food likely to cause adverse health effects to the consumers.
- Food poisoning : the diseases transmitted by the ingestion of foods containing toxic or agents; or the harmful effects of consuming foods contaminated by micro- organisms.
- Gastroenteritis : inflammation of the stomach and small and large intestines.
- Halophile : an organism that requires a salty environment.
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5.12 CHECK YOUR PROGRESS

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1) Define the following:
   a) Food Poisoning
   b) Food borne disease
   c) Neurotoxins
2) Give a few preventive measures to inhibit the multiplication of:
   a) Staphylococcus
   b) B. cereus
   c) C. botulinum
3) Give the symptoms, foods involved and preventive measures of the following diseases:
   a) Salmonellosis
   b) Shigellosis
   c) V. parahemolyticus gastroenteritis
   d) E. coli diarrhoea
   e) Hepatitis A
4) Briefly explain the major reason behind the outbreak of C. perfringens infection.
5) List the causes of ETEC gastroenteritis and preventive measures.
6) Explain the following terms:
   a) Mycotoxins
   b) Ergotism
   c) VOD
   d) Lathyrism
   e) Enteroergotism

UNIT

6

FOOD CONTAMINANTS

STRUCTURE

6.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- list some naturally occurring toxicants in plant and animal foods,
- define and give examples of some anti-nutritive compounds in foods,
- enumerate the various types of environmental food contaminants,
- discuss the harmful effects of the different types of toxicants and contaminants present in our foods,
- suggest ways to reduce our exposure to various food contaminants.

6.2 INTRODUCTION

The food that we eat is the source for all the nutrients required by our bodies to grow and survive.Foods also contain a wide range of natural chemical compounds which have no nutritional fimction. Some of these compounds may even act as anti-nutritional factors, interfering with the utilization of some of the nutrients present in these foods, while others may be potentially toxic, resulting in illness and death, if consumed in large quantities. Food can also become contaminated with harmful substances while it is still in the fields, or while being transported,

stored or processed for consumption. In this unit, we will look at the different types of contaminants that can enter the food chain and how they can affect the quality of the food and our health.

It is also important to know what we can do to reduce our exposure to these contaminants. This is the other aspect discussed in this unit

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6.3 FOOD CONTAMINATION

Food, as we all know, is any edible substance, ice, beverage or ingredient used or intended for use or for sale in whole or in part for human consumption. Contamination means exposing food to filth, toxic substances, manual contact during service or preparation if such food will not be subsequently cooked prior to service, rodent or insect contact or infestation, or any condition which permits introduction of pathogenic or foreign matter. In simple terms, the presence in food of harmful, unpalatable, or otherwise objectionable foreign substances, this may be chemicals, microorganisms or diluents, before, during, or after processing or storage, is food contamination.

Codex Alimentarius (or food code elaborated by the Codex Alimentarius Commission of the Food and Agriculture Organization and World Health Organization) define 'food contamination' ås any substance not intentionally added to food, which is present in such food as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food as a result of environmental contamination.

In day to day practice, our food can get contaminated by the water used for cooking or washing, by the soil in which the food is grown, by the container used for storage, preparation and service, by the personnel handling the food at various stages etc. During recent years, the problem of dioxin contaminated chickens, hormone injected cattle, genetically modified varieties of maize such as star link, animal carcasses used to make animal feed and subsequent mad cow disease among animals consuming such feed, pesticide residue containing mineral water and soft drinks of popular brand etc. had received considerable media attention. The list of contaminated food is getting longer and longer.

Contaminants in foodstuffs can chiefly be classified as physical, biological and chemical contaminants. Physical contaminants include extraneous matter such as sand, soil, hair etc. Biological contaminants consist of microorganisms such as fungi and their metabolic products. Chemical contaminants, on the other hand, are the products of fast growing modern technology. The increasing population, as well as, the mass migration into the cities, demands a massive and rapid increase in our food supply. Increased agricultural productivity requires constant large scale application of fertilizers, insecticides, pesticides, antibiotics and chemicals for stimulating the growt of plants and farm animals. Residues, sometimes at toxic levels, from most of these products, end up in the food supply via the soil,

air and water. Chemical contaminants may also come from other sources besides agriculture. Modernization of the population's lifestyles also has resulted in the production of synthetic chemicals for use in all aspects of modern life — in industry, transportation, housing, household activities, entertainment, leisure activities, education and research.

You would realize some of these contaminants may be naturally occurring in foods, others may be environmental contaminants while some may be intentionally added to adulterate food about which we will learn in the next unit. Here we will focus on all contaminants, natural or otherwise found .in foods. For your convenience we have classified them as under:

- Naturally occurring toxicants, including toxicants in plant, animal food and anti- nutritional factors in foods.
- Environmental contaminants, including biological contaminants, pesticide residues, veterinary drug residues and heavy metals.
- Miscellaneous, including dioxins, acrylamide, contaminants from plastic etc.

6.4 NATURALLY OCCURRING TOXICANTS

Some of the foods contain naturally occurring toxic compounds, which man has identified by experience and learnt to avoid. Naturally occurring toxicants are products of the metabolic processes of animals, plants and microorganisms from which food iafetyproducts are derived. Many of these substances in food products are potent poisons, which produce under certain conditions, severe if not fatal symptoms.

In several cases, man has tried to develop methods to process the food to remove the toxic compounds and has been able to consume the detoxified food.

Unfortunately, some of these compounds have delayed toxicity, and the recognition of their presence in food, as well as, the cause and effect relationships between the observed poisoning and the food is often slow in coming. Hence, we need to be aware of the presence of these food toxicants and their harmful effects.

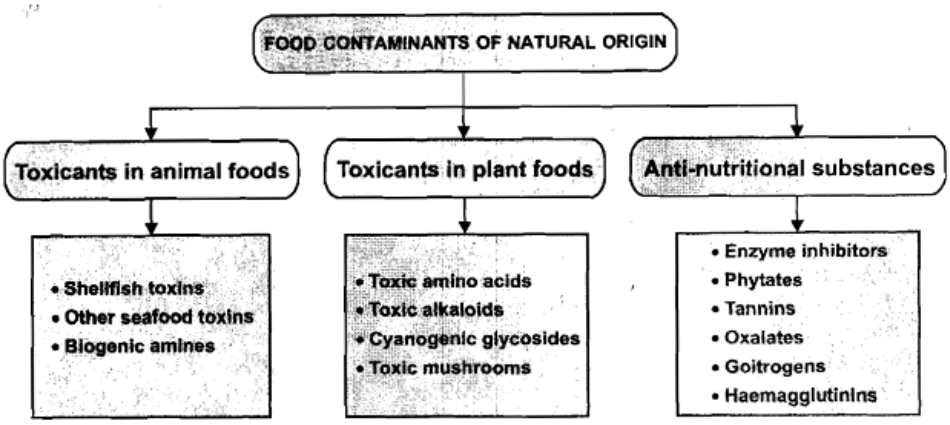

Figure 6.1 : The naturally occurring toxicants

The first two sections deal with potential toxins in animal and plant foods which have resulted in serious disease conditions in man while the third section is devoted to toxins which behave as anti-nutritional compounds.

NOTES

6.4.1 Food Contaminants of Natural Origin.

Seafood Toxins

Some of the most potent toxins are found in marine products, especially shellfish. The bulk of shellfish poisonings classified are infectious in nature. This can be bacterial or viral in nature, with the Norwalk virus most likely accounting,for the bulk of the gastroenteritis cases. The next question is how does shellfish poisoning occurs? Shellfish such as clams, oysters. scallops mussels feed on the plankton and algae in the sea. Some of this plankton toxic for us but not for the shellfish. Poisoning results from consuming shellfish which has fed on this toxic plankton.

What are the consequences of shellfish poisoning?

Four separate types of poisonings due to ingestion of toxins in shellfish have been identified. They are paralytic, neurologic, diarrhoeal and amnesic shellfish poisonings, depending on the kin of symptoms that develop. Let us go through these in details.

a). Paralytic shellfish poisoning (PSP): It causes the most severe symptoms of all the shellfish poisonings. The causative agent is saxitoxin. It is a powerful neurotoxin produced by Gonyau/ax catenella. Initial symptoms of poisoning, which can be seen within 30 minutes of consuming such shellfish, include headache, a floating feeling, dizziness, tingling, burning, numbness in the extremities, which spreads quickly throughout the body producing a general lack of muscular co-ordination Muscle weakness causes difficulty in swallowing or speaking. Abdominal symptoms such as nausea, vomiting and diarrhoea can also occur. It could also result in death due to paralysis of the respiratory system.

b). Diarrhoeic shellfish poisoning: It is characterized by mild gastrointestinal disorder caused by high molecular weight polyethers produced by dinoflagellates.

c) Neurotoxic shellfish poisoning: It causes both gastrointestinal and neurological symptoms and occurs due to the exposure to a group of polyethers produced by dinoflagellates.

d). Amnesic shellfish poisoning: It is characterized by gastrointestinal and neurological disorders and is caused by the presence of an unusual amino acid as contaminant of shellfish from diatoms.

Contrary to a common belief, algal blooms (red tides) are not well correlated to outbreaks of shellfish poisoning. Shellfish poisoning can occur in the absence of a red tide, conversely, red tides do not necessarily mean that shellfish are poisonous. Despite folklore that contends that shellfish are universally safe if eaten during months containing the letter 'r', correlation between outbreaks of shellfish poisoning and water temperature is poor. The incidence of shellfish poisoning has been declining, Safetymost likely because of careful monitoring and improved public

awareness all over the world.

Ciguatera

Ciguatera probably represents the most common cause of poisoning from fish in tropics. Ciguatera comprises over 50% of all reported cases of seafood poisoning. This poisoning is very common in temperate and inland areas. Ciguatera toxin, a polyether, is found in blue-green algae and protozoans and is known to affect thermoregulation and sensory, motor and muscular activities. These organisms are ingested by herbivorous fish, which, in turn, are eaten by larger fish. Ciguatera is concentrated in the flesh, adipose tissue and organs of the larger fish. Ciguatera toxin is odourless and tasteless, and contaminated fish tastes normal. What is more important, here is the fact that the toxin is heat stable and thus may affect people even if fish are prepared properly.

Further, ciguatera toxin is secreted into breast milk and freelycrosses the placenta, affecting the foetus. Symptoms usually are evident within 2- hours after ingestion and may last as long as 48 hours. It produces a spectrum of illness that is not easy to understand. Over 150 symptoms have been described, involving multiple body systems: gastrointestinal, neurological, musculoskeletal, dermatological and cardiopulmonary.

Symptoms generally consist of abdominal crarnps, nausea, vomiting, profuse watery diarrhoea, myalgias (pain in the muscle), arthralgias (neuralgic pain in a joint or joints), weakness and dysuria (painful or difficult urination) Neurologic symptoms tend to occur later (up to 72 h) and may persist for months. These are predominantly paresthesias (a skin sensation, such as buming, prickling, itching, or tingling), but a myriad of other sometimes bizarre neurologic symptoms alsomay be observed, including sensation of loose painåll teeth, tingling in the lips, tongu and throat, vertigo, ataxia, visual changes and seizures. Death is rare, with a reporte mortality rate of approximately 1 in 1000 patients. Contrary to saxitoxin, the cigutera toxin is more potent. In fact, saxitoxin is a derivative of ciguatera toxin.

Scombroid

Ingestion of improperly handled and stored seafood (yellow-fin tuna, skipjack, bonit and mackerel) causes scombroid poisoning. Maitoxin has been implicated in scombroid poisoning, which releases neurotransmitters and increases the contraction of smooth, cardiac and skeletal muscle. Decarboxylation of histidine, a aminoacid, naturally found on fish, into biogenic amines, such as histamine, occurs at temperatures greater than 15°C. Histamine, an organic compound, derived from histidine is released from certain cells upon tissue injury or during the activity of certain antibodies.

At high concentrations, they are risk factors for food intoxication whereas moderate levels may lead to food intolerance. Histamine is not inactivated by heat, therefore, proper cooking is not a remedy for improper storage. Patients sometimes describe a peppery or bitter taste to the fish, but Often the fish tastes

completely normal. A host of symptoms, including skin flushing, facial swelling, dizziness, throbbing headache, oral burning, metallic, sharp or peppery taste in mouth, abdominal cramps, nausea, vomiting, diarrhoea, palpitations, a sense of unease, and, rarely, prostration or loss of vision characterize scombroid poisoning.

A rash that looks like sunburn may occur and a small number of patients have hives, i.e., allergic skin reaction. Symptoms usually occur within 10-30 minutes of ingesting fish and generally are self-limited. Physical signs may include a diffuse erythema (a reddening of the skin due to capillary dilation), tachycardia, wheezing and hypotension or hypertension. Scombroi is second in incidence only 'to ciguatera poisoning, however, it often is misdiagnosed because it resembles an allergic reaction. Best precaution, therefore, is to avoid organ meats and gonads.

Before, we move further, we would like to elobrate further on the biogenic amines.

What are biogenic amines? The biogenic amines are biologically active compounds synthesized from amino acids. Foodborne biogenic amines are most commonly synthesized by spoilage microorganisms and are usually considered to be potential toxins. Biogenic amines should not always be considered to be potential toxicants but can also be considered to be non-hormonal growth promotants.

In our discussion above, we studied that in addition to the release of endogenous histamine during allergic reactions, certain foods contain histamine produced by decarboxylation of histidine by enzymes produced by bacterial contamination of food An example of latter mechanism is scombroid poisoning, which is one of the thre most common illnesses associated with seafood consumption. Other biogenic amines such as putrescine and cadaverine may play a synergistic role with histamine b inhibiting the histamine detoxifying enzymes, diamine oxidase and histamine N- methyltransferase. While allergic reactions affect only susceptible individuals, the contamination of foods with histamine will cause symptoms in all individuals exposed to sufficient amounts of the food involved.

Pufferfish poisoning

Tetrodotoxin (TTX) causes pufferfish (tetrodon) poisoning, also known as blowfish poisoning or fugu. How does a pufferfish look like? TLX is one of the most potent non-protein neurotoxin found in nature that blocks sodium channels of excitable cells and exposure can result in rapid death. Symptoms occur within 15 minutes of ingestion but may be observed as late as several hours later. More rapid onset of symptoms is associated with higher

levels of toxin ingestion. Symptoms principally are neurologic and cardiovascular in nature and may include peri-oral (around the mouth) tingling, a floating sensation, a feeling of overall warmth, weakness, incoordination, slurred speech, bradycardia (slow heart rate), hypotension and dyspnea (shortness of breath). Decreased levels of consciousness, seizures and death have occurred in as few as 17 minutes. TTX I concentrated in organ meat and gonads. Best precaution, therefore, is to avoid eating the organ foods.

Hallucinogenic fish poisoning: Hallucinogenic fish poisoning can occur with the

ingestion ofa number offish species. Indoles with similar effects to the notorious drug lysergic acid diethylamide (LSD) have been implicated with sources in algae and plankton. Hallucinations occur in isolation {with no other symptoms.

The symptoms of acute poisoning include nausea, vomiting, occasional diarrhoea, sweating, headache, hypertension, tachycardia (very rapid heart beat) and twitching among other symptoms. Vasodilation (dilation of blood vessels), hypertension an respiratory depression may occur at doses 20-60 mgfkg. Bradycardia may be present at higher doses. Convulsions and coma have been reported. Effects on the central nervous system may include euphoria, hyper excitability and alertness, rambling speech, deliria, uncontrollability, transcendental mood, distractibility, depersonalization and impairment of judgement. A temporary psychotic state with sensory illusions, distortions or visual hallucinations consisting of shimmering intensification of coloür and texture, brightly coloured lights, geometric designs, animals and occasionally human images may occur. Hearing or tasting colours and seeing sounds have been reported. Rarely, anxiety, fearful auditory, visual and tactile hallucinations, panic states and paranoid delusions, suspiciousness, emotional liability, intense depression, loss of control, suicidaideation and self destructive or aggressive acts may occur. Deaths have resulted from hallucinatory effeets leading to accidental death.

Miscellaneous shellfish poisonings

Other shellfish poisonings include oyster, abalone and red whelk poisoning. Sea urchin gonads contain an acetylcholine like-substance that produces symptoms including salivation, nausea, vomiting, diarrhoea and abdominal pain. Starfish ingestion may be associated with nausea and vomiting as a result of asteriotoxin.

STUDENTS ACTIVITY - 1

1) Mention the different types of shellfish poisonings.
2) List the symptoms of the following poisonings:
   a) Ciguatera poisoning
   b) Scombroid poisoning

6.4.2 Toxicants in Plant Foods

Several foods, some of which we consume regularly, have toxic compounds •in them which are best avoided. These compounds can be proteins, amino acids, alkaloids or cyanogenic glycosides in nature.

Let us have a look at the different toxicants which have been identified in foods for human consumption.

Favism is a condition characterized by haemolytic anaemia (breakup of red blood cells) after eating fava beans. Fava beans, which are a major protein source for the Middle and Far East and North Africa, are a hazard for those individuals who havea deficiency of the enzyme glucose-6-phosphate dehydrogenase. Initial

symptom of the disease favism caused by eating these beans include headache, nausea, vomiting, pain and fever. This is followed by haemoglobin in the urine resulting from a rapid breakdown of red blood cells, jaundice and death.

Gossypol, another toxicant is present in cotton seed and may come into the cotton seed oil if it is not treated properly. Erucic acid, which has been linked to heart disease, is found in mustard and rapeseed oil. In fact, the consumption of bitter cucumber, bitter squash zucchini and other cucurbits has resulted in symptoms of severe cramps, diarrhoea and collapse. This is because of the increased levels of the toxin cucurbitacins in the bitter cucurbits. Bitter cucurbits, should, therefore, not be eaten.

A) Toxic amino acids

Lathyrus sativus (kesari dhal) seeds contain toxic amino acid beta-oxalyl\ aminoalanine (BOAA), is considered to be responsible for the disease lathyrism. It is an excitotoxin, which is a toxin capable of over stimulating and destroying nerve cells, thus contributing to the development of the uppermotor neuron disease. The disease has been especially occurring in parts of the States Madhya Pradesh Chattisgarh, Bihar, Maharashtra and in countries like Bangladesh where the pulse used to be consumed in larger quantities. The classical symptom is the spastic paraplegia, the paralysis of lower limbs.

Consumption of the pulse in lower quantities would result in painful spasms in the calf muscles, heaviness of the lower limbs, pain in the knee and ankle joints and difficulty in walking. The toxic amino acid from Lathyrus sativus can be reduced by steeping the seeds in water and discarding that water, or by using a process similar to parboiling of paddy. It is, however, advisable to avoid consuming this dhal.

B) Toxic alkaloids

Alkaloids are the nitrogen heterocycles which occur mainly in plants as their salts of common carboxylic acids such as citric, lactic, oxalic, acetic etc. Their amine character produces an alkaline solution in water, hence the origin of their name - alkaloids.

When eating potatoes, you must have been told to avoid green potatoes or the green and damaged portions of potatoes. This is because potatoes contain toxic compounds known as glycoalkaloids e.g. solanine, which are concentrated in the green portions and also the peel of the tuber. Alkaloids are the nitrogen heterocycles which occur mainly in plants as their salts of common carboxylic acids. They impart a bitter taste to the potatoes. Symptoms of poisoning, which develop after consuming such green potatoes or the skin of potatoes are diarrhoea, vomiting, severe abdominal pain, apathy, restlessness, drowsiness and visual disturbance. To minimize the hazard, insect attack to potato tubers during growing, mechanical damage during harvesting and storage have to be avoided.

Contamination of food products may also occur when certain toxic plants may be harvested or mixed with the edible species unintentionally. For instance, the

seed of Argemone mexicana, a seed with toxic alkaloid compounds e.g. sanguinarine resembles the seed of mustard which we use for seasoning in our cooking, as wel as, for extraction of mustard oil.

The argemone plant grows wild as a weed alongside mustard in the fields and may accidentally be harvested with the mustard. Consumption of mustard oil contaminated with argemone oil can lead to a condition known as epidemic dropsy, in which there is oedema over ankles, gastrointestinal disturbances and vascular and cardiac complications, which can result in death.

Food Adulteration, as argemone oil is often intentionally added to mustard oil by traders to increase their profit margins.

There are several other examples of food being contaminated with toxic weeds and resulting in serious ailments. Veno-occlusive disease (VOD) of the liver is a well known form of liver injury produced by pyrrolizidine group of alkaloids. In one such outbreak in the tribal areas of Madhya Pradesh, millet called gondhli (Panicum miliare) consumed by the tribals got contaminated with the toxic weed seeds of Crotalaria nanaburn. The tribals consequently suffered symptoms of ascites (fluid accumulation in the abdominal region), pain in thestomach and several of them subsequently died. Such a form of contamination is easily prevented by removal of the toxic plant in the fields by de-weeding. If the contamination is found in the grains before consumption, the toxic grains could be removed either by winnowing or hand picking.

Cyanogenic glycosides

Cyanogenic glycosides are present in a number of food plants and seeds. Cassava is a staple dietary item in tropical Africa, South America and South East Asia. The plant is a rich source of cyanogenic glycosides, which may be hydrolysed chemically or enzymatically to yield the poisonous hydrogen cyanide. Signs and symptoms of acute cassava poisoning are headache, breathlessness, gasping, paralysis, muscle weakness, coma and death. Linamarin, a cyanogenic glycoside, can be removed from cassava by leaching out with water. In 'fact, cassava is consumed only after treatments like soaking, fermentation and drying which will minimise the amount of toxin in the root. Tt can be detoxified by chopping and grinding in running water prior to preparation.

Figure 6.2 : Lima beans

Lima beans contain a high concentration of cyanide precursors. These inhibit

the oxidative processes of cells causing them to die very quickly. Because the body rapidly detoxifies cyanide, an adult human can withstand 50-60 ppm for an hour without serious consequences. However, exposure to concentrations of 200-500 ppm for 30 minutes is usuålly fatal. Other foods rich in cyanide are apple seeds, bitter almonds and laetrile, the bogus cancer remedy produce from peach kernels. Consumption of these foods has resulted in cases of severe illness and even death,

Mushroom Poisoning

Mushroom poisoning is caused by the consumption of raw or cooked fruiting bodies (mushrooms, toadstools) of a number of species of higher fungi. Figure 6.5 shows a variety of mushrooms, of which some could be poisonous as well. The term toadstool (from the German word Todesstuhl, meaning death's stool) is commonly given t poisonous mushrooms, but for the individuals who are not experts in mushroom identification, there are generally no easily recognizable differences between poisonous and non poisonous species. lhe toxins involved in mushroom poisoning are produced naturally by the fungi themselves, and each individual specimen of a toxic species should be considered equally poisonous. Most mushrooms that cause human poisoning cannot be made non toxic by cooking, canning, freezing, or any other means of processing. Thus, the only way to avoid poisoning is to avoid consumption of the toxic species.

Figure 6.3 : Variety of mushrooms

Mushroom poisonings are generally acute and are manifested by a variety of symptoms, depending on the amount and species consumed. There are four categories of mushroom toxins:

- protoplasmic poisons (poisons that result in generalized destruction of cells, followed by organ failure)
- neurotoxins (compounds that cause neurological symptoms such' as profuse sweating, coma, convulsions, hallucinations, excitement, depression, spastic colon
- gastrointestinal irritants (compounds that produce rapid, transient nausea, vomiting, abdominal cramping and diarrhoea), and
- disulfiram - like toxins. Mushrooms in this last category are generally non-toxi and produce no symptoms unless alcohol is consumed within 72 hours after eating them, in which case, a short-lived acute toxic syndrome is produced.

6.4.3 Anti-nutritional Factors in Foods

Many foods, particularly those of plant origin, contain a wide range of anti-nutritional factors which interfere with the assimilation of nutrients by our body. Some of the important anti-nutritional factors are protease inhibitors, phytates, oxalates, tannins, lectins and goitrogens etc.

A) Protease inhibitors

Protease inhibitors are the compounds which are found to some extent in cereal grains such as oats, wheat, barley and maize; vegetables such as onion and beetroot; nuts such as peanuts. These inhibitors interfere with the action of enzymes trypsin and chymotrypsin produced by the pancreas to break down ingested proteins.

Trypsin inhibitors are proteins distributed widely in the plant foods like legumes and certain animal foods like white of an egg. They generally inhibit the activity of trypsin (an enzyme secreted by the pancreas) in the gut and interfere with the digestibility of dietary proteins, thereby, reducing their utiiization. The trypsin inhibitors present in the dhals that we eat daily and the hen egg white, are easily inactivated by the normal cooking procedures and do not pose any problem. More drastic heat treatment is necessary to inactivate these inhibitors in soyabeans, peas, lima and kidney beans and also the duck egg white. Thus, for better digestibility and utilization of the proteins, these foods need to be thoroughly cooked before consumption.

Raw soybeans too have high levels of trypsin inhibitors. These can cause growth retardation and hypertrophy of pancreas. It hampers the release of essential amino acids like methionine. The trypsin inhibitors are generally heat labile and are largely destroyed in the normal process of cooking.

B) Haemagglutinins

Haemagglutinins are the globulin type of proteins which are present in the seeds of plants like double bean, field bean, white bean and horse gram, which have the property of agglutinating RBCs (Red Blood cells). The agglutinins combine with the cell lining of the intestinal wall and thus interfere with the absorption of essential nutrients. Consumption of improperly processed beans result in symptoms such as nausea, vomiting and diarrhoea. It also leads to growth depression, a decrease in food intake and death.

C) Phytates

Phytates are widely distributed in seeds of vegetables, fruits and grains. Unrefined cereals and millets are the richest sources of phytates. Refined or polished cereals, like rice, have lower levels ofphytates. The phytates present in cereals form insolubl complexes with the minerals such as iron, magnesium, zinc and calcium and contribute significantly to their poor absorption from the cereal-based diets. Phytate as an inhibitor present in cereals which prevents the absorption of iron. Germination or overnight soaking o grains reduces the phytate content

considerably because of breakdown of the phytate by enzymes which can do their 'cleaving' job in presence of water or moisture. This also improves the availability of minerals in the grains.

NOTES

D) Tannins

Tannins are another class of compounds which interfere with the absorption of minerals like iron and reduce the availability of proteins by binding to them. Thes are widely distributed in the plant kingdom and are present in high amounts in theseed coat of most legumes, spices, tamarind, turmeric, certain vegetables, fruits an particularly the tea. Millets like bajra, ragi, sorghum also contain a fair amount of tannin. A typical Indian diet based on cereals, legumes, vegetables and spices may contain as much as 2-3 g of tannin. Removal of seed coat of legumes, exclusion of tamarind and avoiding tea with meals may improve iron absorption from the diet by reducing the tannin content of the diet.

