UNIT 6 CHEMICALS FOR CONTROLING MICROORGANISMS

Structure

6.0 OBJECTIVES

This unit introduces you to the concept of preservation of food with chemicals. After going through this unit you will be able to know how chemical reactions causing spoilage are prevented or delayed by use a wide range of chemical additives.

After studying this unit, you should be able to:

- know the various classes of chemical additives used in the food industry;
- explain how these chemicals