E) OxalatesFood Contaminan

Oxalates are widely distributed in plant foods mostly in the form of calcium salts. Oxalates are known to interfere with calcium absorption. High intake of oxalates increases their excretion in the urine, which in turn, may predispose the person to urinary stones. Rich sources of oxalates are green and leafr vegetables and some legumes like horsegram and kesari dhal (Lathyrus sativus).

F) Goitrogens/anti-thyroid substances

Goitrogens/anti-thyroid substances present in certain plant foods have been found to interfere with the uptake of iodine by the thyroid gland in the body. This can contribut to the development of iodine deficiency disorders when iodine intakes are marginal Thiocyanates, isothiocyanates and their derivatives are the chief goitrogens which occur in leaves and vegetables belonging to the Brassica genus and family Cruciferae, like radish, cabbage, cauliflower, rapeseed, mustard, broccoli, brussels sprouts, turnips, etc. Soyabean and other legumes, bajra, peanut and lentils also contain goitrogens. The enzymes required for production of goitrogens in the plant are destroyed by cooking. Goitrogens are also lost through leaching into cooking water.

G) Other substances

Legumes contain a wide range of some other biologically active and anti-nutritional components. These include oestrogenic isoflavones, coumestans (linked with reproductive disturbance in mammals) and saponins. However legumes are a rich source of proteins and minerals for humans and can be safely eaten daily. ne only precaution to be taken is that they should be thoroughly cooked before eating, as cooking destroys most of the anti-nutritional factors.

In fact, the presence of anti-nutritional factors does not mean that we stop consuming the above mentioned foods. Trypsin inhibitors, as mentioned before, are easily destroyed by cooking, germination of grains reduces the phytate content, removing the seed coat of legumes and decreasing the intake of tea and tamarind

can easily decrease the intake of tannins. On)yexcessive intake offoods containing goitrogens in the face of marginal intake of iodine from foods and water may lead to precipitation of iodine deficiency disorders. Hence, a little care and precaution can help.us overcome the problem of contamination, if any caused by these substances.

6.5 ENVIRONMENTAL CONTAMINANTS

Contamination of foodstuffs can occur from different sources in the environment.

Industrial effluents, untreated sewage and household chemical wastes (detergents, soaps, pesticides, discarded batteries, etc.) and residues of pesticides, fertilizers and veterinary drugs used in agriculture and animal husbandry, may find their way into soil, water and air. These toxic chemicals present in the soil, water and air are taken in by the plants and by land and marine animals. For example, selenium, arsenic, fluorides, nitrates in the soil may accumulate in plants to toxic levels.

Indirect contamination of meats, milk or eggs may occur as a result of ingestion Of contaminated plants by animals. Since man is on top of the food chain, he is the worst affected. Many instances of man being poisoned as a result of indirect contamination of food are recorded in literature. In fact, one of the oldest accounts of poisoning is mentioned in the Bible. It is said that the Hebrew were poisoned after consuming quails. Normally quail flesh can safely be eaten. However, in this case, it was suggested that the toxicity resulted from the quails having earlier eaten hemlock seeds, which are poisonous.

In the coming sections, we will discuss about the different types of environmental contaminants. These are:

- Biological contaminants — like fungi and fungal toxins, bacteria and their toxins due to improper storage or processing of the food products
- Pesticide residues — found in milk, grains, oil, bottled water, vegetables and fruits
- Veterinary drug residues — found in milk and milk products, meat and meat products
- Metallic contaminants — e.g. nickel due to the improper processing of vanaspati, suji, from rollers used in processing etc.

6.5.1 Biological Contaminants

In the developing countries, food-borne diseases continue to be a serious health hazard and a major cause of morbidity and mortality. In fact, they are a major public health concern, which cut across national boundaries in terms of human ailments and economic loss. Most of the reported cases of food-borne diseases are due to the consumption of food contaminated with microorganisms. Microorganisms present in the soil, water and air may infect the growing plant and stored foodstuffs and produce harmful metabolites. Warm temperatures and high moisture content serve as ideal conditions for the growth of microorganisms like

bacteria and fungi in stored food products. These types of contaminated foodstuffs have been the cause of many serious poisonings in man and animals which have even resulted in death. Toxins produced by fungi are collectively termed as mycotoxins and the disease caused by them as mycotoxicosis. Mycotoxins have been found in many types of foods for human consurnption, particularly cereals and nuts. Contamination can occur in the field or during storage. Meat, eggs and milk from animals that have fed on mycotoxin contaminated feed can provide an indirect route of exposure for us. Some examples of mycotoxins, you may recall, are aflatQxins produced by the fungi Aspergillus flavus and Aspergillus parasiticus, deoxynivalenol, fumonisin and zearalenone produced by the Fusaria species and ergot alkaloids produced by Claviceps spp. And ochratoxin by Aspergillus ochraceus and Penicillium species.

The foods which are at a risk for aflatoxin contamination include a wide range of commodities like maize, groundnut, dried coconut, cottonseed and spices like chilli pepper. Coffee may contain ochratoxin and deoxynivalenol in wheat.

There have been a few recorded outbreaks as a result of fungal contamination in India. Consumption of bajra contaminated with ergot, derived from the fungus Claviceps fusiformis, has been implicated in a disease outbreak characterized by symptoms of nausea, vomiting, giddiness and drowsiness. Aflatoxicosis, which I caused by consumption of foodstuffs contaminated with aflatoxins, was reported in 1974 among tribals in Western India and more recently in 2004 in Kenya.

The characteristic features of aflatoxicosis were jaundice, rapidly developing ascites and portal hypertension. In 1987, a considerable segment of the population of the Kashmir valley was affected by a gastrointestinal disorder symptomised by abdominal pain and vomiting. The outbreak was associated with the consumption of bread made from mould-damaged wheat and the presence of varying quantities of trichothecene mainly deoxynivalenol.

Bacteria, you may recall reading in Unit 5, also produce toxins which result in food poisoning. Important bacterial agents implicated in poisoning outbreaks in India are Staphylococcus aureus, Salmonella and Bacillus cereus. Bacterial food poisoning is perhaps the most common adverse health effect of consuming contaminated food. Prominent symptoms include vomiting, diarrhoea and in some cases fever.

6.5.2 Pesticide Residues

Codex Alimentarius defines pesticides as any substance intended for\ preventing, destroying, attracting, repelling or controlling any pest including unwanted species of plants or animals, during production, storage, transport distribution and processing of food agricultural commodities, or animal feeds or which may be administered to animals for the control of ectoparasites (parasites that live on but not within their hosts). It includes substances intended for use as a plant growth regulator, defoliant, desiccant, fruit thinning agent or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. It normally excludes chemicals

such as fertilizers, plant and animal nutrients, animal drugs and food additives.

Pesticides are used to protect food from pests, such as insects, rodents, nematodes, fungi, moulds, and bacteria. Pesticides used on food include:

- insecticides to prevent, destroy, kill or mitigate insects
- rodenticides to inhibit growth, destroy or kill rodents
- herbicides to prevent or inhibit the growth of weeds
- fungicides to prevent, destroy or inhibit the growth of mould and fungus
- nematicides to prevent, destroy, repel or inhibit the nematodes, and
- antimicrobials to control bacteria.

Pesticides can also be classified based on their nature as:

- organochlorine pesticides
- organophosphates and carbamates, and
- pyrethrins and pyrethroids

The use of pesticides has decreased several-fold in India and it is likely to increase in the forthcoming years. A significant amount of the pesticides used in-agriculture, leach ihto the rivers (especially from farms bordering river banks) and other wate bodies. It is a well-known fact that indiscriminate use of pesticides has also lead to high residue levels in food. Even small quantities of these residues present in food lead to high levels in the body fat when these food stuffs are consumed over long periods of time. The effects of pesticide consumption are many. They vary from minor health problems like skin and other allergic reactions to carcinogenicity. The long term effects could also be reduction of life span and fertility in addition to several metabolic and genetic disorders.

After pesticides are sprayed, they slowly start dissipating. Every pesticide has some safety or waiting period which is defined as the 'number of days to lapse before the pesticide residues get dissipated'. Pesticide residues are defined as any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide. It includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products and impurities considered to be of toxicological significance. It differs from pesticide to pesticide and also from one crop to the other. Food products become safe for consumption only after the waiting period has lapsed. If fruits and vegetables are harvested before completion of the waiting period, it is likely to have higher level of residues which are hazardous to health. Residues of pesticides have been found in almost all kinds of foods viz. milk and milk products, edible oils and fats, food grains, vegetables and fruits. A recent study estimated that between 50 and 70 per cent of all vegetables grown and sold around the country were contaminated with pesticide residues, some of them well beyond the permissible levels. In fact, our own bodies at present may contain at least one pesticide in detectable amounts. Studies in India have shown the presence of pesticides like DDT and BHC in the breast milk of some women.

Pesticide residues cause acute and long term toxic effects in human beings, animals, fish and birds. During spraying operations, they affect the point of contact such as skin and eyes. Pesticides also affect the internal organs of the body after

they are absorbed. Continued exposure for long periods causes liver or kidney problems an also affects the nervous system. It can also cause mutation resulting in birth defects. Lindane is one of the most harmful organochlorines. If consumed over a period of time, it affects the central nervous system, liver, kidney, pancreas, testes and nasal mucous membrane.

Lindane poisoning symptoms include headache, dizziness, gastrointestinal disturbances, numbness and weakness of the extremities, apprehension and hyperirritability. Assessing the impacts of pesticides, especially organochlorines on fish and wildlife, is becoming increasingly important because of the recent evidence suggesting that some organochlorines, even at low concentrations, disrupt the endocrine system, which is responsible for proper hormone balance.

Food poisoning outbreaks due to pesticides being mixed with food inadvertently have been described. In one instance, people who ate at a community lunch develop symptoms of nausea, vomiting and abdominal pain. On investigation it was discovere that the pesticide 'malathion' had been sprayed in the kitchen where the ra ingredients had been kept for cooking the lunch. Accidental spillage of pesticide on jowar in another case, resulted in abdominal pain, vomiting and loose motions in people who consumed rotis made from it. In another outbreak, several lives were lost when villagers consumed food grains which had been mixed with the pesticide BH for storage and preservation purposes.

In recent times, there are several measures being taken to regulate the contamination of food with pesticide residues to safe levels. In fact, the Prevention of Food and Adulteration Act, 1954 of India has prescribed limits of tolerance for pesticide/insecticide residues in food and food commodities for a selected number of pesticides.

STUDENTS ACTIVITY - 1

1) Enumerate the environmental contaminants. How do they enter the food chain?
2) How do biological contaminants lead to food borne illness?

6.5.3 Veterinary Drug Residues

The advancements in animal husbandry and the field of medicine have resulted in the ever expanding use of drugs. These drugs are used to improve or maintain the health of an animal species regardless of whether these are intended for food products or otherwise. A significant number of these chemicals ultimately in one way or another, end up in our food (as residues in meat or milk) and water supply. The milk and flesh of animals fed antibiotics and other growth stimulating medicines and hormones becomes contaminated with the residues of these drugs. Usually these drugs remain in the body of the animal for a few days and the animal should not be milked or killed for meat during that period after the administration of the drug. Ignorance and non-compliance with safety norms can however lead to these compounds entering our food.

Of the different types of veterinary drugs used in food producing animals, veterinary drug residues, especially antibiotic residues and steroid hormones, are of concern because of their possible adverse effects on persons allergic to certain antibiotics like penicillin and the potential build up-of antibiotic resistant organisms in humans, When the microorganisms present' in our intestines are exposed to low doses of antibiotics in the form of residues in the food that we eat (viz. meat, milk and eggs of contaminated animals), they start becoming resistant to the drug Acute poisoning outbreaks attributed to veterinary drugs have also been described in literature. Some people in Lyons, France developed symptoms of tremor, headaches, abnormally rapid heart rate and dizziness 1 to 3 hours after eating veal liver. On investigation this was revealed to be a case of poisoning by clenbuterol residues in the veal liver.

In addition, antibiotic residues present in milk, intended for the production of cheese or for the formation of milk products requiring the use of bacterial or yeast cultures, may result in killing of these cultures. This results in subsequent economic losses to the dairy industry. Use of steroid hormone-diethylstibesterol, in beef production has now been banned due to indications that it is a carcipogen. Another important hormone that is naturally present in animals and is used to the stimulation of growth and lactation in farm animals is bovine somatotropin (BST). It is legally permitted to be used in India as no residues in animal products are likely to occur.

6.5.4 Heavy Metals

Like the foods we consume, our bodies also contain many metallic elements. Most of these metals are actually required for the normal fünctioning of our bodies. Some of these metals, especially the heavy metals are toxic. Heavy metals like mercury, cadmium, nickel, arsenic, lead and aluminium are used by several industries. These contaminate our foods when factories throw their waste products into the seas and rivers or bury their wastes before appropriately treating them. Smoke from industries, as well as, exhaust filmes from vehicles and machinery pollute the atmosphere. Thus heavy metals enter our bodies via the water we drink, the air we breathe and the food that is grown in such contaminated soil.

Metals may also enter food from metallic cans in which the food is packaged. Acidic conditions in the stored products may cause the surface layer of the cans to dissolve into the food products. Aluminium containers which can also be slowly dissolve under acidic conditions are more rapidly corroded under more alkaline conditions. Another source Of chemical .contaminants is vessels and utensils used in cooking and storage of prépared foods and beverages. Vessels.made of brass are usually tinned from inside. Poor quality tin coating or improper tinning of the vessels can result in tin and copper leaching into the food cooked or stored in the vessel.

Heavy metals pose a substantial risk to human health. These metals are not readily excreted from our bodies and can accumulate to toxic levels over a period of time. The vegetable crop has been found to suck in heavy metal and other contaminants from soil, water and air. Fields on the fringes of urban areas, supplying cities, are the worst affected. Raw sewage water and sludge used for irrigation in

some parts of the country have led to a build-up of heavy metals up to 30 cm in the soil. Recently, an article in the newspaper reporting high levels of heavy metals tested in vegetables, particularly the green leafr vegetables, grown in areas in and around Delhi, is testimony to this problem.

Arsenic

Arsenic is usually classified as a metalloid, since it has properties both of a metal and a non-metal. It is present in small quantities in most human foods. In parts of West Bengal, soil and crops show arsenic build-up after being irrigated with arsenic -rich water. It is introduced into water through the dissolution of minerals and ores and also from erosion from]ocal -rocks. Industrial effluents also contribute arsenic to water in some areas. In fact, contamination of drinking water with arsenic is a major problem in the area, as it -poses serious health concerns: Absorption of arsenic through the skin is minimal and thus hand-washing, bathing, laundry etc. with water containing arsenic does not pose human health risk.

Symptoms of chronic arsenic Ifetypoisoning include general muscular weakness, loss of appetite, nausea and inflammation of the mucous membrane of the eyes, nose and lungs. The most characteristic effects following chronic arsenic exposure are hyperkeratosis (thickening of the skin) seen in the palms and soles of the feet together with hyperpigmentation,particularly in areas not exposed to thé sun. While immediate symptoms of an acute poisoning typically include vomiting, oesophageal abdominal pain and bloody 'rice water' diarrhoea.

Figure 6.4 : Arsenic poisoning

Lead

Lead, even at relatively low levels of exposure can cause severe health effects. Exhaust from vehicles using unleaded petrol serves as an important source of lead in the atmosphere. Lead may also ba present in industrial wastes, paints, ceramic glazes, cosmetics and ultimately may pollute not only the air we breathe but also the soil and water. Several surveys have detected high levels of lead

in different foodstuffs, drinking water and seafoods like shrimps. It affects the human nervous system production of blood cells, kidney, reproductive system and behaviour. It increases the risk for premature birth and can induce miscarriage. The main effects of chronic lead poisoning are seen on the blood cells, nervous, gastrointestinal, reproductive and renal systems. Some of the symptoms of acute poisoning, which occurs on consuming single large doses of the toxin are tiredness, abdominal discomfort, irritability and anaemia.

Mercury

While this metal is a naturally occurring element, coal-fired power plants and other industrial processes pump extra tonnes of this contaminant into the environment Among the various foods, it is seafood, which has been found to be the most commonly contaminated with mercury. Much of this mercury ends up in water and subsequently in the tissues of fish. The source of mercury poisoning is primarily contamination of food from polluted water containing mercuric compounds from industrial waste or organic mercury contained in some fungicides. Food or feed grainstreated with mercury containing fungicides are yet another potential source for transmission of the metal through both animal and cereal foods. Mercury is one of the most toxic of heavy metals, in fact it is a neurotoxin.

In Japan, the Mina-mata disease was attributed to mercury poisoning. The people affected experienced loss of appetite, spastic paralysis, weight loss, tiredness, impaired vision and finally developed kidney failure. In high doses, it can cause neurological problems such as speech and hearing impairment, loss of coordination and a tingling sensation in the limbs. What is most alarming is the fact that mercury can easily pass through the placenta and harms the foetus during pregnancy.

Cadmium

An increase in the soil cadmium content due to soil pollution by industrial wastes, burning of coal, fossil fuels, sewage sludge, medical and municipal waste results in an increase in the uptake of cadmium by plants. High levels of cadmium have also been detected in seafood like shrimps. The cadmium absorbed by our bodies is retained for several years. This is, in fact, a problem with all heavy metals. Our body is not able to effectively throw out these metals. Cadmium is a highly toxic metal. One example of cadmium toxicity was highlighted by Itai Itai (bone damage) disease in Japan in 1960. Chronic exposure to this metal causes renal damage, heart disease, anaemia, skeletal weakening and depressed immune system response.

Aluminium

Most natural foods have relatively low levels of aluminium. Aluminium in foods includes what is present naturally plus that coming from certain food additives, food containers and cooking utensils. Besides these, exposure to aluminium may also occur through the use of some products for treating diarrhoea, haemorrhoid medications, antiperspirants and lipsticks. This metal has been implicated in

Alzheimer's disease, a chronic progressive disease characterized by a gradual loss of cognitive functions. The role of aluminium in a variety of bone diseases is also well recognized.

NOTES

Antimony

Antimony enters the air, soil and water as a by-product from the smelting of lead and other metals. The symptoms of antimony poisoning are coronary and pulmonary problems, stomach pain, diarrhoea, vomiting and stomach ulcers. It plays a role in Sudden Infant Death Syndrome (SIDS).

Chromium

It often accumulates in aquatic life, adding to the danger of eating fish that may be exposed to high levels of chromium. 'Low level exposure can irritate the skin and cause ulceration. The long-term exposure can lead to, kidney and liver damage, as well as, damage to circulatory and nerve tissue.

Copper

Copper, as you may already know, is an essential micronutrient to human life. It normally occurs in drinking water from copper pipes. When consumed in high dosage, it can cause anaemia, liver andkidney damage, and stomach and intestinal irritation. People with Wilson ts disease are at a greater risk for health effects from overexposure to copper.

Nickel

It occurs naturally in some foods and manufacturers use it in the hydrogenation process. Nickel exposure also occurs from both first and second-hand tobacco smoke. It accumulates in aquatic food chains with freshwater organisms being more sensitive than the ones from salt water.

Tin

Canned foods contain higher levels of tin because the tin coating used to protect the steel body of the can from corrosion can slowly transfer tin into food. Though no long-term health effects are associated with consuming tin but it can cause symptoms such as stomach upsets, nausea, vomiting, diarrhoea, abdominal cramps and bloating.

In the sections above, some examples of acute poisoning outbreaks due to the consumption of contaminants have been discussed. Unfortunately, the appearance of the toxic effects of chemical contaminants may not always be immediate. It may be delayed in view of the small quantities ingested over a period of time. Thus, the cause and effect relationship between ingestion of the contaminant and toxic effect seen at a later date cannot easily be demonstrated. This is further complicated by the multiplicity of chemical contaminants that may be ingested at any given time. Ingestion of chemical contaminants can be greatly reduced by following good agricultural practices: minimizing the use of pesticides, chemical fertilizers, following good practices of animal husbandry especially when the animals need

medication and ensuring safe disposal of toxic wastes from our industries. At the household level, we can do simple things like washing thoroughly the grains, fruits and vegetables before consuming them. Removing the peels of fruits and vegetables also helps in removing contaminants adhering to the skin. Fruits and vegetables growing in the vicinity of polluting industrie should be avoided. While consuming non vegetarian foods, organ meats (viz. kidney, liver, brain) should be avoided as they tend to accumulate heavy metals. Fish from deep sea and lakes or free-flowing rivers are safer than those caught in water bodie close to industries releasing effluents or sewage treatment plants.

STUDENTS ACTIVITY - 2

1) What are veterinary drug residues and how do they enter our food chain?
2) How do veterinary drugs pose a threat to us?
3) List the ways in which toxic heavy metals enter our food chain.
4) Suggest measures to reduce our exposure to chemical contaminants.

6.6 MISCELLANEOUS CONTAMINANTS

A host of other toxic chemicals can be present in our foods as contaminants. As the list is endless, we, will be discussing only some of them in this section. Contaminants derived during storage from packaging and canning materials in contact with the foodstuffs are of great concern to us. Such contaminants leach out of packaging materials into the food products. Let us learn more about some of these contaminants.

Dioxins are a group of chemicals (polychlorinated aromatic compounds) with similar structures, chemical and physical properties.

Dioxins, are not produced intentionally or deliberately, but are formed as a by-product of chemical processes. These range from natural events such as volcano eruptions and forest fires to manmade processes, such as manufacturing of chemicals, pesticides, steel and paints, pulp and paper bleaching, exhaust emissions and incineration. For example, we chlorinated waste is burned in an uncontrolled way in an incinerator, the emissions to the air contain dioxins.

Dioxins are not soluble in water and are highly soluble in fat. This means that they bind to sediment and organic matter in the environment and are absorbed in animal and human fatty tissue. In addition, they are not biodegradable, so they are persistent and accumulate in the food chain. This means that once released into the environment, via air or water, they pile up in the fat tissue of animals and humans. Human exposure to dioxins can occur through working in industries where dioxin is a by- product, industrial accidents, food, human breast milk and drinking water. Dioxins can enter the food supply through a number of different routes. Soil is a natural sink for dioxins. Apart from atmospheric deposition, soils may be polluted by sewage sludge or composts, spills and erosions from nearby -contaminated areas.

Dioxins have a broad series of toxicological and biochemical effects and

some of them are classified as known human carcinogens. In laboratory animals, they have been linked to severe effects on the uterus, developmental effects and learning disabilities, developmental reproductive effects (low sperm count, genital malformations) andimmunotoxic effects. These effects occur at much lower levels of exposure than carcinogenic effects.

PCBs or polychlorinated biphenyls are another group of chemicals. They are chlorinated aromatic hydrocarbons. PCB mixtures are still widespread ahd present today, such as in transformers, building materials, lubricants, coatings, plasticizers and inks. Some of the PCB compounds have toxicological properties that are similar t dioxins and ar therefore often termed "dioxin-like" PCBs. Although the production and use of most PCBs has been discontinued in almost all industrial countries, as a result of their widespread use in the past, largeamounts of PCBs remain present until today in electrical equipments, plastic products, buildings and in the environment. As a result, PCBs are also still ending up in waste streams.

Aerial transport and deposition of dioxins and dioxin-like PCBs are also the main sources of contamination of leafy vegetables, pastures and roughages. Dioxins and dioxin-like PCBs are poorly soluble in water, but are adsorbed onto mineral or organic particles in suspension in water and thus enter the aquatic food chain. In general food of animal origin contributes to about 80% of the overall human exposure. Animal fat acts as a sponge for PCB and hence they are found in foods containing animal fat like meat, fish, eggs and milk.

High levels of PCB in the blood have been linked to reduced cognitive skills, mental development and suppressed immune reactions, especially in children exposed to PCB in the womb. The first evidence of mass poisoning by PCB came to light in 1968 in Yusho, Japan. The heat degraded products of this chemical used in the heat exchangers for decolourization of rice bran oil, contaminated the oil. The number ofstill-births in women who consumed this oil increased, as did the number of children born with varied health problems. Recent studies suggest that PCB can also cause short-term memory and learning problems in adults.

Acrylamide is a chemical that appears to be produced naturally in food as a result of baking or frying. It is also likely to be produced by grilling and roasting food. In industry, it is manufactured as a crystalline white powder and is used in the production of polyacrylamide. This is used as an additive for water treatment. On the basis of animal data and understanding of its biological effects, acrylamide is considered to be a probable human carcinogen. It has caused nervg damage in people who have been exposed to it at work. In studies on male mimals, acrylamide was shown to impair fertility. As acrylamide has very recently been discovered in foo such as potato at such high levels so as to cause concern, practically nothing is known about its effects on humans via the diet.

The next most important contaminant which is of concern today in the modem world is the use of plastic. Let us get to know how contaminants from plastic enter the food.

Contaminants from plastics

Plastics are widely used in contact with foodstuffs, namely, in food processing equipment, food utensils and as food packaging. In their manufacture, numerous additives are used depending on the type of produced polymer. These additive include plasticizers, antioxidants, catalysts, suspension and agents, stabilizers and polymerization inhibitors, pigments, fillers etc. These additives are bound either chemically or physically into the polymer and may be present in their original or an altered form. In addition, the polymerization process may leave trace quantities of residual monomer or low-molecular-mass polymer in the plastic. These substances can be of concern if present in amounts more than specified. It is, therefore, necessary to specify the purity of the polymer to be used in the prgparation of plastic intende for food and/or drinking water. This is exactly what is meant by the term "food grade plastic" — which we often see on the plastic containers, packaging materials or utensils.

"Ihe extent to which the migration of contaminants into foods occur, will depend upon factors such as the contact area, the rate of transfer, the type of plastic material, the temperature and the contact time. The migration of substances from plastic into food is also related to the type of food packaged. Alcoholic beverages and edible fats and oils will extract substances more readily than dry food such as cereals.

The high-molecular-mass polymer in plastics itself does not pose a toxic hazard, being inert and essentially insoluble in food. Monomers which make up the polymer are very reactive and biologically aggressive. Some of them have been shown to cause allergic effects, to damage the liver and reproductive functions and to cause cancer.

Plasticizers are used to assist processing and impart flexibility to plastics. They can be present in food packaging materials in significant amounts and have the potential to migrate into food. The migration of plasticizers can be aggravated by heat and by the presence ofa food into which the plasticizing chemical will dissolve (for example, oil, acid or alcohol).

6.7 LET US SUM UP

The maintenance of good health demands that the food we consume should not only be nutritious but also safe and of good quality. There has been a growing concern regarding the environmental contamination of food in the country in recent times. This unit focussed on this aspect.

Further, we learnt that naturally occurring toxicants in some plant and animal foods pose a health hazard. Shellfish toxins, toxic amino acids, alkaloids and cyanogeni glycosides are some of the toxicants that can have very serious and sometimes fatal consequences. Anti-nutritional substances like tannins, phytates, oxalates, enzyme inhibitors, goitrogens etc. interferes with the assimilation o nutrients by our bodies. Hence, it is very important to create public awareness about the different kinds o food toxicants that can be present in our foods and how the common man can reduce his exposure to these toxicants.

Biological and chemical contaminants also make our food unsafe to eat. Bacteria, fungi and their toxic metabolites constitute biological contaminants. The

list of chemical contaminants is long and varied. Going through the unit, you may have realized that as a part of modern advances in agricultural technology, the application of pesticides and tertilizers to crops and the use of various compounds in animal husbandry an veterinary practice have increased, often resulting in residues of these unintended contaminants persisting in the final food product. In addition, contaminants like heavy metals, dioxins, PCB, plasticizers and other chemicals from the packaging materials may leach into the food. This unit, therefore, focussed on the fact that these connminants can have serious health consequences, most of them being implicated as carcinogenic or cancer-causing. It is, hence, vital for us to adopt appropriate measures to reduce our exposure to these chemicals.

6.8 GLOSSARY

- Apathy : lack of interest or feeling, indifference.
- Ataxia : defective muscular co-ordination, especially during voluntary muscular movement.
- Biogenic : produced by living organisms.
- Dyspnea : difficult or laboured breathing.
- Dysuria : painful or difficult urination.
- Edema : swelling due to watery fluid collecting in ffe cavitiesor tissues of the body.
- Erythema : a superficial reddening of the skin, usually inpatches.
- Hyperkeratosis : overgrowth of the horny layer of the epidermis.
- Mutation : a change in the chemical constitution of the DNA in the chromosomes of an organism.
- Myalgia : tenderness or pain in the muscles.
- Paresthesias : sensation of numbness, prickling or !ingling.

6.9 CHECK YOUR PROGRESS

1) Define the term 'Food Contamination'? What are the three main types of contaminants present in our foods?
2) What are naturally-occurring toxicants?
3) What is mushroom poisoning? How can it be avoided?
4) What are anti-nutritional compounds? Give some examples.
5) Define Pesticide residue. What are the different pesticides that are used on our foods?
6) Define the following terms:
   a) Waiting period
   b) Mycotoxin

UNIT

7

FOOD ADDITIVES

STRUCTURE

7.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- list the various types of food additives,
- explain the function of each type of food additive;
- recognize the type of additive added to a food by reading the label on the packaging Of the food, and
- discuss some safety issues regarding intake of food additives.

7.2 INTRODUCTION

Have you ever wondered why butter available in the market has a pleasing yellow colour compared to the white butter we make at home? What prevents salt from becoming lumpy in its shaker? And what allows many foods to be available year-round? The answer to all these questions is — food additives.

Changes in our lifestyle have increased the demand for processed foods. Everyone is looking for convenient, easy-to-cook and ready-to-eat foods which require less time to prepare than the traditional home-cooked foods. Manufacturing of processed foods requires the addition of several chemicals. In this unit we will look at the chemicals which we intentionally put in our foods during processing. These chemicals are known as food additives.

The unit will provide background information about food additives, why they are used in foods and how regulations govern their safe use in the food supply.

7.3 WHAT IS A FOOD ADDITIVE?

NOTES

A food additive may be defined as any substance or a mixture of substances, other than basic foodstuff, which is present in food as a result of any aspect of production, processing, storage or packaging. In simpler terms, food additives are the substances which are added to food by the manufacturers to facilitate processing or to improve appearance, texture, flavour and keeping quality. The term does not include chance contaminants which might unknowingly enter our food, or substances added to food for maintaining or improving nutritional qualities. Its usage is restricted to substances added intentionally to foods. Such substances include oxidizing agents, flavours, propionate sorbate, vitamins etc.

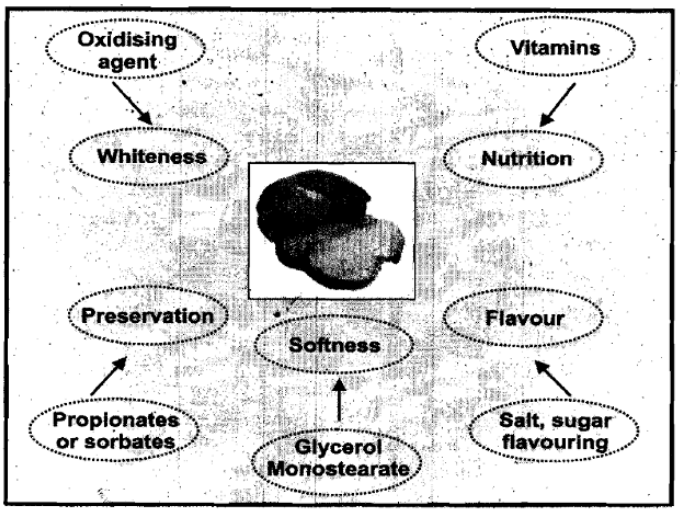

Figure 7.1: The additive required to make good quality bread.

Why are Additives Used in Foods?

Additives perform a variety of useful functions in foods that are often taken for granted. Since most people no longer live on farms, additives help keep food wholesome and appealing while en route to markets sometimes thousands of miles away from where it is grown or manufactured. Additives also improve the nutritional value of certain foods and can make them more appealing by improving their taste, texture, consistency or colour. We can understand this better by looking at what goes into producing good quality bread.

A mild oxidizing agent is added to the flour to obtain whiteness, vitamins may be added to improve nutritional quality, salt, sugar and flavours are added to obtain desirable taste and flavour, glycerol monostearate for soft texture and propionates or sorbates are added for better keeping quality to suit long distance transportation and marketing. Each additional component incorporated in bread

manufacture has a positive impact on the desirable quality of the finished product which is so essential for its marketability or acceptance by the consumer.

Having looked at the role of additives in making good quality bread, the different uses of additives in foods, in general, can be summarized as under :

To maintain product consistency — Emulsifiers give products a consistent texture and prevent them from separating. Stabilizers and thickeners give a smooth uniform texture. Anti-caking agents help substances such as salt to flo freely.

To improve or maintain nutritional value — Vitamins and minerals are added to many common foods such as milk, flour, cereal and margarine to make up for those likely to be lacking in a person's diet or lost in processing.

To maintain palatability and wholesomeness —Preservatives retard product spoilage caused by mould, air, bacteria, fungi or yeast. Bacterial contamination can cause food borne illness which could be life-threatening Antioxidants are preservatives that prevent fats and oils in baked goods and other foods from becoming rancid or developing an off-flavour. They also prevent cut fresh fruits such as apples from turning brown when exposed to air.

T**o provide leavening or control acidity/alkalinity** — Leavening agents that release acids when heated can react with baking soda to help cakes, biscuits and other baked goods to rise during baking. Other additives help modify the acidity and alkalinity of foods for proper flavour, taste and colour.

To enhance flavour or impart desired colour — Many spices and natural and synthetic flavours enhance the taste of foods. Colours, likewise, enhance the appearance of certain foods to meet consumer expectations.

To enhance the keeping quality or stability of a food — Use of certain preservatives, stabilizers, anti-caking agents etc. increases the shelf-life of food products.

WHAT IS THE FUNCTION OF FOOD ADDITIVES?

- To mainuin product consistency
- To improve or mainuin nutritional value
- To maintain paleability and wholesomeness
- To improve flavor or impart desired colour
- To provide leavening or control acidity/alkalinity

Functions of food additives

Different countries have different laws pertaining to which food additives can be used and in which foods. In India, the Prevention of Food Adulteration (PFA) Act and Rules specify the amounts and names of food additives which can be added to certain foods.

Now, let us examine in detail the different types of additives permitted in foods in India and the .role each one plays to make the food product more appealing or acceptable to us as consumers. We will also get to know how safe it is to consum these chemicals as a part of our daily diet in the next section.

7.4 CLASSIFICATION OF FOOD ADDITIVES

NOTES

You would realize, of the many ways the food additives have been classified, the functional classification has received the widest acceptance. According to this, the food additives are classified based on their function in food, i.e. the purpose for which the additive has been incorporated in the food. Based on this, the various clayes of food additives can be identified as:

- antioxidants
- preservatives
- food colours
- food flavours
- emulsifiers and stabilizers
- anti-caking agents
- sequestrants
- acid, bases and buffers
- anti-foaming agents
- sweeteners
- enzymes, and
- leavening agents.

Visit your local grocery store or supermarket and note down the label information on the ingredients of processed food items like jam, tomato sauce, biscuits, bread, soup powder, health drinks (like bournvita, horlicks, etc.), cheese, cheese spread, butter breakfast cereals, sherbets, squashes, pickles, chocolates and canned fruits, vegetables and meat products.

What information related to additives did you find on the label?

Yes, a list of the ingredients, along with the other substances such as synthetic food colours, flavours present in the food item is listed. These other substances are the additives.

In the coming section, we will learn more about the functional role of some of these additives. But, while on the topic of classification of additives, note additives may also be classified as direct or indirect.

If a substance is added to a food for a specific purpose in that food, it is referred to as a direct additive. For example, the low-calorie sweetener aspartame, which is used in beverages, is considered a direct additive. Many direct additives are identified on the ingredient label of foods.

Indirect food additives are those that become a part of the food in trace amounts due to its packaging, storage or other handling. For instance, minute amounts qf. additives coated on packaging substances may find their way into foods during storage. Thad. is why it is essential to make sure that all materials coming in contact with food are safe, before they are permitted for use. Also additives used in, raw materials or ingredients may find their way in to the finished food product.

For example, antioxidants used in edible oil may also befound in chips or any food item prepared with this oil. This is known as the "Carry over' principle.

Before moving on to the functional role of additives, let us recapitulate what we have learnt till now.

STUDENTS ACTIVITY - 1

1) List five reasons why additives are added to foods.
2) What do you mean by'carry over' principle?

7.5 FUNCTIONAL ROLE OF DIFFERENT ADDITIVES

Here, what do we mean by the term åmctional role? You may recall reading about the fianctional role of substances in the Principles of Food Science Course. Functionality (as implied to food ingredients), generally refers to any property aside from the nutritional attributes that influences usefulness of ingredients in the food. Most of the functional properties affect the sensory characteristics (especially textural attributes) of foods, but also can play a major role in the physical behaviour of food and food ingredients during their preparation. The fianctional role, of different food additives classified, as per Codex Alimentarius.

Table7.1 : The functional role of food additives classified, as per Codey Alimentarius

Functional classes (for labelling purposes)	Definition	Sub-classes (Technological functions)
1) Acid	Increases the acidity and/or alkalinity of a food.	Acidifer
2) Acidity Regulator	Alters or controls the acidity or alkalinity of a food.	Acid, alkali, base, buffer, buffering agent, pH adjusting agent
3) Anticaking agent	Reduces the tendency of particles of food to adhere to one another.	Anticaking agent, antistick agent, drying agent, dusting powder, release agent
4) Antifoaming agent	Prevents or reduces foaming antioxidant, antioxidant synergist.	Antifoaming agent
5) Antioxidant	Prolongs the shelf-life of foods by protecting against deterioration caused by oxidation, such as fat rancidity and colour changes.	Antioxidant, antioxidant synergist, sequestrant
6) Bulking agent	A substance, other than air or water, which contributes to the bulk of a food without contributing significantly to its available energy value.	Bulking agent, filler
7) Colour	Adds or restores colour in a food.	Colour
8) Colour retention agent	Stabilizes, retains or intensifies the colour of a food.	Colour fixative, colour stabilizer

9) Emulsifier	Forms or maintains a uniform mixture of two or more immiscible phases which surface as oil and water in a food.	Emulsifier, plasticizer, dispersing agent, surface active agent, surfactant, wetting agent
10) Emulsifying salt	Rearranges cheese proteins in the manufacture of a processed cheese, in order to prevent fat separation.	Melding salt, sequestrant
11) Firming agent	Makes or keeps tissues of fruit or vegetables firm and crisp, or interacts with gelling agents to produce or strengthen a gel.	Firming agent.
12) Flavour enchancer	Enchances the existing taste and/or odour of a food.	Flavour enhancer, flavour modifier, tenderizer
13) Flour treatment agent	A substance added to flour to improve its baking quality or colour.	Bleaching agent, dough improver, flour improver
14) Foaming agent	Makes it possible to form or maintain a uniform dispersion of a gaseous phase in a liquid or solid food.	Whipping agent, aerating agent
15) Gelling agent	Gives a food texture through formation of a gel.	Gelling agent
16) Glazing agent	A substance which, when applied to the external surface of a food, imparts a shiny appearance or provides a protective coating	Coating, sealing agent, polish
17) Humectant	Prevents food from drying out by counteracting the effect of an wetting agent atmosphere having a low degree of humidity.	Moisture/water retention agent, wetting
18) Preservative	Prolongs the shelf-life of a food by protecting against deterioration-caused by agent, bacteriophage control agent, microorganisms.	Antimicrobial preservative, antimycotic
19) Propellant	A gas, other than air, which expels a food from a container.	Propellant
20) Raising agent	A substance or combination of substances which liberate gas and thereby increase the volume of a dough.	Leavening, raising agent
21) Stabilizer	Makes it possible to maintain a uniform dispersion of two or more immiscible retention agent, foam stabilizer substances in a food.	Binder/firming agent moisture/water
22) Sweetner	A non-sugar substance which imparts a sweet taste to a food sweetner	Sweetener, artificial sweetner, nutritive
23) Thickener	Increases the viscosity of a food.	Thickening agent, texturizer, bodying agent.

7.5.1 Antioxidants

'You must have at some point of time tasted a stale deep fried snack prepared at home or bought from a local sweet shop. Do you remember its foul flavour and how you probably had to spit it out? What do you think may have been responsible fo the foul flavour?

The culprit are the unsaturated organic molecules in foods mostly fäts, pigments, vitamins and other nutrients, which are highly unstable towards atmospheric oxidation. These undergo a variety of chemical and physical changes and form obnoxious taints and odours in stored foods. Also the products based on meat, fish, milk and egg which are rich in fats, especially the polyunsaturated fatty acids, are more prone to spoilage and need protection. Auto-oxidation in stored foods not only spoils the flavour but also depletes them of essential fatty acids and vitamins. Secondly, products of oxidation react with the proteins of the food

leading to the loss of essential amino acids, digestibility, flavour, aroma, texture and basically a lowered nutritional value of the food.

What then are antioxidants? What is their role as an additive?

Antioxidant means substance which when added to food retards or prevents oxidative deterioration of food. According to the PFA Rules, this does not include substances like sugar, cereal, oils, flours, herbs and spices. Under Rule 59, no antioxidant other than lecithin, ascorbic acid and tocopherol shall be added to any food. However the following antioxidants, not exceeding in concentration mentioned' against each, may be added to edible oils and fats except ghee and butter, namely:

1)	Ethyl gallate		
2)	Propyl gallate		
3)	Octyl gallate	or mixture thereof	0.01 per cent
4)	Dodecyl gallate		
5)	Ascorbyl palmitate		0.02 per cent
6)	Butylated hydroxyanisole (BHA)		0.02 per cent
7)	Citric acid		
8)	Tartaric acid		
9)	Gallic acid		0.01 per cent
10)	Resin Guiace		0.05 per cent
11)	Tertiary butyl hydro quinone (TBHQ)		0.02 per cent

Dry mikes of rasgollas and vadas may contain butylated hydroxyanisole (BHA) not exceeding 0.02 per cent calculated on the basis of fat content. Flavouring agents also may contain the permitted antioxidants in concentration not exceeding 0.01 per cent. Ghee and butter may contain BHA in a concentration not exceeding 0.02 per cent. Fat spiead may contain BHA or Tertiary-butyl hydroquinone (TBHQ) in a concentration not exceeding 0.02 per cent by weight on fat basis. Ready to-eat dry breakfast cereals may contain BHA not exceeding 0.005 per cent (50 ppm). In ready-to drink infant milk substitute, lecithin and ascrobyl palmitate may be used up to a maximum limit of 0.5 g / 100 ml and 1 mg /100 ml respectively. Wherever BH is used in conjunction with the antioxidants mentioned as items Nos. 1 to 4 above, the quantity of the mixture shall not exceed the limit of 0.02 per cent.

7.5.2 Preservatives

Preservatives are substances which when added to food, retard, inhibit or arrest the activity i of microorganisms such as fermentation, acidification and decomposition of foods. In India, the preservatives have been grouped into two classes — Class I and Class II preservatives.

Included under Class I preservatives are items of common use such as:

a) Common salt

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b) Sugar
c) Dextrose
d) Glucose Syrup
e) Spices
f) Vinegar or acetic acid
g) Honey
h) Edible vegetable oils

Most of these preservatives you will find in food items like pickles, relishes, chutneys and pastes which we make at home. There is no restriction as such on the addition of these preservatives in any food item unless otherwise specified under the PFA Rules.

Under Class II preservatives are included:

a) Benzoic acid including salts thereof
b) Sulphurous acid including salts thereof
c) Nitrates or nitrites of sodium or potassium
d) Sorbic acid including its sodium, potassium and calcium salts
e) Propionic acid including its calcium or sodium salts and its esters
f) Lactic acid including its sodium, potassium or calcium salts
g) Acid calcium phosphate
h) Nisin
i) Sodium diacetate, and
j) Methyl or propyl parahydroxy-benzoate

The use of Class II preservatives is restricted to only certain foods and the amount of the preservative which can be added to these foods is also specified under th PFA Rules. Also the presence of a Class II preservative in any food has to be declared on the packaging of the food as illustrated in Figure 7.5. Use of more than one Class II preservative in a food is prohibited unless specified under the Rules. For instance, sulphur dioxide or benzoic acid can be added in the proportion of 40 parts per million or 200 parts per million respectively in some foods like jams, marmalades and preserves. If both preservatives are used in combination and the proportion of sulphur dioxide is 20 parts per million, the proportion of benzoic acid shall not exceed 100 parts per million.

Figure 7.2: Typical label of a biscuit packet

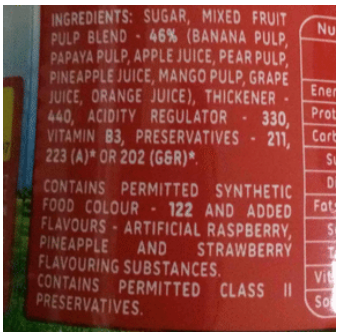

Figure 7.3: Label showing use of class II preservatives

i) **Sulphur dioxide, bisulphites and sulphites**: Sulphites, as a source of sulphur dioxide, has been extensively used as preservatives in foods for quite sometime now. They are effective, versatile and economical additives Which are used as antimicrobials in the preservation of a number of food items viz. jam, jelly, marmalade, fruit, fruit pulp and juices, syrups and sherbets, alcoholic beverages, confectionery, dry fruits and meat products. They are also used as bleaching agents in the refining of sugar as antimicrobial agents, to control enzymatic an non-enzymatic browning reactions in dehydrated fruits and vegetables and to provide protection against oxidative reactions .

ii) **Nitrates and nitrites**: These are added as preservatives to particularly meat products like ham, bacon and pickled meat. They are especially effective against bacteria like Clostridium botulinum and Staphylococcus aureus which have a long history of causing lethal food poisoning. Its preservative action is mainly due to the formation of nitric acid and other oxides of nitrogen and their action increases with decreasing pH value. Nitrates are more effective when they are used in combination with common salt. The presence of nitrites imparts the characteristic pink colour to meat apart from protecting its flavour. It also delays the development of off-flavours during storage. Note, nitrates and nitrites are, however, not permitted to be added to any infant food.

iil) **Benzoic acid and salts**: These are mainly used to protect foods against yeasts and moulds. They are not very effective against bacteria and have to be used in combination with sulphur dioxide in foods prone to spoilage by bacteria. Benzoic acid is used in squashes, fruit syrups, cordials, juices, jams, mannalades, preserves, sweetened ready-to-serve beverages, pickles, chutneys, sauces, tomato puree and paste and fat spread. Its effectiveness increases with the lowering of pH and is most effective below of pH 4.5.

iv) **Sorbic acid and its salts**: These are effective against moulds, yeasts and many bacteria. It is more effective as a preservative than propionates and benzoates at higher pH values and, therefore, it is widely used for bakery and confectionery products like cakes, fillings for chocolates and various types of cheese, cheese spreads and fat spread, paneer and ready-to-eat preserved chapatis. These are also used in the preservation of fermented vegetable products and vegetable pickled in vinegar. Its presence inhibits lactic acid fermentation slightly but suppresses the growth of film-forming yeasts and moulds.

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7.5.3 Food Colours

You will agree that the colour of a food product plays a very important part in its acceptance by the consumer. Many of the food processing operations like drying, canning, roasting, frying etc. lead to loss of the attractive natural colour of foods. This makes the addition of synthetic colour to the processed food essential. You would, for example, surely reject a can of cherries which were brown in colour instead of a bright red or a can of peas which are a dirty greenish-yellow instead of bright green. Colour additives are also used in foods to correct natural variations in foo colour. A manufacturer would want, for instance, that every batch of his orange marmalade is the same shade of orange. A few other reasons of adding colours to foods include:

- to enhance colours that occur naturally but at levels weaker than those usually 'associated with a given food;
- to provide a colourful identity to foods that would otherwise be virtually colourless;
- to protect nutrients such as vitamins and flavours that may be affected by safevsunlight;
- to provide an appealing variety of foods to consumers;
- to compensate for natural or seasonal variations in food, raw material or theeffects of processing and storage to meet consumer expectations.

The addition of colouring matter is, however, restricted to only specified items of food. Any extraneous addition of colouring matter has to be written on the label attached to any package of food.

So next time you purchase a packet of cream biscuits, candy or a tetrapack of fruit juice, check the label for any of the following declarations in capital letters:

CONTAINS PERMITTED NATURAL COLOUR(S)

or

CONTAINS PERMITTED SYNTHETIC FOOD COLOUR(S)

or

CONTAINS PERMITTED NATURAL AND SYNTHETIC FOOD COLOUR(S)

The colouring matter in foods can be broadly classified into two groups — natural and synthetic colovrs. Natural food colours have been in use from prehistoric times. Among the natural colouring matters which may be used, caramel may be used without label declaration. The other natural colouring matter which are permitted are listed herewith. Addition of these has to be declared on the label. These colours may be isolated from natural sources or may be synthesized. These may be used in any article of food, and are listed as:

a) i) Beta-carotene

ii) Beta-apo-8' carotenal

iii) Methylester of Beta-apo-8' carotenoic acid

iv) Ethylester of Beta-apo-8'carotenoic acid

v) Canthaxanthin

b) Chlorophyll

c) Riboflavin (Lactoflavin)

d) Caramel

e) Annatto

f) Saffron, and

g) Curcumin or turmeric

Inorganic colouring matter and pigments are not allowed to be added to any food except titanium dioxide (food grade) is permitted to be added to chewing gum up to a maximum limit of 1 per cent. No synthetic food colours or a mixture, thereof, except the onesare permitted for use in food.

Colour	Common name	Colour index (1956)	Chemical class
(1)	(2)	(3)	(4)
1. Red	Ponceau 4R	16255	Azo
	Carmoisine	14720	Azo
	Erythrosine	45430	Xanthene
2. Yellow	Tartrazine	19140	Pyrazolone
	Sunset yellow FCF	15985	Azo
3. Blue	Indigo Carmine	73015	Indigoid
	Brilliant blue FCF	42090	Triarylmethane
4. Green	Fast green FCF	42053	Triarylmethane

Table 7.2: Synthetic food colours permitted for use in India

These synthetic food colours are permitted for use only in certain foods, whichFood Additives include:

a) Ice cream, milk lollies, frozen dessert, flavoured milk, yoghurt, ice-cream mix powder

b) Biscuits including biscuit wafer, pastries, cakes, confectionery, thread candies, sweets, savouries (dal moth, mongia, phulgulab, sago papad, dal biji only)

c) Peas, strawberries and cherries in hermatically sealed containers, preserved or processed papaya, canned tomato juice, fruit syrup, fruit squash, fruit cordial, jellies, jam, marmalade, candied, crystallized or glazed fruits

d) Non- alcoholic carbonated and non-carbonated ready-to-serve synthetic beverages including synthetic syrups, sherbets, fruit beer, fruit beverages, fruit drinks, synthetic soft drink concentrates

e) Custard powder

f) Jelly crystal and ice candy, and

g) Flavour emulsion and flavour paste for use in carbonated or non-carbonated beverages only under label declaration.

The maximum limit of any permitted synthetic food colours or mixture, thereof, which may be added to any food article enumerated in the PFA Rules shall not

exceed 100 parts per million of final food or beverage for consumption except in case of food articles mentioned in clause (c) where the maximum limit of permitted synthetic food colours shall not exceed 200 parts per million of the final food or beverage for consumption.

The misuse of non-permitted colours and usage of excess quantity of permitted colours have several health effects.

Colours	Adverse health effects
Metanil Yellow	Cancer, Stomach ache, testicular degeneration
Malachite Green	Tumours of lung, breast ovary and liver
Liver chromate	Anaemia, paralysis and abortion
Rhodamine B Sudan III Auramine	Pathological lesions in vital organs like kidney, spleen and liver.

Table 7.3 : Adverse health effects of non-permitted colours

So next time when you buy food which has food colour, check to be sure it is safe. Now we move on to the study of flavouring substances which impart, as well as, enhance the flavour of different food preparations.

7.5.4 Flavouring Agents

Flavouring agents include flavour substances, flavour extracts or flavour preparations, which are capable of imparting flavouring properties, namely taste and odour to food. Flavouring agents may be of three types natural flavours, nature identical flavouring substances and artificial flavouring substances.

Natural flavours .are those exclusively obtained by physical processes from vegetable, sometimes animal raw materials. Nature identical flavouring substances are the substances chemically isolated from aromatic raw materials or obtained synthetically. They are chemically identical to the substances present in natural products. On the other hand, artificial flavouring substances are those which have not been identified in natural products and are hence chemically synthesized.

The use of the followirig flavouring agents are prohibited in any article of food in India, namely:

a) Coumarin and dihydrocoumarin

b) Tonkabean (Dipteryl Odorat) and

c) B asarone and cinamyl anthracilate

d) Estragole

e) Ethyl Methyl Ketone

f) Ethyl-3-Phenylglycidate

g) Eugenyl methyl ether

k) Methyl a napthyl Ketone

'i) P.Propyl anisole

j) Saffrole and Isosaffrole

k) Thujone and Isothujone and ß thujone

Also, diethylene glycol and monoethyl ether may not be used as solvent ID flavours. Monosodium glutamate, popularly known as ajinomoto is used chiefly in Chinese cooking to enhance flavour. It is permitted to be added to foods in restricted amounts (so that the total glutamate content of the food is not more than one per cent). Its addition needs to be declared on the label of the food product along with a warnin that the food is unsuitable for children below twelve months of age. This is because the safety of this flavour has not been conclusively shown in infants. In fact, addition of any extraneous flavour to a food has to be declared on the label attached to any package of food in capital letters as - "CONTAINS ADDED FLAVOUR". Having learnt about flavouring agents,

7.5.5 Emulsifying and Stabilizing Agents

It is a well known fact that oil and water are immiscible liquids i.e. they can not be dissolved in one another. So how do you mix the two liquids in a food product in which both are essential ingredients? Well, with the use of emulsifying and stabilizing agents. What are these substances? Let's find out.

Substances which are capable of facilitating a uniform dispersion of oils and fats in aqueous media or vice versa, and / or stabilizing such emulsions are known as emulsifying and stabilizing agents. Suéh substances are widely used in the commercial production of bread, confectionery, ice cream, chocolate and soft drinks. A long list of these substances is permitted to be added to food products in India. These substances include:

Agar, alginic acid, calcium and sodiurn alginates, carrageenan, edible gums (such as guar, karaya, arabic, carobean, furcellaran, tragacanth, gum ghatti), dextrin, sorbitol, pectin, sodium and calcium pectate, sodium citrate, sodium phosphates, sodium tartrate, calcium lactate, lecithin, alburn gelatin, quillaila, modified starches, hydrolysed proteins, monoglycerides or diglycerides of fatty acids, synthetic lecithin, propylene glycol stearate, propylene glycol alginate, methyl ethyl cellulose, methyl cellulose, sodium carboxy- methyl cellulose, stearyl tartaric acid, esters ofmonoglycerides and diglycerides of fatty acids, monostearin sodium sulphoacetate, sorbitan esters of fatty acids or in combination, poly-oxy-ethylene sorbitan monostearate sodium stearoyl-2-lactylate and calcium stearoyl-2-lactyiate, polyglycerol esters of fatty acids and polyglycerol ester of interesterified ricinoleic acid, glycerol esters of wood resins (Ester Gum).

No emulsifying or stabilizing agent can be used in any food except where the use emulsifying stabilizing agent is specifically permitted under the PFA Rules.

Polyglycerol esters of fatty acids and polyglycerol ester of interesterified ricinoleic acid may be used in bakery products and in chocolate to the extent of 0.2 per cent by weight. Diacetyl tartaric acid, esters of mono and diglycerides may be used in bread and cakes.

The following emulsiWing or stabilizing agents are not permitted for use in milk and cream, viz:monoglycerides or diglycerides of fatty acids, synthetic lecithin, propylene glycol stearate, propylene glycol alginate, methyl ethyl cellulose, methyl cellulöse, sodium carboxymethyl cellulose, stearyl tartaric acid, esters of monoglycerides and diglycerides of fatty acids, monostearin sodium sulphoacetate, sorbitan esters of fatty acids or in combination.

Modified starches are being used the world over by the food processing industry as thickeners, binders and stabilizers. nese starches contribute in making our sauces thick in consistency, potato chips crisp and giving that special smooth texture to the puddings. According to the PFA Rules, these starches are permitted in baked foods, confectionery, snacks, flavours, some dairy products, glazes, icings, gravies, sauces, soups and fruit beverages up to a maximum concentration of 0.5 per cent by weight.

Gums derived from plants and seaweeds have been in use for thousands of years. In India gums have traditionally been used in the preparation of ladoos, a sweet preparation. Gums, you may recall reading, are obtained from various sources. Gum arabica, karaya and ghatti are tree exudates, guar gum, cassia gum and konjac mannan are seed and root gums, pectin is obtained from the peel of fruits, sodium carboxymethyl cellulose are obtained from cellulose pulp, gellan gum and xanthan gums are microbial gums, whereas, agar, alginate are seaweed extracts. Gums are widely used in various food products owing to the different properties they possess. They are used as a thickening agent in jams, gravies and sauces, and as a gelling agent in pudding desserts, as an encapsulating agent in stabilizing flavours. Pectin, sodium alginate, calcium alginate, alginic acid and propylene glycol alginate are permitted as additives in fruit products.

7.5.6 Anti-caking Agents

We have all faced the problem of trying to take salt out of the salt shaker on the dining table. Moisture in the air tends to make the salt lumpy and then no matter how vigorously you shake, the salt simply refuses to flow out. How can we prevent this?

Yes, with the use of anti-caking substances. Anti-caking substances are anhydrous substances that can pick up moisture without themselves becoming wet and these are added to products such ‘as table salt and dry mixes (soup powder, garlic and onion powder; fruit powder) to a maximum level of 2 per cent. You must have seen advertisements of free flowing salt where the manufacturers claim that their salt does not form lumps. Such salt has anti-caking agents added to it in order to have this “free flowing” property. The anti-caking agents permitted for use in India include:

a) carbonates of calcium and magnesium
b) phosphates of calcium and magnesium
c) silicates of calcium, magnesium, aluminium or sodium or silicon dioxide
d) myristates, palmitates or stearates of aluminium, ammonium, and
e) calcium, potassium or sodium.

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In addition, calcium, potassium or sodium ferrocyanide may also be used as anti-caking agents in common salt, iodized salt and iron fortified salt in quantity not exceeding 10 mg/kg singlyor in combination expressed as ferrocyanide.

7.5.7 Sequestrants

Sequestrants ate substances that complex with transition metal ions like copper, iron, cobalt and nickel. These metals are powerful catalysts in the auto-oxidation processes and their binding helps in eliminating/ retarding the oxidative breakdown of foods which would otherwise result in decolourisation, rancidity and production of an off taste in the food product: Addition of sequestering agents is permitted in a specified list of foods only. Some examples of commonly used sequestering agents are citric acid, phosphoric acid, tartaric acid, ethylene diamine tetra acetate (EDTA) etc.

7.5.8 Buffering Agents (Acids, Bases and Salts)

Buffering agents are materials used to counter acidic and alkaline changes during storage or processing of the food, thus improving the flavour and increasing the stability of foods. These agents are also permitted to be added in limited quantities to only specific foods in India. Some examples of buffering agents include — acetic acid used in beverages and soft drinks, calcium oxide in specified dairy products, ammonium phosphate monobasic added as a bread improver in flour, ammonium carbonate as a leavening agent for baked foods and confectioneries, citric acid, malic acid, DL lactic acid and L (+) tartaric acid as acidulants in miscellaneous foods.

Anti-foaming agents are the next type of food additives about which we shall study. As the name suggests, these are the agents which retard foam formation. Let us get to know about them.

7.5.9 Anti-foaming Agents

While deep fat frying you must have noticed that some oils, especially, unrefined oils like mustard oil tend to produce a lot of foam. The anti-foaming agents are added to retard deteriorative changes and foaming height during heating of edible oils and fats. In India, dimethyl polysiloxane may be used as anti-foaming agent in edible oils and fats for deep fat frying upto a maximum limit of 10 ppm.

The last category in food additives is sweetening agents. We all are aware of what these are. Let us get to know little more about them.

7.5.10 Sweetening Agents

Sweeteners are such a common ingredient of different dishes and food items that you may find it surprising to see them listed as a food additive. There are three types of sweeteners based on the calorific value (the number of calories obtained per gram of the sweetener). They can be classified as caloric sweeteners, low calorie sweeteners and non-caloric sweeteners (which contain little or no calories). Let us have a look at each of these.

NOTES

Caloric sweeteners

These sweeteners are substances which provide not only sweet taste but also contribute 4 calories per gram of substance. Commori natural sweeteners that are used in foods are cane sugar, glucose syrup, jaggery, honey, khandsari sugar, dextrose, invert sugar or golden syrup and icing sugar. From the nutritional point of view, the increasing incidence of diabetes and obesity among population groups should caution us against excessive use of caloric sweeteners. These sweeteners have also been associated with dental problems like caries and gum disorders.

Low-caloric sweeteners

These substances are relatively less sweet than sucrose (sugar) and provide energy between 1 and 3 calories per gram. Examples of these sweeteners include sugar alcohols, also known as polyols (xylitol, sorbitol, mannitol, etc.) These are known to occur naturally in a number of fruits and vegetableæ but are more often manufactured for use on a commercial scale. Use of polyols not only aids diet control by reducing the calorie intake, but also these do not cause dental caries. In food processing, they impart special properties to products, improving their texture and stability.

Non-caloric sweeteners

These may be natural in origin or synthetic (artificially prepared). Natural non-caloric sweeteners include a variety of proteins which are found in some tropical plants and fruits miraculin, monellin and thaumatin. These sweeteners have yet to be thoioughly evaluated for their safety. Besides, it has to be economically viable to produce these commeqcially. Synthetic high intensity sweeteners are more popular. Some are also permitted for use in India. They are called intense because they are required in very small quantities. You must have seen diabetics or those on a weight reducing diet consuming these artificial/intense sweeteners as they provide sweetness to the foo to which they are added but do not give any calories. These sweeteners also do not cause dental caries. Saccharin, aspartame and acesulfame potassium are the commonly used artificial/intense sweeteners in India. They are also sold as table-top sweeteners for you to add to tea, coffee, milk etc. instead of sugar. In addition, the use of these artificial sweeteners is permitted in a limited number of foods.

Both aspartame and acesulfame K are about 200 times sweeter than sucrose, while saccharin is 300 times sweeter. Acesulfame K {s heat resistant and, therefore, suitable for cooking. Saccharin is one of the oldest sweeteners in use today. It was at one time implicated as a cancer-causing chemical, however, scientific studies have now shown it to be safe.

Addition of artificial sweeteners to foods has to be declared on the label. Every package of aspartame (methyl ester), acesulfame-x and saccharin sodium marketed as table-top sweetener and every package of carbonated water synthetic soft drink concentrate containing either of these artificial sweeteners and every advertisement for such table top sweetener or such carbonated water synthetic soft

drink concentrate shall carry the following label:

- Contains ..... (name of artificial sweetener)
- Not recommended for children

Packages of aspartame (methyl ester) marketed as table-top sweeteners and every package of food containing aspartame, and the advertisement for such table-top sweetener and food shall also carry the following label:

- Not for Phenyl ketonurics

You may be wondering, why the label should caution not for phenylketonurics. This is because aspartame upon digestion breaks down into its constituent amino acids — aspartic acid and phenylalanine.

Phenylketonuria is a hereditary defect which affects the way in which the body breaks down phenylalanine, which in turn leads to concentration of toxic metabolites in the nervous system causing brain damage. Hence, it is dangerous for people suffering from this disease to consume this sweetener.

Figure 7.4 : Label showing swetner in a product

Sucralose is a relatively new synthetic intense sweetener. It is derived from ordinary sugar by selective treatment resulting in a product which is 600 times sweeter than sugar. Sucralose does not break down in the body and it is poorly absorbed in humans. Saccharine, on the other hand, is absorbed by the body and then excreted unchanged by the kidneys. Sucralose is yet to be approved under PFA Act for use in India.

7.5.11 Other Additives

Enzymes play important roles in various aspects of food processing. They are mainly used in the industry to split carbohydrates, proteins and lipids. A large number of food processing industries make use of enzymes namely for cheese production, making of bread, crackers, chocolates, soya sauce, tenderizing meat etc.

Leavening agents are what make fluffy pastries, spongy cakes and breads and crispbiscuits possible. The term leavening refers to introduction of a gas (generally

carbon dioxide) in the batter or dough leading to its expansion. A variety of chemical leavening agents are in use today to improve the appearance, texture and taste of foods. Yeast was traditionally used as a leavening agent. The principle disadvantage in its use is that the fermentation process is slightly diffcult to control and at times can lead to undesirable flavours. Chemical leavening agents like baking soda (sodium bicarbonate) do not have this problem. The vast majority of chemical leavening systems are based on the reaction of an acid with sodium bicarbonate t release the carbon dioxide. There are a number of acids which might be used and they differ in the speed at which they release the leavening gas. Examples include cream of tartar (rapid release), sodium aluminium phosphate or sulphate (slow release) and anhydrous monocalcium phosphate (for an intermediate speed of release).

STUDENTS ACTIVITY - 2

1) Give examples of the following:
   a) any two antioxidants that can be added to edible oil in India.
   b) two classes of preservatives which can be added to prevent spoilage of foods.
2) Which food additive can be added to salt to make it "free flowing"?

7.6 SAFETY ISSUES

Did you know that some of the foods that we (especially children) eat almost daily like biscuits, bread, sugar confectionery, chewing gum, carbonated beverages and fruit squashes and syrups have a large number of food additives? Biscuits may have up to 12 additives and bread up to 9. How safe is it to consume so many additives on a daily basis?

A large number of substances in use today as food additives are "generally recognized as safe" or GRAS substances. GRAS substances are those substances whose use is generally recognized by experts as safe, based on their extensive history of use in food or based on published scientific evidence. Salt, sugar, spices and vitamins are classified as GRAS substances, along with several hundred other substances. In deciding whether an additive should be approved for use, the regulatory authority considers the composition and properties of the substance, the amount likely to be consumed, its probable long-term effects and various safety factors. Absolute safety of any substance can never be proven. Therefore, it must be determined if the additive is safe under the proposed conditions of use, based on the best scientific knowledge available. If an additive is approved, regulations determine the types of foods in which it can be used, the maximum amounts to be used and how-it should be identified on food labels.

Although most food additives are considered to be without any potential adverse effects, there have been problems concerning the safety of some of these chemicals.

The safety of the antioxidant BHA, for instance, has been questioned in light of the fact that its consumption leads to cancer in rodents (rats, mice). The preservatives such as benzoic acid and sulphites have been associated with allergies. A small segment of the population Has been found to develop hives, nausea, diarrhoea, shortness of breath or even fatal shock after consuming sulphites. This is true especially for the sensitive asthmatics, who may develop an allergic response at high levels of intake. Nitrites, on the other hand, can form cancer-causing nitrosamines in the foods in which they are added as preservatives. Monosodium glutamate (MSG) intake of 1.5 g or more can result in acute illness characterized by burning or tingling sensation on the face, neck and head, tightness, stiffness or pressure in the chest and facial muscles. This is known as the "Chinese Restaurant Syndrome " because these symptoms have been seen in people who had consumed Chinese food. In the 1970's, a theory linking additives to childhood hyperactivity was popularised. Well-controlled studies conducted since have however produced no evidence that food additives can cause hyperactivity or learning disabilities in children.

As we have seen earlier, the permitted colours are also not totally safe. High levels of erythrosine intake have been associated with thyroid tumours. Ponceau 4R, tartrazine and sunset yellow FCF have provoked allergic reactions in several individuals even at low .levels of intake. The allergic responses vary from rashes to swelling and worsening of the condition of patients with asthma. The incidence of tartrazine sensitivity appears to be higher in asthmatics. Persons who are sensitive to aspirin may also be sensitive to tartrazine and hence should avoid foods and even medicines having this yellow dye. Among the permitted food colours, tartrazine is the most frequently reported to be associated with irritability, restlessness and sleep disturbance in some young children. Allergic reactions have also been seen in some people who consumed foods to which natural colours like annatto and carmine had been added. So, the general rule that all that is natural is safe, does not work.

The rule, therefore, is that one should choose foods that are free of additives or at least select those brands of processed foods which have a minimum number of additives. Foodé with artifiéial or synthetic colours and class II preservatives should specially be avoided. We have learnt above that, the label of the food product declares the presence of the additives used in the product. Hence only properly labelled foods should be selected. All additives should be subject to an ongoing safety review as scientific understanding and methods of testing continue to improve. In fact, a monitoring system should be set up which investigates all complaints by individuals or their physicians that are believed to be related to specific foods, food additives or vitamin and mineral supplements.

The safety of food additives is evaluated at an international level through the Joint Expert Committee, from the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), on Food Additives (JECFA). Assessments are based on reviews of all available toxicological data in both humans and animal models. From the avgil+ble data, the maximum level of additive that has no demonstrable toxic effect is determined. This is called the "no-observed-adverse-effect level" (NOAEL) and is used to determine the "Acceptable Daily Intake" (ADI) for each food additive. The ADI provides a large safety margin and is the amount

ofå food additive that can be consumed daily over a lifetime without any adverse effect on health. We will learn more about the ADI later in Unit 12.

The Codex Alimentarius Commission, a joint FAO/WHO activity which develops guidelines for food safety globally, is also drawing up new "General Standards for Food Additives" (GSFA), with the ai of establishing a harmonized, workable and indisputable international standard for world trade. Only those additives that have been evaluated by the JECFA are included.

In the Indian context, a list of food products and additives which are under mandatory certification of Bureau of Indian Standards (BIS) through PFA Act, 1954 has been provided. This list is provided in Annexure 1, Table IV at the end of the course. Thanks to strict regulation and thorough testing, food additives can be considered safe components in our diet that are contributing to the rapid evolution of the food supply in Europe and throughout the world.

STUDENTS ACTIVITY - 3

1) Which food additive is implicated in causing the classical symptoms of the "Chinese Restaurant Syndrome"? How will you know whether this food additive is present in a food item?
2) Discuss the importance of reading the label of a processed food item before consuming it.

7.7 LET US SUM UP

This unit focused on food additives and their utility in foods. The use of various food additives has increased with the growth in the food processing industry. Additives have been used for many years to preserve, flavour, blend, thicken and colour foods.

We leamt that additives help assure the availability of wholesome, appetizing and affordable foods that meet consumer demands from season to season. However, it is important to make sure that each substance is safe at its intended levels of use before it may be added to foods.

We learnt that food additives are classified based on their ftlnction in food, i.e. the purpose for which the additive has been incorporated in the food. The various classes of food additives can thus be listed as — antioxidants, preservatives, food colours, foo flavours, emulsifiers and stabilizers, anti caking agents, sequestrants, acid, bases and buffers, anti-foaming agents, sweeteners, enzymes and leavening agents. Further, the functional role of each of these additives has been discussed in this unit. In India the Prevention of Adulteration (PFA) Act and Rules governs the food additive that can be used, the foods to which it can be added and the quantity in which it can be added.

Finally the unit highlighted the safety issues linked with additivies. Although most additives are generally regarded as safe for consumption, some of them may

cause problems especially in sensitive individuals. Hence, in general, consumers should to-' to choose food products with a minimum number of additives. This cap be achieved by reading the label of a processed food item before consuming it.

7.8 GLOSSARY

- Aqueous : containing water
- Anhydrous : without water or moisture, dry.
- Anti-foaming agents : added to retard deteriorative changes and foaming height during heating of edible oils and fats.
- Antioxidants : substances which when added to foods retard or inhibit oxidation reactions.
- Buffering agents : materials used to counter acidic andalkaline changes during storage or processing of the food, thus improving the flavour and increasing the stability of foods.
- Dispersion : to distribute uniformly in a medium.
- Leavening Agent : substance added to dough to make it ferment and rise.
- Preservatives : substances which when added to food retard, inhibit or arrest the activity of microorganisms.
- Rancidity : having a disagreeable smell or taste from partialFood Additives decomposition, especially of a fatty substance.
- Sensory quality : that which appeals to the senses, viz. taste, sight, smell, texture.

7.9 CHECK YOUR PROGRESS

1) Define food additives.
2) List five reasons why additives are added to foods.
3) Distinguish between direct and indirect food additives.
4) Why are artificial sweeteners also referred to as intense sweeteners?
5) What do you understand by the term 'functional role' of additives? Give any five functional roles of food additive.

UNIT

8

FOOD ADULTERATION

NOTES

STRUCTURE

8.1 LEARNING OBJECTIVE

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

- list foods commonly adulterated,
- identify some common adulterants added to different types of foods,
- classify the adulterants,
- discuss the reasons for adulteration,
- explain the harmful effects of these adulterants, and
- describe some simple tests for the detection of some common adulterants.

8.2 INTRODUCTION

In the previous units, we have studied about food additives that have been .in use in different food items. We learnt that food additives are substances which are added to food by the manufacturers to facilitate processing or to improve appearance, texture, flavour and keeping quality.

Besides, food is subjected to addition of undesirable substances naturally, accidentally or deliberately or removal of certain constituents which is called adulteration. What are the substances which can be termed as an adulterant? Do they have any potential harmful health effects? And if yes, are there any measures by which we can detect these and prevent the onset of a disease? This unit will

focus on these aspects.

Further, the unit will describe in detail the foods commonly adulterated, the different classes of adulterants and reasons why adulterants are added to particular foods. Simple tests for the detection of these adulterants have also been outlined. The harmful effects of various adulterants on health have been discussed to understand the implications of consuming adulterated foods.

8.3 FOOD ADULTERATION

Let us first discuss what we mean by the term — 'adulteration'.

Under the PFA Act, the definition of food adulteration takes into account not only the intentional addition or substitution or abstraction of substances which adversely affects the nature, substance and quality of foods, but also their incidental contamination during the period of growth, harvesting, storage, processing, transportation and distribution.

To put it in simple terms, let us take an example of milk. Under the PFA Act, a trader is guilty if he sells milk to which water has been added (intentional addition) or the cream of the milk has been replaced by cheap vegetable or animal fat (substitution) or simply the cream has been removed and the milk is sold as such, with a low fat content (abstraction). Unintentional contamination of the milk, due to carelessness on part of the trader is also considered as adulteration under the law. For instance, if the cans in which the trader is transporting or storing the milk, had been earlier treated with the chemicals like washing soda or boric acid or some detergent and not been washed thoroughly with water, residues of the chemicals may get mixed with the milk. Such milk would be considered adulterated. In addition, food is also considered to be adulterated, if it does not conform to the basic quality standards. For instance, the maximum amount of moisture allowed in a milk powder sample is 4%. If a sample is found to have greater moisture levels, it is considered to be adulterated.

The malpractice of food adulteration is still widely prevalent in our country. There are very few studies on the extent and nature of food adulteration in the country. Whateverstudies are available, are restricted to a select few cities and hence are not adequate to give a true picture for the country as a whole. The only data that are available are the reports from the food testing laboratories of the Central and State Government. According to these official reports, the extent of food adulteration in India has been gradually diminishing from 31% in 1960s to less than 10% in the 1990s.

Food is a basic need for all. A food should not only be available in sufficient quantity, you would agree, it should also be nutritious, safe and wholesome. Pure food is essential for the maintenance of health. Food adulteration, therefore, not just lowers the quality of the food but also poses a serious health hazard. Consumption of poor quality or unwholesome food by the citizens ofa nation can lead to ill-health and thus poor work efficiency. Providing good quality food is thus of considerable importance for public health and the national economy. Several laws have been

enacted an implemented by the Central and State Governments to help maintain food quality at various stages from production through storage, processing, internal and external trade and consumption. The Prevention of Food Adulteration (PFA) Act, 1954 and the Prevention of Food Adulteration Rules, 1955 are the main statutes which protect the consumer and aim to provide him safe food. We will be learning more about these laws and regulations later in Unit 14 of this Course. Now, let us dwell on why is the food adulterated, i.e. the reasons for adulteration. Particularly in the light of the ill-consequences of food adulteration, why do individuals practice food adulteration.

Reasons for adulteration

The practice of adulterating food is as old as the art of buying and selling food for cash or commodities. The question that might arise in your mind is, why do people practise adulteration of food when they know that it adversely affects the health of felloW human beings? The answer is straight forward — 'the possibility of making greater profits', which has always been the lure for people indulging in the adulteration of food. Increasing the bulk or quantity of a food item by adding cheaper substitutes is the most common way of increasing profit margins. Adding water to milk or stones to food grains is perhaps the oldest form of adulteration. Similarly, to save money, a sweetmeat maker may place aluminium foil instead of silver foil on the sweets he makes. Apart from this, the other reasons include masking food spoilage and ignoranc of the people handling food. Let us study about these.

Traders of perishable food commodities sometimes try to mask food spoilage by using various adulterants. For instance, the insect infested dry ginger may be coated with ultramarine blue to cover the holes. Poor quality fruits, vegetables and pulses are sometimes artificially coloured to give them the fresh look. Adulterants like artificial colours are also added to foods to improve their consumer appeal. Thus several prepared food items being sold in restaurants and eateries such as rice and meat preparations, sweets etc. have added colour because the consumer prefers it.

Preservation of food for supply to distant places and to avoid its wastage during the glut season has resulted in the use of food additives and chemicals. Ignorance about their proper use is probably a major factor responsible for people adding non-permitted additives to foods or adding excess of an additive. For instance, by law, you cannot add any chemical to preserve milk. However, milk vendors very commonly add chemicals like sodium bicarbonate to neutralise developed acidity in the milk and increase the shelf life. Others might add more than the permissible level of a preservative to a food item, like a juice, to make it last longer.

However, it cannot be denied that many cases of adulteration occur simply due to the negligence and lack of awareness on the part of manufacturers, distributors or retailers. As such, the grain lying exposed to rodents and insects in warehouses can get adulterated by faecal matter and insect larvae merely due to negligence ratherthan any profiteering motive. Similarly, if the ambient moisture level is not controlled, the fi)0d grains. may abSorb excess moisture, making them susceptible to mould growth.

How can then, we, as a consumer work towards this age-old problem?

Well, one of the most effective ways could be by raising the standard of public morals and spreading awareness among manufacturers, traders and consumers. This would essentially root out the menace Of adulteration. It is also necessary that those who infringe the food laws must be hunted out, prosecuted and suitably punished. This will serve as a deterrent to others who may be tempted to make a fast buck at the cost of human life.

8.4 FOODS COMMONLY ADULTERATED

Which foods are commonly implicated in the malpractice of adulteration? What leads to adulteration of a particular food? Which adulterant is used and why? We will learn about these aspects in this section.

If we analyze the data on adulteration collected during surveys across the country, we will notice that almost all kinds of foodstuffs have been found to be adulterated. No food is spared. However, the nature of food adulteration may vary from State to State or region to region. In one region, one type of food commodity may be more prone to adulteration, simply because sales of the commodity are high in that region. A type of adulterant may be more common in a particular area because it is cheap and readily available. Taking the example of edible oil, if for instance, groundnut oil is the most widely consumed oil in a State and then it would be obvious that the adulteration of this oil would be most common. And if cottonseed oil is the cheapest and most readily available oil in that area, then it would be used to adulterate the more expensive groundnut oil. Listed herewith are some of the foods that have been commonly found to be adulterated. You will find that these are the ones which we consume on a daily basis.

These foods include:

- Food grains like wheat, rice, pulses and their products like wheat flour, semolina (suji), gram flour (besan) etc.
- Edible oils and fats like groundnut oil, safflower oil, sunflower oil, mustard oil, yanaspati etc.
- Spices, both whole and ground, like red chilli powder, turmeric and coriander powder, asafoetida (hing), saffron etc.
- Milk and milk products like milk powder, butter, ghee, khoa, sweets Coffee, tea
- Sweetening.agents like sugar, honey, gur
- Non-alcoholic beverages like aerated drinks, squashes, juices, sherbets, and
- Miscellaneous items like confectionery, jams, sauces, ice creams and prepare food items like sweets (laddoo, burfi, jalebi), curries, rice preparations like biryani, tandoori meat dishes.

It is important to understand that adulteration of a food can take place at any of the stages in the supply chain of the foodstuff as highlighted in Figure 8.1. The food chain could be as follows: Primary production primary food processing secondary food processing food distribution food retailing food catering. Agricultural inputs

during primary food production such as pesticides and veterinary drug residues, whose residue could be found in foods, are also considered as adulterants. Both during primary and secondary food processing, adulterants may enter the food chain. Besides, adulterants may also find their way during food distribution, food retailing and food catering.

NOTES

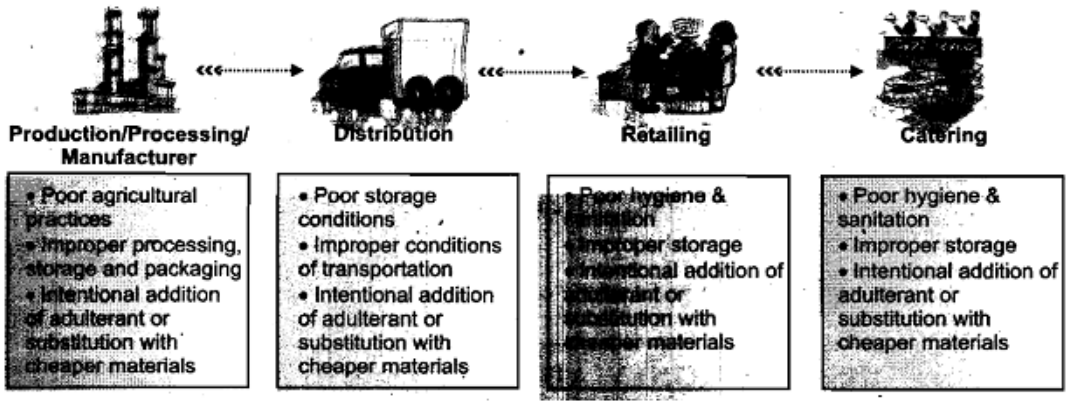

Figure 8.1 : Typical supply chain for a food commodity

The manufacturer may intentionally adulterate the food to increase his profit margin or he may contaminate the food due to faulty processing technology. Either way, the adulterant enters the supply chain at the source. In most of the cases, however, the distributor (the link between the producer and the seller of the food) or the retailer introduces the adulterant into the food. Inappropriate storage and transportation conditions may also contaminate the food at this stage.

In fact, any commodity that commands a premium in the market, and is either expensive or has a high volume sales, is a target for adulteration. Surveys on the current trends in food adulteration reveal that adulteration of milk and milk products, edible oils and fats and spices is most common. This is because the total sales value of these foods is high.

You would have observed that the foods which are in a powder, minced or paste form are more susceptible to adulteration. This is because it is more difficult for the naked eye to detect adulteration in these foodstuffs. For instance, when buying minced mutton, it is difficult to tell whether the goat meat has been mixed with meat from other animals or that green coloured sawdust has been added to coriander powder.

Adulteration of foods sold loose- by the retailer is also more common as compared to the packaged foods. This is simply because in the latter case, the adulterated food can be traced back to the manufacturer or distributor. It can be bad for business if the brand name gets a negative publicity with accusations of adulteration. A trader selling foodstuffs viz. oil, wheat flour, sugar, spices, tea etc. in loose forrn can easily adulterate them and, if caught, shift the blame on the manufacturer or distributor. It becomes difficult to fix the responsibility in such a case and the culprit Often escapes punishment. So, what can be done to overcome this situation? Well, it could

be that the manufacturers willing to curb this malpractice should discourage their products from being sold loose to the extent practicable. The package also needs to have a suitable message indicating that the product is not to be sold loose.

Even if the product is not sold loose, it may be a target for adulteration if the package is easy to tamper with. Manufacturers can curb this by implementing more effective tamper-proof or tamper-evident packaging. This would make it quite uneconomical for the wrong-doers to attempt adulteration by tampering with the packaging. By now, you must have understood the social, as well as, economic aspects associated with the adulteration process.

8.5 COMMON ADULTERANTS

The adulteration of food has progressed from being a simple means of fraud to a highly sophisticated and lucrative business. Although simple forms of adulteration like addition of water to milk and coloured starch to turmeric or red chilli powder are still prevalent, newer forms and types of adulteration are emerging. Pesticide residues in vegetables, fruits, food grains, bottled water and antibiotic residues in milk and meat are now more in evidence. Use of newer adulterants like ultramarine blue in dry ginger to hide holes and other damage done by insects, urea in puffed rice to improve its texture and aluminium foil in betelnut or supari instead of silver foil has been observed.

What do we mean by the word adulterant?

Any substance which is used to adulterate a particular item of food is called an adulterant. It is any substance that lessens the purity of effectiveness of a substance.

Food items	Adulterants detected
Milk	Antibiotic residues, formalin, boric acid, pesticide residues, neutralizers like sodium bicarbonate, urea, water, sugar, starch, foreign fat, ammonium sulphate, cellulose.
Milk powder	Pesticide residues, sugar, starch, fat deficiency, excessive moisture.
Ghee and vanaspati	Extraneous colours, animal body fat, hydrogenated vegetable oils, excessive moisture.
Edible oils	Castor oil, mineral oil, argemone oil, triorthocresyl phosphate, oil – soluble colours, aflatoxin, pesticide residues, cheaper vegetable oils.
Spices	Non-permitted colours, mineral oil coating, husk, starch, foreign seeds/resins, extraneous matter, exhausted spices.
Non alcoholic beverages	Saccharin, dulcin, brominated vegetable oils, non-permitted colours, excess permitted colour.
Confectionery, sweets and savouries	Non-permitted colours, aluminium foil, permitted colour more than prescribed limit.
Coffee	Date or tamarind seeds, artificial colour.
Tea	Colour, iron filings, foreign leaves, exhausted leaves.
Pulses and their products like *besan*	*Lathyrus sativus, Vicia sativa*, artificial colours, talc, foreign starch, extraneous matter.
Cereals and their products like *maida, suji*, flour	Fungal infestation, pesticide residues, sand, dirt, foreign starch, powdered chalk, iron filings, aflatoxins, insect damage.

Table 8.1 : different types of adulterants that are being added to our food

Let us now discuss about the adulterants found in each of these commonly consumed food items separately. We shall start with milk.

NOTES

Milk

In milk, the most widely used adulterant is water. Not only do the milk vendors add water to the milk sold loose but there also exists a racket of removing a portion of the milk from plastic pouches of well known companies and diluting the remaining milk with water. Such addition ofwater is very easily detected by measuring the specific gravity or relative density of the milk. Sometimes, to avoid detection, the vendors increase the specific gravity of diluted milk by adding sugar, starch or urea. Addition of preservatives like formalin, boric acid, hydrogen peroxide and neutralizers like sodium bicarbonate and caustic soda is also prevalent to increase the shelf life of the milk. This is especially done in summer months when milk spoils easily and by vendors who have to transport the milk over long distances. Contaminants usually found in milk are the pesticide residues (from pesticides sprayed in cattle sheds), antibiotic residues (from medications given to the cattle) and aflatoxin (from aflatoxin contaminated feed given to the cattle).

Edible Fats and Oils

The most common adulterant in edible oils is-a cheaper oil, which rnay or may not be edible. The cheaper oils generally used to adulterate expensive cooking oils are castor oil, \ mineral oil, argemone oil, palmolein, cottonseed oil and rapeseed Oil. Ghee is usually found to be adulterated with vanaspati or hydrogenated oils. Lard, a cheaply available animal body fat, may also be added. Contaminants which have been detected in oils are the pesticide residues (from the pesticides which had been sprayed on the oil seed crops before harvesting) and aflatoxin especially in unrefined groundnut oil (from use of poor quality, fungus infested groundnuts). The process of refining the oil destroys the aflatoxin and hence it is safer to consume refined oils.

Spices

Cheaper agricultural produce like wheat starch, jowar, rice, corn and arrowroot starch are used in a number of expensive foods like ground spices (red chilli powder, turmeric, coriander powder, garam masala etc.). The starch which is white in colour is usually dyed to the colour of the spice to which it isbeing added. Sometimes essential oils derived from expensive spices like cloves are extracted and the exhausted spice is sold as such. Cinnamon bark may be mixed with the bark of another similar looking tree, asafoetida may be mixed witha foreign resin, seeds of black pepper may be mixed with papaya seeds and mustard seeds may be mixed with argemone seeds which look similar.

Miscellaneous food items

Colour seems to be an adulterant, which is added to a large variety of foods viz. non-alcoholic beverages, confectionery, sweets and savouries, to improve their appeal to the consumer. According to the PFA Act, only some artificial or synthetic colours

are permitted for use in foodstuffs. Colours other than the ones prescribed by law are referred to as non-permitted colours. The most commonly used non-permitted synthetic colours reported in various studies are Orange II, Sudan dyes, Metanil Yellow, Auramine, Malachite Green and Rhodamine B. In addition, extraneous matter like sand, husk, sawdust, wood pieces, stones, straw etc. are also used as adulterantsespecially in cereals and pulses to increase the bulk. Similar looking foreign pulse grains, which are mostly toxic, may be used to adulterate toor or århar dhal. Metal adulterants include iron filings (in suji) and nickel (in vanaspati) which are present mainly as a result of poor processing techniques and aluminium foils used instead of silver foils in several products like sweets. Intense or artificial sweeteners like saccharin may be added in excess to non alcoholic beverages or to foods in which it is not permitted like confectionery and sweets. Non-permitted sweeteners like dulcin and several other chemicals like urea, acetic acid, sodiuin hydroxide, sodium bicarbonate are also used as adulterants.

From the discussion above, it must be obvious to you that a wide variety of adulterants are present: To help us get to know them better, these have been classified into different categories based on their nature. Let us next look at the classification of these different types of adulterants used so commonly in our food.

8.5.1 Classification of Adulterants

If you look at the definition of adulteration carefully, you would realize that the definition of food adulteration according to the PFA Act clearly distinguishes the types of adulterants as those added intentionally and those present as contaminants due to improper storage, handling, transportation or processing of the foodstuff. Briefly summarize here the different types of contaminants which can be present in the foods. These are:

- antibiotic residues — for e.g. milk and milk products, meat and meat products.
- pesticide residues — like milk, grains, oil, bottled water, vegetables and fruits.
- metallic contaminants — e.g. Nickel due to the improper processing of vanaspati, iron filings in tea, suji, from rollers used in processing microbial contaminants — like fungi and fungal toxins, bacteria and their toxins due to improper storage or processing of the food products..

It is evident that a majority of the adulterants are chemicals. Some of these chemicals are nothing but additives which are permitted under the PFA Act for use in specific foods. So, if they are additives, why are we categorizing them as adulterants now? Remember, they are categorized as adulterants only when they are added to foods in which they are not permitted. For instance, saccharin is not permitted to be used in confectionery, but it can be used in non alcoholic beverages. In some cases, these chemicals are being used in excess of the permitted levels. For example, benzoic acid is permitted in pickles at 250 ppm, but may be found at much higher levels in some samples. Similarly, certain permitted synthetic colours may be added in excess of the permissible limit of 100 ppm or may be added to foods in which they are not permitted. Non permitted colours, which are mostly coal tar dyes are also widely used in different foodstuffs.

Categories	Adulterants
Coal tar dyes	Orange II, Sudan, Metanil Yellow, Auramine, Malachite Green, Rhodamine B
Cheaper oils	Castor oil, sesame oil, rapeseed oil, palmolein, mineral oil, turpentine, soyabean oil
Cheaper agricultural produce	Wheat starch, maize starch, jowar starch, rice starch, arrowroot starch, date seeds, amaranth seeds
Chemicals/Additives	Saccharin, sodium bicarbonate, sodium carbonate, acetic acid, ammonium sulphate, copper sulphate, urea, dulcin, brominated vegetable oil, monosodium stearate, ammonia, calcium oxide, benzoic acid, diazepam, ammonium chloride, chloral hydrate, triorthocresyl phosphate
Extraneous matter	Wooden pieces, chalk, cashew husk, yeram husk, coffee husk, silver oak leaf, sand, sawdust, stones, fenugreek, cellulose, resin, tamarind husk, grass.
Metals	Aluminium, iron filings, lead chromate, nickel
Fungi	Fungal toxin, ergot, aflatoxin
Insect infestation	Weevilled grains
Residues	Pesticides residues, veterinary drug residues, acetylene

New Adulterants

In thß fast-changing food scenario in India, along with increased food production and availability and stringent international food trade laws and norms, the traders try new ways and means of cheating the consumers and food control authorities by adulterants which are not likely to be detected by analysts. The newer adulterants identified are included

1. Legumes/pulse Toxic lentils (imported), Leucaena leucocephala seeds
2. Veterinary drug residues
3. Flours Mouldy wheat flour
4. Bakery products Animal fat
5. Vanaspati Industrial contaminants like orthonitroaniline

STUDENTS ACTIVITY - 1

1) Name a few adulterants which are commonly added to:
   a) Milk
   b) Cooking oil
   c) Ground spices
2) Name two non-permitted colouring agents which are still added to lots of foods

.

8.6 HARMFUL EFFECTS OF ADULTERANTS

There are a wide range of potentially toxic adulterants which might be present in our food. Very few studies are available on the health consequences of consuming adulterated food. Investigations into causes of food borne disease outbreaks help us to appreciate the health implications of food adulteration. In the developing countries food borne diseases continue to be a serious health hazard and an important cause of illness and death. At present, the reporting of food borne diseases in our country is very poor. You would remember studying about this aspect in a greater detail ih

Most of us don't even complain to the food vendor about the poor quality of his food. Even the health authorities sit up and take notice only when a large number of people are taken ill or die as a result of food poisoning. Let us look at some of the ill-effects of consuming adulterated foods including well publicised instances of acute poisoning outbreaks.

Most of the examples are instances of food borne illness due to the consumption of poor quality or stale food contaminated with harmful bacteria or their toxins. You might have read in the newspaper reports about marriage parties taking ill after consuming the food served or groups of people suffering vomiting and diarrhoea after consuming some sweet preparation after a religious or social function, which are very common especially durihg summer months. Unhygienic handling of foodstuffs and non-refrigeration of cooked food especially in hot and moist weather encourages the growth of bacteria in the food. Mouldy food can also lead to ill-health, although there have been a few recorded outbreaks as a result of fungal contamination in India. Ergot bajra has been implicated in an outbreak where the disease was characterized by symptoms of nausea, vomiting, giddiness and drowsiness.

Aflatoxicosis (liver damage), which is caused by the consumption of foodstuffs contaminated with aflatoxins, was first reported in 1974 among tribals in Western India. An outbreak associated with the consumption of bread made from mould-damaged wheat containing trichothecene mycotoxins was reported in the Kashmir valley. People who consumed the contaminated wheat flour, developed symptoms of abdominal pain and vomiting. These outbreaks have already been discussed in detail earlier in the unit entitled 'Food Contaminants' i.e. Unit 6 and you can refer back to the unit for details of these outbreaks, as well as, toxic effects of other contaminants like veterinary drug residues, heavy metals, pesticide residues etc. You will recall that selling unintentionally contaminated food is also an offence under the PFA Act and such food is called adulterated.

Let us leam about the harmful effects of adulterants in different foods.

Toxic adulterants in milk and their ill-effects

Milk, as you would have realized, is a highly perishable food item which is prone to microbial spoilage. You might have observed that if you leave milk at room temperature in summers, it begins to sour in a matter of few hours. If this milk is heated, it curdles or splits. Bacteria naturally present in the milk or those which enter the milk due to improper handling, multiply in number on keeping the milk at room temperature.

In the process, they produce acid which makes the milk sour and ultimately

curdles it. Milk vendors who have to transport milk to long distances, especially in hot weather, add chemicals like carbonates or alkalis for neutralizing developed acidity in milk. Such addition of chemicals is not permitted by law. Chemicals tike sodium carbonate (washing soda) can be harmful when ingested with milk and can have deleterious effects on the intestinal lining by irritating it. Sodium hydroxide (caustic soda) is also used for neutralizing acidity in kmilk. It is strongly alkaline and corrosive. It rapidly destroys organic tissues.

Formaldehyde is another adulterant used to increase the shelf life of milk by killing the bacteria. It is a disinfectant against bacteria, fungi and many viruses and actually used in the preparation of lotions, soaps and mouthwash. Ingestion of formaldehyde solution causes an intense pain with inflammation, ulceration and necrosis of mucous membranes.

Hydrogen peroxide is another preservative which may be used to inhibit microbial growth and prevent milk spoilage. Strong solutions of this chemical produces irritating burns on the skin and mucous membranes and its continuous use even as a mouthwash has been known to cause damage to the papillae of the tongue. Urea, which may be added to increase the specific gravity of milk diluted with water, can cause gastrointestinal irritation. It may also cause loss of appetite, nausea and vomiting when taken in excess.

Food Adulteration Toxic adulterants in oil and their ill-effects

Mustard and other vegetable oils have been found to be adulterated with argemone oil. Epidemic dropsy, first reported from Kolkata in 1877, we learnt is the disease resulting from the ingestion of toxic alkaloids like sanguinarine, present in Argemone mexicana seeds. The disease is characterized by oedema or swelling over ankles, gastrointestinal disturbances, blood vessel changes, changes in the eyes and cardiac insufficiency. Outbreaks of epidemic dropsy have been reported from Itarsi, Madhya Pradesh, Delhi, Rajasthan and Andhra Pradesh in India. A massive outbreak of the disease was reported in Delhi in 1998, which resulted in several deaths.

In May 1982, there was an epidemic outbreak in Spain because of the ingestion of adulterated oil containing vanous proportions of rapeseed oil denatured with aniline. This was known as 'Toxic Oil Syndrome' (TOS) which affected about 25,000 people and resulted in the death of about 2.5 % of the people. Pentachlorophenol was also detected in the oils, which along widi anilides, contributed to the toxic effect seen. An outbreak of tricresyl phosphate poisoning in Kolkata has also been reported. About 600 people were affected with paralysis of the hands and feet due to the consumption of rapeseed oil adulterated with tricresyl phosphate.

Mineral oil (liquid pargffin), a cheap inedible oil used as an adulterant, may result in anal seepage and irritation, if consumed in excessive amounts. Prolonged ingestion may interfere with the absorption of fat-soluble vitamin like vitamins A, D, E and K. The admiristration of castor oil by mouth as a laxative was widely practised earlier.Such an Intake, particularly in large doses, may produce nausea, vomiting, colic pain and a severe laxative effect. Similar effects may be seen after consumption of cookirg oil adulterated with castor oil. Castor oil in doses that exert

a laxative effect is reported to inhibit the absorption of fat-soluble vitamins, notably vitamin A and vitamn D.

Toxicity of food colours

The relevance of colours in foods, undoubtedly, cannot be denied. It is colour which nakes a food appealing, attractive and desirable to the consumers. Though, you would wonder that the use of certain colours has been banned in foods. Why is it so ? This is because they are well known for their toxicity in experimental animals. Uuramine was found to inhibit growth and lead to dysfunction of the liver and kidney. Rhodamine B was shown to cause retardation of growth, haemolysis of red blood cells and degenerative changes in the liver and kidney. It also adversely affected the immune system.

Sudan dyes were found to be toxic to the liver and produced kidney ,esions. Malachite green caused a decrease in food intake, growth rate and fertility rate. It also caused damage to organs like liver, kidney, heart and spleen, as well as, lesions of skin, eyes, lungs and bones.

Orange II led to retardation of growth, ncreased mortality and haematological changes. Metanil yellow consumption could ead to degenerative changes in the stomach, ileum, rectum, liver, kidney, ovary and cestis. Metanil yellow is one of the most commonly used water soluble non-perrnitted dye to colour foodstuffs including pulses with a false presumption that it could be washed out in pre-cooking washings of the pulse.

In humans, some of these colours have been shown to lead to acute food poisoning outbreaks. Metanil yellow has been reported to cause symptoms of giddiness, vomiting and cyanosis. The people who developed these symptoms had eaten laddoocoloured with this dye.

In another incident, biryani coloured with metanil yellow caused similar symptoms 2 to 4 hours after consumption. Lead chromate added as a colourant to chilli powder caused lead poisoning among Gurkha soldiers with symptoms of stomach ache, nausea, constipation and anaemia.

All the above colours can dso mutate genes (mutagenic) and most of them have Safetybeen identified as potential cancer causing agents. The most common harmful effect seen is an allergic response to these colours. Tartrazine is the food colour most frequently associated with allergic reactions. Asthmatic people are especially sensitive to this yellow colour and many have reported a worsening of their asthma attack after consuming food containing tartrazine.

S.No	Food	Chemical/Adulterant used	Ill-effects
1)	Milk	- Sodium carbonate or washing soda	Irritates the intestinal lining
		- Sodium hydroxide or caustic soda	Corrosive, destroys organic tissues
		- Formaldehyde	Intense pain with inflammation, ulceration and necrosis of mucous membranes.
		- Hydrogen Peroxide	Irritating burns on the skin and mucous membranes
		- Urea	Gastrointestinal irritation, loss of appetite, nausea and vomiting.

2)	Oil	- Argemone oil	Epidemic dropsy, characterized by oedema over ankles, gastrointestinal disurbances, blood vessel changes, changes in the eyes and cardiac insufficiency
		- Pentachlorophenol and Anilides	Toxic Oil Syndrome (TOS) and death
		- Tricresyl phosphate	Paralysis of hands and feet
		- Mineral oil (liquid paraffin)	Anal seepage and irritation, interfere with the absorption of fat soluble vitamins (A,D,E,K)
		- Castor oil	Nausea, vomiting, colic pain and a severe laxative effect, inhibits the absorption of fat-soluble vitamins, notably vitamins A and E
3)	Food Colours	- Auramine	Inhibits growth, dysfunction of the liver and kidney
		- Rhodamine B	Growth retardation, hemolysis of RBCs, degenerative changes in the liver and kidney, adversely affects the immune system
		- Sudan dye	Toxic to the liver and produced kidney lesions
		- Malachite green	Decreased food intake, growth rate and fertility rate, damage to organs like liver, kidney, heart and spleen as well as lesions of skin, eyes, lungs and bones.
		- Orange II	Growth retardation, increased mortality and haematological changes
		- Metanil Yellow	Degenerative changes in the stomach,

Table 8.4 : Adulterants and their ill-effects

In the light of the, consequences of consuming adulterated food, it is crucial that we Should be aware of these adulterants and more so have a basic knowledge on how to detect them in foods, using simple household techniques. The next section presents the methods for detection of some adulterants. We hope you will find this information useful and applicable.

8.7 METHODS FOR DETECTION OF SOME ADULTERANTS

Samples of food are regularly picked up by the food inspectors and analyzed in Food Laboratories under the PFA Act. However, the findings of the tests conducted are not made public. Traders found to be adulterating are prosecuted and sometimes the court cases take years to resolve. As consumers, we can not Wait that long to know if the food we are eating is safe or not. So how can the consumers come to know if their food is adulterated

How to know if the food is adulterated?

There is a provision under the PFA Act by which the general public can

pick up samples of suspect food items and send them for analysis to the Food Laboratories.

A minimum fee has to be paid for the analysis, which is refunded if the sample is found to be adulterated. The public can send thesesamples for testing to other private laboratories also.

Figure 8.3: Methods for Detecting adulterants in food

Sl	Food	Adulterant	Method of detection
1	Milk, milk product, powdered spices	Starch	Mix sample in a test tube with water, add a few drops of iodine solution. A blue colour indicates the presence of starch.
2	Milk	Water	Measure the specific gravity with a lactometer by immersing it in milk kept in a deep vessel. The normal values lie between 1.028-1.032. But this is not a foolproof method, as, in addition to water, sugar or urea may have been added to the milk to increase its specific gravity.
3	Milk	Developed acidity	Place a test tube containing 5 ml of the milk sample in a boiling water bath and hold for about 5 minutes. Remove the tube and rotate in an almost horizontal position. The film of milk on the side of the test tube is examined for any precipitated particles. Formation of clots is indicative of developed acidity in the milk due to microbial spoilage. Such milk is unsuitable for consumption.
4	Milk, milk powder	Neutralizers like carbonates	To about 5 ml of milk in a test tube add 5 ml of alcohol and a few drops of rosalic acid solution and mix the contents of the test tube. A rose red colour is obtained in the presence of a carbonate, whereas, pure milk shows only a brownish colouration.
5	*Ghee*, butter	Margarine or *vanaspati*	In one tea spoonful of completely melted sample, add 5 ml concentrated hydrochloric acid. Shake for 5 minutes, add a pinch of sugar or furfural. Appearance of pink colour in the acid layer indicates added *vanaspati*.
6	Oils and fats, black pepper	Mineral oil	To 2 ml of oil sample taken in a flask, add 20 ml of 0.5 ml normal alcoholic potash. Heat for 30 minutes and add 20 ml hot water. If turbidity appears, mineral oil is present.
7	Sweetmeats, ice cream and beverages, *sella* rice pulses, spices	Metanil yellow	Extract colour with lukewarm water from food samples and add a few drops of concentrated hydrochloric acid. A magenta colour indicates the presence of metanil yellow.

NOTES

8	Pulses, whole and split, *besan*	Kesari dal	*Kesari dal* is wedge shaped, with a slant on one side and a square face on the other side. Physical examination can detect the adulterant
		Metanil yellow	Put the sample in dilute hydrochloric acid. Pink colour develops indicating the presence of the adulterant.
9	Mustard seeds	Argemone seeds	Argemone seeds have a rough surface and mustard seeds are smooth. Upon pressing, mustard seeds are yellow inside while argemone seeds are white.
10	Black pepper	Papaya seed	Papaya seeds are comparatively shrunken, oval and greenish brown to brownish black in colour.
11	Tea leaves, sugar	Iron filings	Easily separated using a magnet.

STUDENTS ACTIVITY - 2

1) Name the adulterant and the harmful effects associated with the following:
   a) Epidemic dropsy
   b) Toxic oil syndrome
   c) Aflatoxicosis
   d) Non-permitted colour used to dye pulse
2) Why are only a few colours permitted for use in foodstuffs?

8.8 LET US SUM UP

In this unit, we studied thåt an access to genuine and pure food commodities is of paramount importance for the social health and welfare of a community. Adulterants lower the quality of the food and also sometimes make it hazardous for our health.

In this unit, we have discussed about the problem of adulteration of food, a practice still widely prevalent in our country. Any foodstuff that commands a premium in the market can be adulterated. Foods sold loose or without prpper packaging are easy to adulterate. AISO foods sold in powder, paste or mince form are more likely to be adulterated. Surveys have indicated that milk and milk products, edible oils and fats and spices are the foods most commonly found adulterated.

Various types of adulterants can be intentionally added to foods and several others can be present as unintentional contaminants due to negligence on part of the food producers or traders. Adulterants can be classified based on their nature.

The variety of adulterants which have been detected in different foods have been enumerated in this unit. Colour seems to be an adulterant which is added to a large variety of foods to improve their appeal to the consumer.

Economic gain is the primary motive behind adulteration. Profit margins are increased by using cheap substitutes, masking spoilage in foods and increasing the shelf life of the food by addition of preservatives. Such interference with foodstuff may potentially lead to food which is harmful to health. Harmful effects of consuming adulterated food were described in this unit. While the consumption of some of the adulterants has resulted in minor health problems like stomach upsets others have even resulted in the death of a large number of people. A few adulterants can be detected by simple tests at home while others require detailed laboratory analysis. Simple tests were highilighted in this unit for the detection of various adulterants in different foods.

8.9 GLOSSARY

- Dysfunction : an abnormality or impairment of function.
- Edible oils : vegetable oils and fats; includes any margery, vanaspati, bakery shortening and fat —spread asspecified in the PFA Act, 1954 and rules made there under, for human consumption.
- Extraneous : of external origin.
- Food adulteration : intentional addition or substitution or abstraction of substances which adversely affects the nature, substance and quality of foods. Also incidental contamination during the period of growth, harvesting storage, processing, transportation and distribution. Food bornecarried or transmitted by food.
- Food-borne : disease caused due to the consumption of food which is contaminated by microorganisms.
- Food-borne disease : an incident in which two or more persons experience out breaksa similar illness, usually gastroenteritis, after ingestion of a common food which is identified as the source of food borne disease.
- Haematological : to do with the physiology of blood.
- Lesions : any damage to the body, wound, sore.

8.10 CHECK YOUR PROGRESS

1) Define food adulteration.
2) Which foods are more likely to be adulterated? List some foods which are

commonly found adulterated.

3) How would you classifr food adulterants?

4) List some common reasons for food adulteration.

5) How would you test if:

a) artificial colour has been added to tea leaves?

b) silver foil has been replaced by aluminium foil?

NOTES

UNIT

9

FOOD SAFETY IN FOOD SERVICE AREAS

STRUCTURE

9.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- describe the various features that are involved in designing a catering establishment.
- describe the importance of layout, equipment, storage and transportation
- describe what are street foods and its basic safety measures,
- discuss about temporary food services and methods to ensure food safety,
- explain the need of food safety in various modes of public transport

9.2 INTRODUCTION

In the units so far we have learnt about the various food hazards and their implications on food safety. Food handling practices, hygiene and sanitation in food service establishments, you would realize, also play an important role in food safety. So then, what should be the approach to food safety in this context.

This unit focuses on food safety approaches in food service establishments. The approach to food safety, you would learn, has to be initiated from the selection of a site to the construction of a food service establishment. The various features

that have to be considered in selecting the site, designing the premises, kitchen, selecting the equipment, food service area, storage and drainage which have a bearing on food safety will be discussed in detail in this unit.

Other than the permanent food service establishments, there could be other different types of situations where the food needs to be prepared and served, for example, in functions, for travelling public or may be even on the roadside. The facilities to ensure food safety may not be available in these other food areas. How to ensure food safety in such situations and what are the precautions to be taken, is the other aspect discussed in this unit.

9.3 FOOD SAFETY AND FOOD SERVICE ESTABLISHMENTS

We would like to begin our discussion on this topic by first understanding what are food service establishments and other food areas. Perhaps you would already know what a food service establishment is.

Yes, it is any facility, where the food is prepared and served. To elaborate further, it is a place where food is prepared and intended for individual portion service and includes the site at which the individual portions are provided, whether consumption occurs on or off the premises. The term, however, excludes food processing establishments, retail food stores, private homes, where food is prepared or served for family consumption and food service operations, where a distinct group mutually provides, prepares, serves and consumes the food limited to a congregation, club or organization.

While studying about food service establishments, you might come across terms like, fixed and/or temporary food service establishments, mobile food units etc. What are these food units?

Let's get to know about them. A food service establishment which operates at a specific location and is connected to electric utilities, water and sewage disposal system is called a fixed food establishment. A temporary food service establishment, on the other hand, is defined as a food service establishment that operates at a fixed location for a period of time (not more than 14 consecutive days) in conjunction with a single event or celebration. A mobile food service establishment is a self-contained food service operation, located in a vehicle or a movable stand, otherwise propelled, used to store, prepare, display or serve food intended for individual portion service. It is also known as a mobile food unit.

Next, why are we talking about food safety in food service establishments/food areas?

Primarily, because most food borne illness outbreaks have involved food prepared away from home. In a study conducted in USA regarding the location of the outbreaks, it was found that a majority of the outbreaks have been reported from the food service establishments, followed by the outbreaks at home and food processing establishments. You may have visited food service establishments such as a dhaba, restaurant or perhaps eaten food from a road side vendor and

often enjoyed various delicacies offered by them. But, are you aware that such places could be a major contributor to food borne diseases. How and which factors can cause such diseases? You will realize that there are several reasons for the occurrence of food borne disease outbreaks.

The most important of them are the factors which contribute to the contamination of foods by microorganisms, which when ingested, will lead to an outbreak. These include:

i) factors which affect the growth of microorganisms

ii) factors which affect the survival of the pathogens, and

iii) factors which affect the contamination like food handlers and cross contamination.

Of all the factors which contributed to the outbreaks, the most important ones were:

i) preparation of foods too far in advance

ii) foods left at room temperature or foods cooked in large pots

iii) improper warm holding e.g. below 60°C

iv) improper cooling, e.g. leaving the cooked foods at room temperature or storing the foods in large containers in refrigerators

v) inadequate reheating

vi) handling of foods by colonized infected persons

vii) inadequate cleaning of equipments and utensils

viii) cross contamination from raw to cooked foods

ix) toxic containers, and

x) contaminated raw ingredients.

It can be clearly seen that the possibilities of a combinations of factors listed above, exist in the food service establishments due to the nature of their operations. Besides, various features such as the site, the premises, kitchen, equipment, food service area, storage and drainage need to be considered in order to ensure safe food. Food stands, fixed establishments and other food sales, provide good opportunities for the organizations to raise money, but the food they prepare and offer for sale, must be safe for the consumer.

When we, the customers, buy food, we have the right to expect that it will be safe and wholesome. Therefore, the approach to food safety in food service establishments has to be initiated right from selection of the site, designing the premises, kitchen, selection of the equipment to food service area, storage and drainage. Similarly, in other food areas such as mobile units or street foods, the facilities to ensure food safety must be considered.

9.4 FOOD SAFETY MEASURES IN A FOOD SERVICE ESTABLISHMENT

Food safety in food service establishments must be initiated right from the time the establishment is being planned. The various features/requirements, from the food safety perspective, that have to be considered in selection of the site, designing the premises, kitchen, selection of the equipment, food service area, storage and drainage have been considered next.

We start with the requirements specific to premises

9.4.1 Premises

For the general cleanliness of the catering establishment, preventive measures must be implemented throughout the establishment and all outside areas, apart from food preparation and storage areas.

The premises should be kept clean and free of waste materials. Only articles necessary for the operation and maintenance of the food service establishment should be stored on the premises. There should not be unnecessary movement of personnel not connected with food preparation and serving in those areas.

The surroundings should be neat, clean and maintained in good repair. The entire building should be so constructed and maintained such that the dust, dirt, cockroaches and rodent harborages are eliminated. The entry of dogs, cats, rodents, birds, flies and other insects should be minimized. Drainage system should be satisfactory, with suitable traps and grills. Internal manholes should be airtight with double sealed covers. Equipment wash areas should have floor drainage with floors having an adequate gradient to drains. Separate toilets, hand washing, staff rest room, locker facilities should be available and should be disconnected from the food areas. Garbage area should be protected against the entry of flies, cockroaches and rodents. 'No smoking' and other hygiene-related notices should be prominently displayed.

Water and steam hoses, for washing and sanitizing, should be provided. An adequate supply of potable water should be there. The units should be so designed so that the work flow is satisfactory and in particular, 'dirty flow' do not cross 'clean flow' lines in order to minimize the risk of cross contamination. For example, in an abattoir, live birds are received at the dirty end and meat is out loaded from the clean side of the abattoir. Food preparation areas should be completely separated from the wash-up and garbage areas. It should have an adequate natural and/or artificial lighting and ventilation.

Next, we shall look at the other areas/objects within the premises such as floors, walls, ceilings, doors, windows, ventilation etc. for the safety features.

A). Floors

The floors should be durable and smooth but not slippery, non-absorbent and easy to clean and maintain. Meticulous care should be taken to ensure that crevices are not formed in the comers of the floor, which are potential pockets of dirt deposition and consequent food contamination. There should be trapped floor drains to carry away the liquid wastes.

B). Walls and Ceilings

Wall surfaces must be durable, smooth, non-absorbent and easy to clean.

Ideally, they must be solid and covered at the junctions with floors and ceilings. The inner walls and pillars should be preferably covered with an appropriate material facilitate easy washing and good upkeep. Walls and ceilings in the food preparation area and washing area must be of a light colour to aid in the distribution of light to facilitate thorough cleaning.

Food grade gloss paints/other suitable non-absorbent wall coverings may be used. Wherever possible, the joints of walls and ceilings should be rounded to prevent accumulation of dirt. Gaps between walls and any cladding should De small. Corner of the walls need special attention. The wall surfaces around sinks, wash basins and equipments must be specially treated to be resistant to heat and other physical damage by use of ceramic tiles or cladding. Pipe work should be bracketed at least 150 mm from walls to make the cleaning easier.

All lagging should be smooth and non-absorbent. Gaps around pipes passing through the walls should be effectively sealed. The ceilings must be smooth, hard, non-absorbent and easy-to- clean. If it is suspended, access should be provided to enable pest control inspections/ treatment and cleaning. The walls, ceilings, equipments, light and other fixtures like fans etc. should be easily cleaned. From the point of view of upkeep and maintenance of hygienic conditions, steel and aluminum is preferable over wood.

C). Doors and Windows

All doors should be self-closing and made rodent-proof. They must be properly fitted with hard, smooth, durable, non-absorbent surfaces that are easy to clean; Doors that are required to be left open should be fitted with a suitable insect/ bird proof screening. Windows and frames must be easy to clean and maintained in a good condition. Alf the windows must be fitted with fly-proof screens and arrangements must be made for making them pest proof.'

D). Ventilation

Sufficient ventilation is essential in the kitchen for avoiding the soiling of walls, ceilings and floors and also to reduce the temperature of the working areas. It facilitates removing the contaminated air, excessive heat, cooking grids, steam, grease and condensations during food preparation, cleaning and other operations of food handling. Any screens and hoods fitted near the cooking area should be of materials and design to facilitate the cleaning operation.

They should be checked and cleaned periodically. Exhaust fans have also to be provided, if possible, for good air circulation.

E).Lighting

Ample and properly distributed light assists in proper food preparation and handling, as well as, detects dirt and pests. Wherever possible, natural light should be provided. Fluorescent light fittings should be fitted with glare free vapour proof diffusers. Food handling areas like preparation tables; sinks etc. should be well lit. Care should also be taken to light the cold rooms and food storage areas.

All the light fittings should be periodically inspected and repairs should be undertaken immediately.

9.4.2 Equipment and Utensils

Various equipments and utensils are required to run an establishment. Equipments include all stoves, ranges, hoods, meat blocks, tables, counters, refrigerators, freezers, sinks, dishwashing machines, steam tables and similar items, other than utensils, used in the operation of a food service establishment. Utensils, on the other hand, are the implements such as pots, pans, ladles or food containers used in the preparation, storage, transportation or serving of food. Selection of the equipments, which can meet sanitation standards, is essential to ensure food safety. The basic safety criteria to be considered while selecting an equipment are highlighted herewith. The equipment should be such that it:

- has as few parts as possible
- be easy to take apart
- have smooth surfaces with no pits, crevices, ledges, bolts and rivet heads
- have rounded edges and corners inside with smooth surfaces
- be coated with materials, that do not crack or chip, and
- be made of materials that are not toxic, do not absorb liquids or fats and do not
- colour or flavour the food.

As for installing and laying out the equipment, remember it should be so arranged that food is not easily contaminated and all areas are easy to reach and clean. For example, dirty dish table should not be next to the vegetable preparation sink. The equipment should be 1.5 feet away from the walls, so that the staff can go round and clean.

What about utensils? Materials used for making utensils should not allow the migration of deleterious substances or impart colours, odours, or tastes under normal conditions of use. It should be:

- safe
- durable, corrosion resistant, non-absorbent
- sufficient weight and thickness to withstand repeated ware/wash
- finished to have a smooth, easily cleanable surface
- resistant to pilling, chipping, crazing, scratching, scoring, distortion and
- decomposition
- lead-free i.e. ceramic, china and crystal utensils that are used in contact with the
- food should be lead-free, and
- specific, for example, galvanized metal should not be used for utensils that are
- used in contact with the acidic foods.

9.4.3 Kitchen Layout

Generally, enough attention is not paid for the layout of kitchen as compared to the dining and customer-related areas. Kitchen should never be used as a thoroughfare to other parts of the establishment.

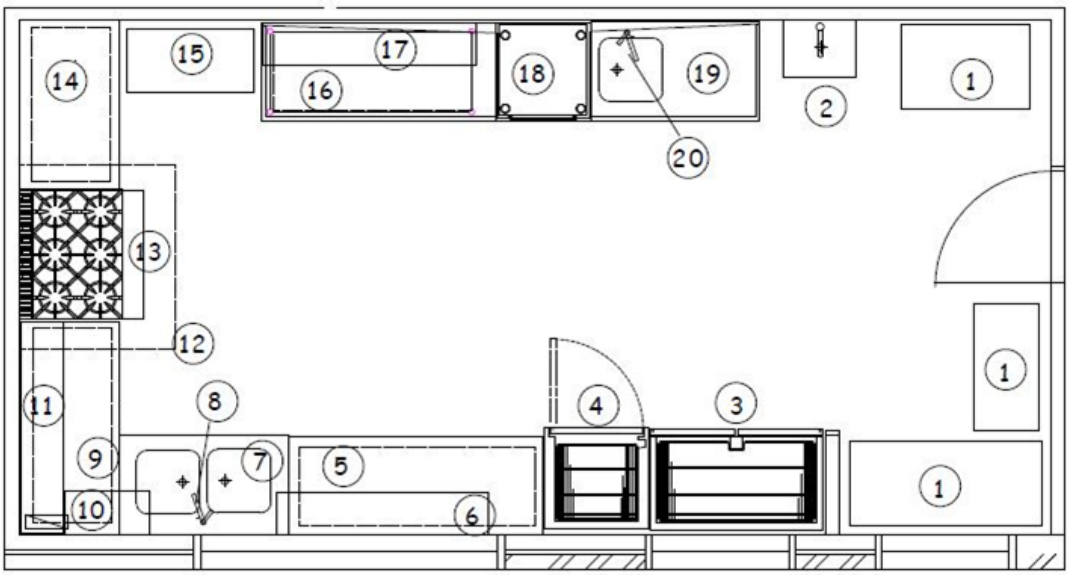

Figure 9.1: Kitchen layout

While designing the kitchen, the chief factors to be considered are the work-flow, the nature of the work and position of the windows, doors and drains. Fullest use of natural lighting and efficient use of drainage should be done. Free-standing kitchen units are much more hygienic than those filled close to walls or comers. "Island" layout is easier to clean. Ovens, stores and mixing machines should be in the center of the room.

Cooking stoves and cooking ranges need a canopy and an exhaust fan ventilation system to draw off the fumes. Processing areas of vegetables, raw meat and fish should be clearly demarcated. Cooking units, where steam is produced, should be located near the house side wall to avoid long drainage channels running through the kitchen. Pots and pans should be stored on racks or slatted shelves. Next, let us study what should be the optimum storage facilities for different types of foods that could help in the prevention of food borne illnesses.

9.4.4 Storage

Proper storage of raw materials procured for food preparation is very essential in preventing food borne illness. You have already -learnt earlier that foods are classified into non-perishable, perishable and highly perishable commodities from the storage point of view. Each of these food types requires different conditions of storage.

Non- perishable foods like food grains, spices etc. need to be stored at a room temperature in metal or plastic bins with proper lids. They should be at least 6 inches above the floor in a manner that protects food from splash or other contamination and also permits easy clean up. Perishable foods like fruits, vegetables, butter, eggs have to be stored in refrigerators. It is important to know the most appropriate positions for each of the food in the refrigerqtor. Food that is to be stored for a long time needs to be stored in deep freezers in the refrigerators, if it is a domestic refrigerator. Deep freezers specially meant to keep the food at —180C, are separate in the commercial establishments.

Some general requirements, specific to storage of foods are highlighted herewith:

a) Containers of food are to be stored a minimum of six inches (14.24 cm) above the floor to protect the food from splash and other contamination, and at a height to permit easy cleaning of storage area.

b) Food, containers of food and food wrapping materials are not to be stored under exposed or unprotected sewer lines. The storage of same in toilet rooms is prohibited.

c) Food not subject to further washing or cooking is to be stored and protected against cross-contamination from food requiring washing and cooking.

d) Packaged food is not to be stored in contact with water or undrained ice. Ice intended for human consumption is not to be used as a medium for cooling stored food, food containers or food utensils.

e) Food which is not readily identifiable is to be stored in properly labeled original product containers or in containers labeled to identify the food by a common name.

9.4.5 Transportation

The protection of food from contamination and the maintenance of food at the proper temperatures are critical for the safety of a food. During transportation, cross contamination can cause disease. To ensure safe food, the general requirements of containers for food transport have been stipulated which include:

1) It should not contaminate the food or packaging for e.g. tanker used for non-food transport should not be used to transport food.

2) It can be effectively cleaned, kept in good condition and whenever necessary, can be disinfected.

3) It should provide effective protection from contamination, including dust and fumes.

4) It should maintain the temperature, humidity, atmosphere and conditions necessary to protect food from harmful or undesirable microbial growth and deterioration likely to render it unsuitable for consumption, for example, insulated tankers for chilled milk transport etc.

During transportation, including transportation to another location for service or catering operations, food is to meet the requirements relating to food protection, temperature, handling and storage. The challenge is to maintain the proper refrigeration temperature and to keep the cold-chain from breaking during steps such as staging, loading and unloading of containers and in storage. Food, utensils, equipments and tableware are to be protected from contamination during transportation by the use of covered containers, complete wrappings or packaging.

9.4.6 Sanitary Facilities

The sanitary facilities like toilets, wash basins, hand dips and rest rooms should be provided to the food service establishment personnel. Let us learn about these facilities.

Washrooms, Lunchrooms, Change Rooms

Self-closing doors must be provided for all washroom facilities. Washrooms, lunchrooms and change rooms must be separate from and not directly entered from food processing and handling areas. Such facilities are to be properly ventilated and maintained.

Hand Washing Facilities

Sufficient numbers of hand washing sinks, with hot and cold potable water, soap, sanitary hand drying supplies or devices, must be provided in washrooms. A sufficiency of suitably located hand washing sinks is also necessary in food processing and handling areas. Hand-washing sinks should be separate from sinks used for equipment cleaning and other operations.

9.5 FOOD SAFETY MEASURES IN STREET FOODS

The rapid urbanization has led to a sudden and unprecedented urban growth along with an increase in the size of the labour force in the cities.

All these changes have brought about a marked difference in the life-style of the people. There is an increased demand for ready-made foods or fast foods. Studies on dietary trends are showing an increase in the consumption of street foods in urban areas. The vast segment of the population in the country is consuming what we call as street foods. You must have seen, as well as, sometimes consumed street foods.

What are 'street foods' or what foods come under these? Are these foods safe for us? Let us find out.

The term street foods, primarily, describes a wide range of ready-to-eat foods and beverages sold and sometimes prepared when the customer orders the meal, and which can be consumed where it is purchased or taken away. Jt is low in cost compared with restaurant meals and offers an attractive altemative to home-cooked food. Street foods are defined by Codex Alimentarius as ready-to-eat foods and beverages prepared and/or sold by vendors and hawkers especially in the streets and other similar public places. Street foods often reflect traditional local cultures and exist in an endless variety.

There is much diversity in the raw materials, as well as, in the preparation of street food beverages, snacks and meals. Some of the foods sold on the streets are — fried snacks, noodles or cereal-based meals, cakes and pastries, soups, porridges, drinks, fruits, meat, poultry, fish, eggs etc. Street foods are also prepared in a variety of ways such as boiling, frying, baking, steaming etc., as well as, served raw. Vendors' stalls are usually located outdoors or under a roof which is easily accessible from the street and have low-cost seating facilities. Street food vending actually assures food safety for low income urban dwellers. It provides an affordable source of nutrients to many sectors of population, including the urban poor.

On the other hand, street food vending also provides a livelihood for a large number of workers. It offers business opportunity for developing entrepreneurs. So then what is the problem with street foods? The major concern is of their safety. Street foods are perceived to be a major public health risk. Why? Primarily, because they may cause serious health hazards as proved by the presence of pathogenic organisms, especially E. coli, micrococci, Klebsiella and Proteus etc. in the food samples. How does this happen?

This is due to the fact that the street food vendors lack basic infrastructure and services such as potable water supplies. Further, it is also recognized that street food vendors are often poor, uneducated, lack appreciation for safe food handling and have a poor knowledge in basic food safety measures. These various factors which contribute to street foods posing significant health problems are summarized herewith:

- Lack of basic infrastructure and services, such as potable water supplies.
- Difficulty in controlling the large numbers of street food vending operations because of their diversity, mobility and temporary nature.
- Insufficient resources for inspection and laboratory analysis.
- General lack of factual knowledge about the microbiological status or the precise
- epidemiological significance of many street-vended foods.
- Poor knowledge of street vendors in the basic food safety measures.
- Inadequate public awareness of hazards posed by certain street foods.

Considering these factors, there is an urgent need to create awareness among the vendors, as well as, among the consumers about the concept of safe

food. Street food vendors need to be educated regarding the following factors as they are vital in the maintenance of food safety. Let us get to know these.

A). Raw Materials

The raw material itself is the most common source of contamination. The ingredients can carry harmful or potentially harmful microorganisms and toxins. The type and extent of biological contamination of raw materials used in street food vending will differ little from those used in other food service sector. The greatest difference will be noted when vendors purchase raw materials of a lower grade because of their lower cost.

Raw materials need to be observed for visible deterioration and off- odours. Raw materials need to be examined for the presence of physical hazards and also signs of chemical contamination. It is advised to buy AGMARK/BIS certified products for quality assurance. Vendors should pay attention to the containers of chutneys, pastes, sauces and other food supplements, where there is a chance of fungal growth and visible deterioration.

B) Water and Ice

One of the most critical problems in street food vending is the supply of water in sufficient quantities of an acceptable quality for drinking, washing, cleaning and other operations. Water used for drinking and preparation of foods should be potable otherwise it can contaminate food.

Water used for washing utensils, foods and hands should be safe and should not be reused. A bucket or a similar container can be used for washing, but it should be emptied and cleaned after every wash. Ice (that is used in beverages) and foods should be prepared from potable water.

C) Preparation and Processing

Preparation and processing is a critical area in the series of steps to which the foods are subjected, before their sale and consumption and is an important aspect in deteriorating the safety of foods. How can then, we ensure the safety of foods while preparing and processing them? Well, to begin with, foods that are eaten raw e.g., salads, peeled and cut fruits should be washed sufficiently with safe water to reduce contamination on the surface. Food should be processed by heat treatment. It should be thoroughly cooked, which means that the temperature of all pails of the food must reach at least 70^0C.

D) Transportation, Handling and Storage of Prepared Foods

The prepared foods have to be transported from the place of production to the point of sale/consumption. You must have noticed people on bicycles or in auto rickshaws who transport prepared food items. Have you ever wondered that these could be a potential hazardous source of various contaminants? So, how to prevent prepared foods from spoilage during transport?

First of all, the vehicle used for transport should be clean and should not carry animals, toxic chemicals and contaminating materials along with the prepared foods. The time required for transporting the preparations and vending units should be such that the bacterial proliferation does not reach hazardous

levels. Problems of transport are minimized if the point of sale is near the place of preparation. After the food is transported safely,. handling practices and storage facilities must be considered. This would also account to holding of prepared foods at appropriate temperatures where the growth and action of microorganisms is the least. Prepared foods served hot should be kept at a temperature of at least 600C to prevent microbial growth, particularly if the sales period exceeds 4-5 hours. Prepared foods which are to be served cold and which may support the growth of pathogens should, if the cooling capacity is available, be stored at less than 100C. The vendors should be encouraged to discard leftovers.

E) Equipment, Utensils and Containers

Now let us see what measures should be taken in account of ensuring food safety with respect to equipment, utensils and containers of street foods. Note the equipment, utensils and other containers should be made up of materials which do not release toxic and hazardous metals like copper, lead, cadmium etc. into food and beverages, especially when the foods are acidic.

The design, construction and maintenance of equipment are also important to food safety. The use of inappropriate materials and poorly maintained materials may hamper proper cleaning and sanitization of surfaces, leading to microbial growth and an increased likelihood of contamination. If raw meat, poultry and fish are handled, their preparation should be, carried out using separate equipment and utensils.

F) Vending Units

You would have seen vending units for various food items at food service establishments. What food items are delivered through these? What should be its features and how should it be cleaned so as to minimize chances of contamination? These are the issues which are discussed here.The use of such vending machines for quick dispensing of foods is on an increase. The most popular items dispensed with vending machines include milk, coffee, tea, fruit juices and ice cream. The food safety problem may be confronted with the increasing use of such machines which could be due to:

(i) usage of substandard raw materials

(ii) lack of periodical cleaning/servicing of machines, and

(iii) non-usage of disposable receptacle or containers.

Figure 9.2: Vending unit

The usual care taken during preparation of food article by conventional methods such as use of potable water, adequate washing and cleaning of raw materials like fruits etc. has to be ensured. Regular cleaning of the vending machines and servicing of machinery should be undertaken. All machines should be regularly restocked, cleaned and maintained to ensure that the highest possible standards are achieved. Where necessary, temperature controls in these machines should be maintained.

Only disposable cups should be preferred in places where the vending machines are placed. A proper recording of cleaning and maintenance is essential. Vending units should be designed and constructed so that they are easily cleaned and maintained. Preparations should not be carried out on or near the ground. Bowls and dishes should be stored upside-down to prevent the accumulation of dust and foreign matter.

G) Requirements at the Point of Sale

Food vendors are generally seen at the roadside under the tree or on a pavement from where the traffic passes by, rain and wind often comes and accumulates dust on uncovered foods. These may act as a source of contamination for even hygienically prepared foods. So what place and conditions should be considered for reducing the risk of contamination? To begin with, the foods should be prepared and sold in a clean, well-lit place, protected from strong sun, dust, rain and wind. It should be away from the sources of contamination such as solid and liquid wastes and from animals, including pets as well as pests.

Sales point, stationary and/or ambulatory should be located in a place where the risk of contamination from rubbish, sewerage and other materials and toxic substances is absent or minimal. If such risks cannot be completely eliminated, at least care should be taken to ensure that the prepared food offered for sale is suitably covered from contamination. When required, food should be wrapped in a clean paper, plastic or foil and other suitable material.

Newspaper and other unsanitary wrapping materials should not be used for packing or serving the food. Vendors who are patronized by high risk groups e.g. schools, hospitals should be particularly vigilant in controlling food safety. Finally, a word about waste disposal and pest control.

H) Waste Disposal and Pest Control

You will realize that the possible causes of street food contamination include: absence of proper hygiene and sanitation improper food handling practices

- use of contaminated water and poor quality raw materials
- use of ice made from contaminated water
- exposure to dust and flies
- poor packing and storage
- improper environment, and
- inadequate facilities for garbage disposal.

Yes, as you can see unclean environment and inadequate facilities for garbage disposal along with pest control are the major areas of concern in

ensuring food safety, especially in a country like ours. Waste products and left-over foods, if not disposed off hygienically, would pose a great threat to the food safety. It is essential to maintain adequate hygienic and sanitary conditions to avoid contamination of any type and spreading of harmful food borne diseases.

Finally, pest control is also a crucial factor in determining the safety of prepared foods. You would agree, this too is linked to the waste disposal strategies. An effective waste control system, itself would help in controlling the degree of pest growth and infestation. Hence, it becomes all the more imperative to ensure that all waste is handled and disposed off in such a manner so as to avoid contamination of food, water and the environment.

Liquid waste should be emptied into the nearest drain. Remaining foods may be separated and kept for feeding animals. Animals should not, however, be allowed to eat from utensils used to serve customers. Solid waste should be kept in covered containers to be removed at least once daily. With this, we come to an end of our study of factors influencing the food safety of street foods. Before we move on to the other topic, we would like you to take a look at a few simple tips to make sure that contamination does not occur by the consumption of street foods.

Here are some key Do's and Don'ts for the food handlers

Plan carefully

- Don't prepare/cook foods too far in advance.
- Don't buy more food than can be stored safely.

Temperature control

- Do keep hot food hot (above 630C) and cold food cold (below 80C).
- Don't leave food around on the stall for several hours.
- Do cook food thoroughly.
- Don't cut the cooking time because of a long queue of people.
- Make sure food is thoroughly thawed before cooking.

Avoid contaminating food

- Don't let raw foods or unwashed fruit come into contract with food that is ready to-eat.
- Do use separate utensils, chopping boards and knives for raw and cooked foods.
- Do display food off the ground.
- Do cover food with cling film, foil or place food in plastic containers.

Personal Hygiene

- Do wear clean over clothing.
- Do wash hands regularly, especially after handling raw food or refuse.

9.6 TEMPORARY FOOD SERVICE

We often participate in many social gatherings, be it weddings, birthday

parties or religious functions etc. Food service curing such occasions have become an inseparable part, and so with it comes the possibility of food getting contaminated. Here, we shall look at the various measures that need to be considered for preventing the chances of food getting contaminated. We already know that the temporary food service units operate at a fixed location for a period of time, in conjunction with a single event or celebration.

Normally, it is arranged with a specific purpose meant to cater to a group of individuals for a day or two. These are arranged invariably in the public places earmarked for such functions where specific provisions for preparation of foods (kitchen) are available or make shift cooking facilities are created. Under such circumstances, the management should ensure that there is an adequate space for cooking, proper utensils, storage and water facilities.

The kitchen or cooking area should bg properly ventilated with adequate exhaust facilities. Proper covers should be provided for ail utensils. Sufficient water sources should be made available with the provision for washing utensils and crockery before and after use. Care should be taken that potable water is made available for drinking purposes.

It is pertinent to mention here that if cooled water is to be provided by the addition of ice blocks, it is desirable to ensure that:

(1) the ice is prepared from potable water in the ice factory

(2) ice blocks are thoroughly washed with potable water before being placed in stored drinking water in order to eliminate extraneous matter, like saw dust/husks

(3) after washing the ice blocks, these are placed in the water rather than kept on the floor, and

(4) the water container is appropriately covered.

Remember, ice not prepared from potable water under hygienic circumstances is the potential source of health hazard.Regarding water and waste disposal, the waste water should not be allowed to stagnate in and around the area lest it becomes a breeding ground for insects and poses a health hazard to the community. Special attention has to be paid for the disposal of left-over foods. It should not be used for human consumption. The garbage disposal, including left-over food (in the plates), poses a serious health hazard in the transmission of food borne diseases. It is often noticed that no care is taken to ensure proper disposal and it is a common sight to see the garbage piling on the road side. It would be ideal to provide incinerator in each function hall. Alternatively, the management should ensure appropriate disposal of wastes.

9.7 FOOD SAFETY ON WHEELS, WINGS AND WAVES

Today, people are travelling from one place to another for various reasons like business, pleasure or even otherwise on a holiday. With an increase in travel and tourism, there is a need for extra care in the food safety practices to be adopted to

ensure safety of the commuting passengers. The main modes of transport for long distances are buses, railways, airlines within the country, and airlines and ships for going abroad. Hence safety on wheels, wings and waves is crucial.

The foods served on wheels, wings or waves have to be prepared under the supervision of trained personnel who are well versed in the safety methods to be adopted in food preparation. If not, the contaminated food can affect simultaneously few hundred persons at any given time on a train, air craft or ship. The food handlers should be educated in the proper handling techniques and especially should be made aware of the risks involved in storing foods at room temperature for longer periods. They have to be educated with regard to personal hygiene. We shall learn about these safety measures next, starting with the railways.

9.7.1 Railways

Normally, when we decide to dine out, we have a choice of either going to a restaurant or a hotel or a fast food joint etc. However, while travelling, one has to depend entirely on the food available on the trains or on canteens or food vendors at the railway stations.

The railways serve food to passengers on the train at selected places. The foods to be supplied are prepared in advance. Therefore, it is important to ensure that the food should not be prepared too early before the arrival of train. The cooking and packing time has to be kept to a minimum to ensure that the food is fresh. Adequate cooling and hot storage facilities for the food prepared in bulk has to be installed, as there is always the danger of trains getting delayed by several hours due to various reasons.

In such cases, any lapse in the storage of cooked foods exposes the passengers to a great risk of contamination. It is the duty of the railway catering services to install adequate hot and cold storage facilities and also to instruct the personnel in-charge of preparation and selling of food at the railway station, to safeguard the foods sold on a platform from exposing to environment by proper covering of the foods. To avoid contamination, the foods have to be served in a packed form or single use paper plates etc. to avoid contamination while washing and re-use. While packing foods, adequate precautions have to be taken in selecting the packing material. Packing in old newspaper or other material which has the possibility of contaminating the prepared food, has to be avoided. Finally, enough care has to be taken to supply potable water for drinking purposes. Railways, with a casual catering work force of about 20,000, is one of the biggest employers in the catering field.

9.7.2 Airlines

In the case of airlines, the commuting passengers in domestic flights stay abroad the air craft only for a few hours. In some international flights, the passengers travel for much longer periods. The passengers of the airlines are quite educated and are generally safety conscious unlike the majority of the railway passengers. There have been several instances in the past of huge compensatory claim suits due to serving of unsafe food.

As such, like in any other system, the safety precautions like avoiding cooking far in advance of the flight, proper packaging and storing etc. can go a long way in ensuring the safety of the passengers. As the passengers in air flights can be from Indian citizens to foreign nationals, the serving of safe food enhances not only the Indian culinary talents but also the reputation of airlines. Finally, food safety on waves i.e. abroad ships.

9.7.3 Food Safety Abroad Ships

Unlike the journey in railways or airlines, the time for travelling abroad a ship may extend from several days to several weeks. The food safety practices adopted abroad a ship has to be of a high order, otherwise, there is a danger of passengers getting sick, which will have a great impact. If the crew gets sick due to contaminated food, it poses a major problem. The danger of infected food handlers has an important role to play in the safety of foods prepared. The foods purchased for the long journey have to be of best quality and packed and stored properly.

We hope the discussion above would have given you a good insight about food safety measures to be adopted on wheels, waves and wings.

9.8 LET US SUM UP

In this unit, we studied about various features that need to be considered while planning a catering establishment. The various factors included ways to maintain a clean and hygienic premise, which further involved parameters such as floors, walls and ceilings, doors, windows, ventilation and lighting. Selection of equipments and utensils to adequately suit the requirements, as well as, sanitary standards, installing and laying them was described.

Considerations to be kept in mind while planning the kitchen layout, sufficient storage and transportation facilities were the other factors that were briefly dealt with. Further, in this unit, we studied about the concept of street foods and the various measures that are involved in ensuring their safety.

These included raw materials, water and ice, preparation, processing, transportation, handling and storage methods. Apart from these, the requirements at the point of sale and methods of waste disposal and pest control were discussed. The food safety factors specific to temporary food service establishments were also discussed.

Finally, the methods to ensure food safety on public transport modes were dealt with. The major modes of transport included were short and long distance covering i.e., railways, airlines and ships.

9.9 GLOSSARY

- Equipment . it includes stoves, ranges, hoods, meat blocks, tables, counters, refrigerators. freezers, sinks, dishwashing machines, steam tables and similar items, other than utensils, used in the operation ofa food service establishment.

- Food borne illness outbreak : an incident in which two or more persons experience a similar illness, usually gastroenteritis. after ingestion ofa common food which is identified as the source of food borne illness.
- Processing : to manufacture, compound, intermix or prepare food products for sale or for customer service.
- Utensils any implement used in the storage, preparation, transportation, or service of food.

9.10 CHECK YOUR PROGRESS

1) Give the basic criteria to select:
   a) Equipments
   b) Utensils
   c) Containers for food transportation
2) List the chief factors to be considered while planning the kitchen layout.
3) Explain the various storage techniques for different foods.
4) What is a food service establishment? Why is food safety an important consideration in a food service establishment?
5) Enumerate the general considerations to be kept in mind while planning clean and hygienic premises.
6) How can we ensure safety and quality of raw materials used in preparation of street foods?
7) What food safety problems are usually encountered with vending units?
8) What precautions must be taken to prevent contamination of foods served in railways?

UNIT

10

HYGIENE AND SANITATION IN FOOD SERVICE ESTABLISHMENTS

STRUCTURE

10.1 LEARNING OBJECTIVE

After studying this unit, you will be able to:

- define sanitation and discuss the types and uses of cleaning compounds,
- enumerate various disinfectants or sanitizers,
- discuss effective ways of disposing waste,
- adopt the practical measures of pest and rodent control,
- discuss the health status of employees handling food,
- describe the various parameters to ensure personal hygiene of the food handlers
- enlist employee facilities to ensure food safety.

10.2 INTRODUCTION

We already studied about food safety measures in food service establishments and other food service areas.

In this unit, we shall focus on sanitation and hygiene of food service establishments and its personnel. As you read through the unit, you will realize

that sanitation is not just cleanliness, it is much more than that. A food or an equipment can be free of visible dirt and still be carrying microorganisms or chemicals that can cause food borne disease or spoilage of food.

So then, how do we maintain good sanitation? What are the aids used for cleaning and sanitizing units? How waste disposal and pest control can influence the food sanitation programme? These are a few issues we will discuss in this unit.

Further, you must understand that a major risk of food contamination lies with the food handler. Dangerous organisms present in or on the food handler's body can multiply to an infective dose, given the right conditions come into contact with food or the surfaces used to prepare food. The food handlers infect the food, as well as, acquire the contamination from the food. It has been found that in all cases involving infected food handlers, they have acquired the infection from food handled in the course of their work. Food handlers, infected or colonized with pathogens may contaminate food, thus transmitting food borne illness.

In this unit, we will learn more about food handlers health status, personal hygiene and other requirements like cloak room facility, medical facilities etc. for ensuring food safety.

10.3 SANITATION IN FOOD SERVICE ESTABLISHMENTS

We start our study of this topic by first defining what is sanitation? A three-word definition of food sanitation is protection from contamination.

Primarily, sanitation comes from the Latin word Sanitas, which means health. Sanitation means creating and maintaining hygienic and healthful conditions. Food sanitation means creating and maintaining hygienic and healthful conditions in the food preparation, storing and serving areas. Sanitation is a dynamic and ongoing function and cannot be sporadic or something that can be turned on once a day, once a week, etc. Therefore, another definition could be sanitation is a way of life. What do you think? Sure, you would agree with this concept.

So then, why is sanitation important in food service establishments? There can be no two views about the fact that all food products must be protected from contamination from receiving (and before) through distribution.

Yes, contamination from microorganisms which can cause food spoilage and food bore diseases. Sanitary practices and hygienic conditions are important because food is being processed, prepared and sold in large volumes than before. Sanitation can reduce contamination of food by microorganisms which are a major cause of food borne illnesses. Further, sanitary principles also apply to waste disposal and can help reduce pollution and improve ecological balance in and around the food service unit. We already learnt that all plants and animals have a natural microflora associated with it. These microflora are one of the sources of microorganisms associated with spoilage.

Equipment, employees, air and water, insects and rodents, sewage all

are potential sources of contamination. Therefore, healthy sanitary practices, appropriate cleaning programme and pest management system must be developed and implemented within the food service establishments to prevent microbial contamination and ensure safe food. Cleaning and sanitization should be accorded utmost priority. By cleaning we mean, free from dirt, stain, or impurities, unsoiled. The cleaning process, therefore, primarily removes the soil deposits. Sanitizing, on the other hand, destroys microbes that are left on the cleaned surfaces. Various cleaning agents, sanitizers, disinfectants are available and approved for use in food service units.

10.3.1 Cleaning Agents

Food particles and other debris provide good nutrients for the microorganisms to grow. In fact, the food particles protect microorganisms during cleaning. Hence, it is essential to clean food debris before applying sanitizers. Before we understand about cleaning agents, we must know how they work. Cleaning agents work in two ways:

1) lower the energy of the bond between the food debris and the surface, so that the debris can be dislodged and loosened, and

2) suspend the debris in the solution so that they can be flushed away.

Depending upon the type of soil (food debris), water supply, use for specific purposes, area and kind of equipment to be cleaned, various kinds of cleaning compounds are used. Good cleaning compounds are economical, easy to measure and dissolve well.

They are approved for use on food surfaces, are not corrosive and do not cake, leave dust, or break during storage. They are classified based on their chemical properties i.e. alkaline cleaning compounds and acid cleaning compounds. Before the advent of these chemicals, there are certain natural compounds which have been in use in India.

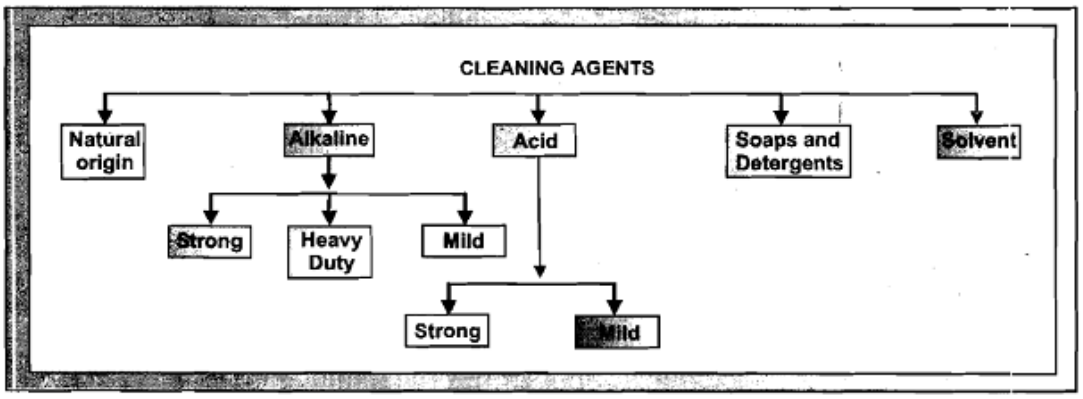

Figure 10.1 : Classification of cleaning agents.

A) Cleaning substances of natural origin

Bengal gram powder or besan is a natural cleaning powder that has been used in India, since times immemorial. It has been traditionally used to remove oily adherences of cooking utensils.

B) Alkaline cleaning compounds

Carbonates, bicarbonates, hydroxides of various metals are called alkaline compounds. Alkaline cleaning compounds have a pH between 7 and 14.

Cleaning compounds which have a pH near 14 are called strong alkaline cleaners, e.g. sodium hydroxide, which destroys microbes, dissolves protein and effectively disperses and emulsifies the soil. Use of silicates with sodium hydroxide makes it less corrosive but improves its penetrating and soil removing property. These are used specially in commercial ovens and smokehouses. These cleaners have strong dissolving powers and are very corrosive.

If these come in contact with skin, they can lead to burns, ulcers and scarring. In fact, a prolonged contact may cause permanent damage. Inhaling its fumes or mist can cause lung damage. Another type of alkaline cleaner is heavy-duty alkaline cleaners. These have moderate dissolving powers and are either slightly corrosive or not corrosive at all. These are often used for cleaning in-place or high pressure or other mechanized systems. They are very good at removing fats but do not remove mineral deposits. One of the widely used and cheap heavy-duty cleaner is sodium carbonate. Now, we come on to the third category i.e. mild alkaline cleaners.

These are used to clean lightly soiled areas by hand. These compounds are good at softening water but do not remove mineral deposits. Sodium bicarbonate is an example of a mild alkaline cleaner.

C) Acid cleaning! compounds

Acid-based cleaners like phosphoric acid and hydrofluoric acid are commonly . used. They are very useful in removing minimal scales that are dried on or encrusted on equipments or utensils surfaces.

They are especially good at removing mineral deposits on metal surfaces. The acid cleaners dissolve the minerals in the deposits so that they can be easily removed. Organic acids, such as citric acid, tartaric acid are also used as cleaning compounds and are excellent water softeners, rinse off easily and do not corrode surfaces or irritate the skin. Inorganic acids, though excellent at removing and controlling mineral deposits, can be very corrosive to surfaces and irritating to the skin. These are used for special cleaning purposes, and are comparatively less effective against the soil caused by fats, oils and proteins. Like the alkaline cleaning compounds, acid cleaning compounds can also be classified into strongly acid cleaners and mildly acid cleaners. The strongly acid cleaners corrode concrete, most metals and fabrics. Further, if heated, it produces corrosive and toxic gases, which can damage the lungs. However, they are very effective cleaning agents.

They remove encrusted surface matter and mineral scale from stem equipment, boilers and some food-processing equipment. The most commonly used strong acid cleaner is phosphoric acid, as it works well with many surfactants and is not very corrosive. Hydrofluoric acid is another acid cleaner, however, it is corrosive to stainless steel and dangerous to handle because it tends to release hydrogen gas. Mildly acid cleaners are slightly corrosive and may cause sensitive reactions. A few examples are hydroxyacetic, acetic and gluconic acid. Cleaners like acetic acid and gluconic acid are good manual cleaners.

D) Soaps and detergents

Soaps and detergents emulsify fats, oils and grease so that they are easily washed away. They usually contain chemical builders to enhance their cleaning efficiency.

Soap is an oldest and best cleaning compound used but it forms an insoluble curd with hard water, hence not preferred. Instead, detergents are used. A detergent is a substance which assists in cleaning when added to water.

These are normally sodium salts of fatty acids. To be effective, a detergent must have a good wetting capacity and the ability to remove soil from surfaces and carry away residues. Soaps and detergents for household cleaning have a pH of 8.0 to 9.5.

E) Solvent cleaners

Solvent cleaners are based on ether or alcohol and work well on soils caused by petroleum products, such as lubricating oils and greases. These are used to remove large amounts of petroleum deposits in areas free of protein-based and greasy soils. They may be mixed with wetting agents, water softeners and other additives.

In addition to these cleaning compounds discussed above, depending upon the type of food debris, certain additives are also used as cleaning agents for better performance. They may be:

- Sequestrates, which chelate metals like magnesium and calcium and prevent their interaction with food components or utensils. It actually is a chemical added to cleaning compounds to prevent the salts of calcium and magnesium in hard water from forming deposits on equipment surfaces.
- surfactants, which are complex molecules that blend with a cleaning compound to reduce the bond energy around the soil and allow closer contact between the soil and the cleaning compound. In other words, these agents help to spread cleaning or sanitizing compounds and the surface to be cleaned.

Before we end our discussion on cleaning agents, we would also like to focus on issues related to choosing a cleaning agent. It is important to choose the right cleaning agent for the type of soil. A good rule to remember is that 'like cleans like' i.e., an acid soil requires an acid cleaner, while an alkaline soil is best removed by an alkaline cleaning agent. Heavy-duty alkaline cleaning agents work best with heavy deposits of fats and proteins. Acid cleaning agents remove mineral deposits and other soils that are not removed by alkaline cleaning agents.

Phosphates complexed with organic chlorine are the most common types of cleaner-sanitizers. Having studied about cleaning agents, next let us get to know about disinfectants and sanitizers.

10.3.2 Disinfectants or Sanitizers

We learnt earlier that a cleaning process removes the soil deposit. A disinfectant is a chemical substance which is capable of killing microorganisms. A disinfectant is also referred to as sanitizer, signifying the properties of their activity in maintaining sanitary conditions.

What are the disinfecting agents used in the food industry?

The disinfecting agents used generally in the food industry include:

A) Chemicals, such as

a) Chlorine releasing compounds

b) Iodophors/lodine compounds

c) Quarternary Ammonium Compounds (QUATS)

B) Amphoteric compounds

C) Heat

D) Radiation

Let us study these in detail.

A) Chemicals

Food processing and food service operations use various chemical sanitizers for different areas and types of equipment. Before we learn about these sanitizers, we need to know that the effectiveness of chemical sanitizers depends on few factors which include:

- **Exposure Time** — The death of microbial colonies follow a logarithmic pattern i.e. if 90% of microbes die in 10 minutes, 90% of the remaining microbes die in the next 10 minutes and so on.
- **Temperature** — Microorganisms are killed more quickly at higher temperatures by the use of chemical sanitizers. In other words, higher temperatures usually speed up the death rate of bacteria than their growth.
- **Concentration** — The higher the concentration of sanitizer, quicker is the rate of microorganisms kill
- **pH** — Small changes acidity or alkalinity affect the activity of sanitizers.
- **Cleanliness** — The reaction of the soil on equipment and surfaces with sanitizers leads to neutralization of the sanitizer in such a way that it does not work properly.
- **Water hardness** — Hard water makes sanitizers less effective. The calcium and magnesium salts in hard water neutralize quaternary ammonium compounds. If the water has over 200 ppm of calcium, a sequestering or chelating agent should be added.

a) Chlorine-releasing compounds

Of all the chlorine - releasing compounds, hypochlorites have been the choice disinfectants used in food industry. The hypochlorites are powerful disinfectants with a wide range of anti-bacterial activity including bacterial spores. The salts of hypochlorous acid (HOCI) like sodium hypochlorite (NaOCl) are widely employed. They dissociate to form OCI, which is the ion that is responsible for the bactericidal property. The diluted solutions of sodium hypochlorite are used widely but they should be used very carefully as they are corrosive and are skin irritants. They have to be prepared fresh before use.

Advantages	Disadvantages
▪ Kills all types of vegetative cells ▪ Easily available and cheap ▪ Hard water does not make them less effective	• Unstable, heat and light breaks them down and organic soil makes them less effective • Corrode stainless steel and other metals • Can be in contact with food handling equipment for a short time, else they corrode it

Table 7.2: Advantages and disadvantages of using chlorine-releasing compounds

b) Iodophors

In these disinfectants, iodine is incorporated along with a detergent. They are not as effective as hypochlorites against bacterial spore but also get inactivated in the presence of organic matter. They have a long shelf life, but once dissolved, the iodine may vapourize. Iodophors, are generally used in the dairy industry due to their bactericidal capacity, as well as, the presence of phosphoric acid which is helpful in the control of milk stone. The stone is the deposition of mineral salts on equipments due to the presence of fats and proteins. It is a very good hand sanitizer and hand-dipping agent because it does not irritate skin. However it has following disadvantages:

- expensive than chlorine compounds
- cause off-flavours in some food products
- vapourize at 500C (approx.), and
- sensitive to pH changes.

c) Quaternary Ammonium Compounds (QUATS)

These compounds are ammonium salts and are quite expensive and less effective when compared to hypochlorites and iodophors. The solutions of these compounds have the tendency to stick to the surfaces and require thorough cleaning. They have to be used in higher concentrations when used with hard water. The most common quaternary compounds are the cationic detergents, which are poor detergents. QUATS form a bacteriostatic film over the surfaces, which is better at killing some bacteria when compared with other sanitizers.

They do not kill bacterial spores, rather they inhibit their growth. They work at a high pH and are effective against moulds. Having studied about the chemical sanitizers above, we move on to other disinfectants and sanitizers which can be used in food service establishments.

d) Antphoteric compounds

Amphoteric compounds are essentially alkyl or acyl amino acids. They combine

detergent and disinfectant properties. They are generally very expensive than other disinfectants.

C) Heat

The efficiency of heat, as a sanitizer, depends on the humidity, temperature required and the length of time it takes to destroy microbes at that temperature. The most common types of heat used for sanitization are steam and hot water. The sterilization of an item depends on the time-temperature relationship. This means that if equipments are sterilized at a lower temperature, they must be kept at heat temperature for longer duration while if they are sterilized for a shorter duration, the temperatures must be higher. Examples of time-temperature combinations are 15 minutes of heat at 85^0C or 20 minutes at 82^0C.

D) Radiation

Radiation as ultraviolet light or energy cathode or gamma rays destroys microorganisms. However, it is not entirely effective in food processing and food service facilities for the following reasons:

- Some bacteria are more resistant to radiation and need a longer exposure for destruction
- Rays kills only the microorganisms that are very close by
- Dust, grease and opaque or cloudy solutions absorb radiation and prevent it from killing microbes.

The discussion above, we hope, provided you a comprehensive understanding about cleaning agents, disinfectants and sanitizers.

10.3.3 Waste Disposal

An adequate and hygienic waste disposal system is a necessity for any food service establishment. What does this waste material consists of and what is the appropriate method of discarding it? Let's find out.

Well, the waste materials from food establishment include food scraps, vegetable peels, empty covers and other liquid wastes which cannot be washed down through the 'sewage lines. All such wastes should be collected in waste bins specially kept for collection. They should be first collected in plastic bags before putting them in the waste bins with lids. The solid wet wastes should be collected in the polythene covers and sealed before disposal. In the kitchen, the wastes generated due to continuous operations of food preparation .should be immediately collected into foot-operated suitable waste bins which have tight-fitting lids. They must not be allowed to accumulate except where it is unavoidable.

They should be frequently transferred to the big waste bins kept outside the food preparation area and cleaned each time with disinfectants. All waste bins should be set up in a corner outside the kitchen over a raised platform or stands specially made for placing the bins which should be easily removable. They should be closable and maintained in a sound condition. They must have tight lids to avoid the pollution of surrounding areas. The area around the waste bins should be always kept clean and nuisance-free by using disinfectants. There should be a tap point in this area for ready cleaning operations. Good control and management of refuse and refuse areas

can also prevent odour nuisances occurring and avoid pest and insect infestations.

10.3.4 Pests and Rodent Control

In any food establishment, varieties of insects, pests and rodents pose a big threat to the maintenance of hygienic surroundings. They contaminate food with hair, fur, droppings. eggs and dead bodies, as you have already learnt earlier. They can also cause considerable damage to food stocks and premises. The common pests found in food processing and food service establishments include two groups of insects, the flies and cockroaches, which are the important carriers of food borne diseases. Flies feed indiscriminately on waste matter, animal wastes and on food from kitchens.

The housefly may successively visit a dirty cup, clean glass, a waste material and a dish containing cooked food. The flies leave an invisible trail of bacterial and other disease causing germs. Remember, housefly can spread typhoid, dysentry and diarrhoea. They may also have a part in spreading cholera and many other diseases.

Ants are considered harmless but they too create nuisance. They live in walls and soil. They eat a wide variety of foods. The cereal mite which is widely distributed is found stored in dry food commodities like flour, suji etc. There are other insects like borers which can cause damage and contamination of foods due to their quick movements from place to place.

Preventive measures are ideal. It should be ensured that no food scraps are left lying out. No dirt or rubbish is allowed to accumulate. Ali holes, gaps, drains and air ducts should be covered with thick wire mesh or grating.

Drying the raw materials like grains, adequately preserving commodities like suji, maida (refined flour) at low temperature are ideal. Regular checkups must be made to ensure that the premises are free from pests. The persons responsible for pest control should:

- inspect all internal and external areas of food premises
- revisit if there are signs of infestation
- ensure that insects are properly identified to carry out effective treatment, and
- maintain the records of chemicals, pest problems, indications of infestation.

Insect control

The insects can breed and hide in garbage and other places where there is availability of waste materials. The cockroach lives and breed in moist dark places around plumbing cupboard, pantries and under refrigerators. The best prevention approach is to fit all the doors, windows and ventilation with wire-mesh. The flying insects can be destroyed by employing fluorescent tubes which attract and destroy them due to an electrified field. They are collected in a collecting tray. The crawling insect hideout should be sealed by blocking all the cracks etc. which harbor insects. They are generally destroyed by spraying and using commercial insecticides like pyrethrum.

The cockroaches can be prevented entry by painting a band of insecticide between the joints of wall and floor. Of late, aerosol sprays have become very popular in eliminating flying insects. But care has to be taken to avoid contamination of foods

and food contact surfaces getting sprayed with the aerosols.

Rodent control

Rats and mice are destructive and cause huge loss of stored food commodities. They transmit pathogenic bacteria. Rats and mice are generally most active during twilight hours. If food and wastes are stored and handled properly, the rodent infestation could be reduced or eliminated. They can squeeze past narrow openings and gnaw the edges of wooden doors. Rodents gain entry into the premises in bags of flour in straw packages, boxes, cartons etc. If proper storage practices are not adopted and things are scattered, rodent infestation is sure to occur.

Rats need lots of water, in fact, they drink three times the amount they eat. Signs of rodent infestations are evident by presence of droppings, greasy foot prints and rat odour. Baited traps and other tracking methods could be followed to ensure that rodents are not present in the food area.

Other control measures include:

- regular checking of new deliveries, stored stock and equipment for signs of infestation
- storage of open dry foods in solid with close-fitting lids
- storage of goods off the ground and clear of walls, with adequate space between stocks
- clear spoilage as soon as possible, and
- empty bins in the kitchen frequently and keep them clean.

Prevention

Best preventive measure is to correct all dripping taps, repair defective gutters and also make the food unavailable by proper storage of foods in metal containers. The empty cartons, boxes should be stacked on a pallet and away from walls, as rats prefer to move nearer to the walls.

Here, it can be summarized that pest control is essential in any food service establishment because of:

- preventing the spread of disease
- preventing the wastage of food
- preventing damage generally caused by gnawing of electric cables or pipes, and
- preventing loss of customers who are well-aware and educated about hazards of eating in infested premises.

Food refuse container should be cleaned after discarding. Care has to be taken to remove food scraps, crumbs, vegetable peelings etc. They should not be left on the floor and ensure that premises is as clean and neat as possible. The rodents can be refused to gain entry into the building by rodent proofing the building by changing the defective doors, windows, cupboards and covering up of small openings especially the corners of doors and windows, pipes, floor drains, exhaust fan openings. To control the rodents, either traps or poisoning is employed. Care has to be taken while rodenticides are employed as their poisons are harmful to human beings. The rodent

eradication programme has to be undertaken by an experienced and trained person.

Apart from all these measures, a properly planned maintenance of premises with periodic checks of food storage, preparation areas and efficient handling of wastes helps in preventing the pests' entry into the food service establishment.

To protect the premises from insects, rodents and pests and reduce the risk of infestation, the following points have to be kept in mind:

- Keep the premises clean
- Clean all spillages promptly
- Check all incoming goods and boxes
- Keep doors and windows screened
- Keep reusable boxes, crates etc. out of the kitchen
- Keep drains clean and in good condition
- Cover the waste bin. Empty accumulated wastes promptly and wash it regularly along with the surrounding area
- Keep the shelves, cupboards and drawers in good repair
- Use of proper "dunnage" racks below stored products, so that the areas can be
- cleaned without difficulty and moisture does not migrate
- Sightings of pests or pest damage are reported to management
- Periodically undertake vermin elimination programme with the help of a trained person

10.4 HYGIENE REQUIREMENTS FOR LICENSING AND SALE

The Government of India has prescribed the following hygiene requirements under the PFA Rules 1955, for licensing and sale of food items:

a) No license shall employ in his work any person who is suffering from infectious, contagious or loathsome disease.

b) No person shall manufacture, store or expose for sale or permit the sale of any article of food in any premises not effectively separated to the satisfaction of the licensing authority from any privy, urinal, sludge, drain or place of storage of foul and waste matter.

c) Every utensil or container used for manufacturing, preparing or containing any food or ingredient of food intended for sale shall be kept at all times in good order and repair and in clean and sanitary conditions. No such utensil or container shall be used for any other purpose.

d) No person shall use for manufacturing, preparing or storing any food or ingredient of food intended for sale, any utensil or container, which is imperfectly enameled or imperfectly tinned or which is made of such materials

or is in such a state as to be likely to injure such food or render it noxious.

e) Every utensil or container containing any food ingredients intended for the manufacture of food / sale, shall at all times be either provided with a tight-fitting cover or kept closed or covered by a properly fitting lid or by a closed fitting cover or gauze, net or other material of a texture sufficiently fine to protect the food completely from dust, dirt, flies and other insects.

f) No utensil or container used for the manufacture or preparation of or containing any food or ingredient of food intended for sale shall be kept in any place in which such utensil or container is likely by reason of impure air or dust or any offensive, obnoxious or deleterious gas or substance or any noxious or injurious emanations, contaminated and thereby render the food noxious.

10.5 HEALTH STATUS OF FOOD HANDLERS

The term 'food handler' applies to the persons who prepare food and sell it. He is the key person to maintain food safety in the food service establishments since he/ She works with unpackaged food, food equipments or utensils, or food contact surfaces. In this context, therefore, people known or suspected to be suffering from or to be a carrier ofa disease or illness, likely to be transmitted through food, should not come to work or allowed to enter any food handling area if there is a likelihood of their contaminating food.

Every employee should be thoroughly checked for medical clearance before being employed. This gives an indication of this general health status. Although his subsequent ill health could not be assessed on his initial health report, it would be easy to monitor him afterwards for a major illness. The first principle to be taught to the employee is that he should inform the management about his health problem so that a preventive strategy could be worked out. Medical examination of a food handler should be carried out if clinically or epidemiologically indicated.

The conditions or the specific infections which should be reported to management so that any need for medical examination and/or possible exclusion from food handling could be considered, include:

- jaundice
- diarrhoea
- vomiting
- fever
- sore throat with fever
- visibly infected skin lesions (boils, cuts, etc.)
- discharges from the ear, eye or nose

Food handlers should not have:

1) Salmonella typhi

2) Shigella

3) Shigatoxin producing E. coli

4) Hepatitis A virus

It is important to remember that any worker infected by the above mentioned microbes, should pot touch food or equipments/utensils used to process, prepare or serve food. Contaminated foods can cause several illnesses, including:

- Respiratory diseases, e.g. cold sore throats, pneumonia and tuberculosis
- Gastrointestinal diseases, e.g. vomiting, diarrhoea, dysentery
- Typhoid fever
- Infectious hepatitis

The important thing to note is that even after worker has recovered from the illness, he/she often becomes the carrier. This means they still carry the disease-microorganisms in or on their body This requires special attention.

10.6 PERSONAL HYGIENE

The word hygiene means using sanitary principles to maintain health. Just as food hygiene refers to all conditions and measures necessary to ensure the safety and suitability of food at all stages of the food chain, personal hygiene refers to all conditions and measures necessary to ensure the cleanliness of a person's clothes and body. Food worker need to be healthy and clean to prepare safe food. The food handler should keep his hands, arms and exposed parts very clean.

They should wash their hands after touching bare human body and after using the toilet room. Hands, breath, hair, sweat, coughs and sneezes all carry microorganisms. Even if a food handler does not feel sick, he or she could still be carrying the microorganisms that can cause illness if they get into the food. Hence, it becomes vital to consider the sources of microbial contamination. All food handlers should remember the following:

- Scrupulous personal cleanliness is essential for those responsible for food storage, preparation, cooking and service
- Food should be touched by hand only when there is no alternative
- Refrain from behaviour which could result in contamination of food, for example,smoking, spitting, chewing or eating, sneezing or coughing over unprotected food
- Eating and drinking, while working, can spread germs from the person's mouthto hands
- Hands should be clean at all times with short nails and no nail paint
- Personal effects such as jewellery, watches, pins or other items should not beworn or brought into food handling areas, if they pose a threat to the safety andsuitability of food, and
- illness must be immediately reported.

Personnel should always wash their hands when personal cleanliness may affect food safety, for example:

- at the start of food handling activities
- immediately after using the toilet, and
- after handling raw food or any contaminated material, where this could result in contamination of other food items. They should avoid handling ready-to-eat food, where appropriate.

To understand why employees need good personal hygiene it is vital to consider the following sources of microbial contamination:

1). Skin

The skin constantly deposits sweat, oil and dead cells on its outer surface. When these materials mix with dust, dirt and grease, they form an ideal medium for the bacteria to grow. Therefore, bacteria from skin can contaminate food. If the secretions build up and bacteria continuously grow, the skin can become itchy and irritated. Food handlers rub or scratch the skin and transfer bacteria when they touch it. Regular bathing and washing often reduces the number of microorganisms. Poor skin bare and skin disorders can also cause bacterial infections like boils. Boils, you may already know, are severe local infections caused by the infections in hair follicles skin glands after the outer layers of skin get damaged.

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. The body forms a barrier around the boil to prevent the infection from spreading. Hence, a boil should never be squeezed. If it is squeezed, it will spread the infections and cause a cluster of boils called as a carbuncle.

Food handlers should use a hand dip for disinfection after touching boil or pimple. To prevent contamination of food by harmful bacteria, employees should where appropriate, wear suitable protective clothing, head covering and footwear, cover boils, cuts, wounds and septic spots with suitable water-proof dressings.

2). Hands

Bacteria may be picked up by the hands when they touch dirty equipment, contaminated food, clothing or parts of the body. Food handlers should wash hands frequently and use a hand dip sanitizer after touching these things so that they do -not contaminate food. Food handlers must wash their hands regularly and especially:

- before starting work
- on returning to work after each break
- after going to the toilet
- on entering the food processing/preparation area
- in-between handling of raw and cooked foods
- after combing or touching the hair
- after eating, smoking, coughing or blowing the nose
- after handling waste food or refuse

- after handling cleaning chemicals, and
- after contact with pests or contaminated food.

Washing the hands with soap and water removes transient bacteria and using a hand soap that contains an antiseptic or sanitizer controls resident bacteria.

3). Finger nails

One of the easiest ways to spread bacteria is through dirt under the finger nails. Food handlers should never handle food if their finger nails are dirty. Food handlers should not have long finger nails or artificial finger nails, while working. Jewellery Food handlers should not wear jewellery in food processing or food service areas, as they harbor dirt and bacteria. It can fall into the food and can contaminate the food, further it can also get caught in machinery, causing a physical and safety hazard.

4). Hair

Hair is constantly falling out and along with dandruff, can result in the contamination of food. Scalp carries microorganisms especially Staphylococci. While handling food, food handler should wear a hairnet or suitable head covering such as a cap or scarf which completely encloses the hair. Combing of hair near the work area should be avoided and take place only in the cloak room and should not be carried out while wearing the protective clothing, as hair may end up on the shoulders and then in the product. Lastly, the workers should always wash their hands whenever they scratch their heads.

5). Eyes

Normally, eyes do not carry bacteria. But whenever there "is an eye infection, food handlers may rub their eyes with hands and thereby there is a chance of the food getting contaminated.

6). Mouth

Mouth carries many bacteria, particularly Staphylococci. Many bacteria and viruses found in mouth can cause disease, especially if the employee is ill. Food handlers, while working, should not eat sweets, chew gums, tobacco, pan masala, gutka etc. or blow into glasses to polish them. Tasting food by licking finger or an unwashed spoon is a bad practice and should be avoided. Smoking should not be allowed in food service establishments. Smoke can cause transmission of bacteria from mouth to the food. Smoking leaves an irritating taste in the mouth which makes the person to spit. Spitting should not be allowed in food processing operation.

7). Nose, Throat and Lungs

Compared to mouth, nose and throat have fewer bacteria. Up to 40% of adults carry Staphylococci bacteria in the nose and mouth. Employees who have sinus infection will be suffering from nasal discharges, they should be careful in handling the food.

They should use decongestants to reduce discharge, wash and disinfect their hands after blowing their noses. Picking or scratching the nose is not acceptable. Cough and sneezing can carry droplet infection for a considerable distance and

person with bad cold should preferably not handle open food.

Sore throat is usually caused by a type of Streptococci. Streptoco&i cause scarlet fever, rheumatic fever and tonsillitis. These diseases spread if employees' personal hygiene is poor.

Influenza infects the body through lungs; secondary bacterial infections by Staphylococci, Streptococci or Pneumococci can cause death. All such ailments must be reported to the supervisors and medical clearance should be sought.

8). Personal habits

Do you know that apart from personal hygiene, faulty personal habits of the food handlers have an adverse effect on the quality and safety of foods?

Personnel engaged in food handling activities should refrain from behaviours which could result in contamination of food. What are these habits or activities? Let's find out. Smoking, pan chewing, eating etc. should not be done in food handling areas. Smoking, in fact, should be prohibited in the work area.

Not only is this to prevent cigarette ends and ash contaminating food but also because:

- people touch their lips whilst smoking and they may transfer harmful bacteria to food
- smoking leads to coughing and droplet infections, and
- cigarette ends contaminated with saliva are placed on working surfaces and hence can contaminate food

Food handlers should not have bad hygiene practices like nail biting, keeping the fingers in ears or nose, tasting food through finger etc. Supervisory staff should carefully observe the food handlers for their behaviour while carrying out the job and should be suitably advised.

9). Clothing and Headgear

Food handlers should wear protective clothing while they are in food handling areas. Clothing should be light in colour, mostly white is preferred. It should be made up of a material that can be easily washed and kept clean. Nylon clothing has an advantage that it can be washed at the end of working day, dried overnight and needs no ironing. But in our hot climate, cotton clothing is preferred, but it has to be washed and ironed regularly.

Cooks should wear white caps/protective headgear to protect the food from hair, as well as, to protect the hair and scalp from the effects of steamy heat. This helps to ensure that hair and dandruff does not contaminate food or surfaces. The long hair should be tied back. These clothings should not be worn outside the food premises not used. to and from work and not worn during lunch time sporting activities. This is to prevent contamination from bacteria and dirt and physical contamination from buttons etc. falling into open food.

Also, outdoor clothing and personal effects must not be brought into food rooms unless stored in suitable lockers. Suitable footwear should be worn to prevent slipping and to protect the feet.

10.7 FACILITIES TO EMPLOYEES

The management, in any food service unit, must have a protocol to. make sure employees use hygienic practices and provide them with facilities, services and training to make it easy for the employees to stay clean and hygienic.

- **Toilets**

Adequate toilet facilities must be provided for employees, particularly separate facility for male and females. However, number of toilets to be provided in each food service establishment depends on the number of work force.

Fruit Products Orders, Meat Food Product Orders and Milk and Milk Product Orders specifically indicate the number of toilets to be provided under sanitary requirements. Wash hand basins should also be provided within the areas, with adequate hot and cold water supplies, soap, and a suitable hand drying facility (preferably paper towels).

Cleaning and disinfection should be carried out at least once per day. Construction materials for ceilings, walls, floors and cubicle partitions should be durable and impermeable to water. Junctions between walls and floors should be covered and wall angles should be rounded. Floors should slope towards drain. All sanitary conveniences within the food premises must be provided with adequate natural or mechanical ventilation. Efficient ventilation to the outside atmosphere, possibly aided by extraction fan, is vital. This is to prevent (as far as possible) aerosols and offensive odours from permeating the food rooms.

Lavatories, must not lead directly into rooms in which the food is handled. Toilets must be ventilated and must not communicate with a food room. This means there must be a lobby between the toilet and any food room. Ideally this lobby should be ventilated. All toilet facilities should be well maintained and operating at all times. Sufficient wash basins should be provided in all toilets. Hot and cold water taps are required, which should be foot operated. Liquid or powdered soap dispenses should be provided rather than cakes, as they are likely to p« contamination from one food handler to often Hand drying should be by means disposable paper towels or by warm air driers.

- **Wash hand basins**

An adequate ' number of wash hand basins must be available which' are suitably located and designated for cleaning hands. The number of basins will depend on the size of the business and the size and layout of the premises. They must be located close to toilet facilities and at strategic places in the premises, so that workers have convenient access to them.

Wash hand basins must be provided with hot and cold (or appropriately mixed) running water, materials for cleaning hands and for hygienic drying. Antibacterial soap and paper towels are ommended. Where necessary, the provisions for washing food must be separate from the hand washing facility.

- **Hand dip**

Hand dip facility consisting ofa bowl containing sanitizers need to be made available

at convenient location. The sanitizers in the bowl need to be changed every day. It has been often observed that once sanitizer solution is kept in the bowl, is not changed. Often bacterial slime is formed at the bottom of the bowl. Studies carried out on food safety in many food industries like milk, milk products, mushrooms have indicated that food handlers are the main source of contamination. A simple hand dip facility would minimize the contamination from food handlers.

- **Cloak rooms**

Best place for sitting, the cloak room should be at the entrance of the factory/ food service establishment. Adequate changing facilities for personnel must be provided. Provision must be made to allow food handlers to change and to store their street clothes and personal effects away from open foods. It is a good practice to have separate changing rooms and to provide secure storage for personal effects.

Lockers should be used for keeping only outdoor clothes and personal items should not be üsed to store food. Locker taps should be sloped or abutted against ceiling in order to prevent their use as storage space and a collection point for litters. Litter is often thrown behind the lockers and so lockers should be located centrally in rooms with an access nearest to walls.

Cloak rooms should have toilet facilities. Showers should be provided for employees handling raw meat, poultry, fish and for those working in humid conditions. Showers should be provided at the rate of 1 per 20 employees.

- **Canteens**

Food service facilities of one form or the other must be provided for employees. Depending upon the type of service i.e. canteen or cafeteria, the layout and maintenance has to be designed. Dining, service, storage, waste disposal, washrooms and kitchen should be regularly cleaned. All corridors should be screened and the doors should be self-closing. If the full canteen facilities are not provided, vending machines snacks should be made available.

- **Health facilities**

As a minimum requirement, one first-aid room which can also be used as a rest room, should be provided. If the numbers of employees are more, part-time or full-time medical officer may be employed. First-aid room must provide the following facilities to the employees:

- cover all cuts with a blue waterproof plaster or porous plaster and blue waterproof Safety finger stall, and
- medication should not be kept in the first-aid box or given to staff.
- In addition to the facilities enumerated above, it is the duty of the management to put in place measures which would minimize hazards associated with staff.

- **Minimizing hazards associated with staff**

The hazards of contamination and cross contamination can be minimized by making sure that the staff:

- receives appropriate training and supervision when new to the job and whenever changes in staff duties or in processes require them to have additional understanding and skills relating to food safety and hygiene
- attend suitable training courses in hygiene awareness and maintenance of hygienic practices and standards
- wash with soap and dry their hands immediately before starting work and frequently throughout the day and always after using the toilet, combing hair, handling waste, eating, blowing nose, and after handling any item likely to harbor a hazard to food safety, e.g. used packing material, food containers, etc.
- keep hands clean throughout the milking operation, cheese-making and retail activities
- wear suitable clean working clothes. The light coloured clothing must be worn, which covers personal clothing and which should not have pockets. Poppers may be preferable to button fastenings, as buttons may fall into products. It is good practice for food handlers not to wear one piece overalls as they may come into contact with the floor, e.g. when using toilet facilities
- use plastic aprons where appropriate
- keep their hair clean and tidy. If hair is long, it must be kept tied back neatly away from the face. Do not smoke, eat or drink in work areas
- follow recommended good practices by not wearing jewellery or watches
- when the food handlers join the business, they should have no medical condition which would affect the safety of the food being handled, e.g. this would include people who have been ill with symptoms of Salmonellosis and who have subsequently recovered but who may still carry the bacteria which could be passed on to food
- keep any wounds to the skin covered with a waterproof dressing
- notify the concerned authorities when they (or a partner or other family member) are ill where there might be food safety implications
- if they are suffering from illness, do not milk animals and do not handle the food
- do not work if they are suffering from diarrhea and/or vomiting
- do not return to work after illness until fully fit, and
- are free of medical conditions which would affect food safety when they return from holiday or a break.

10.8 LET US SUM UP

In this unit, we studied about sanitation practices to be followed in maintaining hygiene in food service establishments. In this respect, action of cleaning agents was described followed by the classification of cleaning agents into alkaline and acid compounds. Further, the properties of disinfectants/sanitizers in maintaining the

sanitary conditions in the food industry were discussed. A variety of disinfecting agents including chemicals, heat and radiation were also described. Finally, the measures of pest and rodent control were discussed along with the hygiene requirements for licensing and sale of food items under the PFA Rules, 1955.

The second part of the unit focused on the health status of employees handling food. The personal hygiene of food handlers was emphasized that included the various body parts, such as skin, hands and fingernails, hair, mouth, nose and throat. Also, the various facilities to be provided to the employees to ensure minimal risk of food borne diseases were described in detail. The provision of toilets, cloak rooms with adequate facilities, canteens or vending machines, hand-dip sanitizers and first-aid and other medical facilities to the food handling staff as one of the measures to ensure food safety were discussed.

10.9 GLOSSARY

- Amphoteric compounds : alkyl or acyl amino acids.
- Boils : severe local infection caused by infections in hair follicles or skin glands after the outer layers of skin gets damaged.
- Carbuncle : a cluster of boils.
- Decongestant : a medicine to treat nasal infections. planks and pieces of wood used to protect
- Food borne illness : illness or disease caused by the ingestion of foods containing toxic or infections agents.
- Tonsilitis : inflammation of the tonsils.

10.10 CHECK YOUR PROGRESS

1) Explain the working of cleaning agents.
2) How can cleaning compounds be classified? Give examples.
3) Explain the following terms:
   a) Food Sanitation
   c) Disinfectant
   d) Detergent
   e) Surfactant
4) Give any two ways of hygienic waste disposal.
5) Why do you think pest and rodent control is essential?
6) List a few ways by which food handlers may act as an important source of transmitting food borne illnesses.

NOTES

7) What are the specific infections that need to be looked in for before employing a food handler?

8) How can one avoid microbial contamination through the following:
   a) Skin
   b) Hands and nails
   c) Nose, mouth and throat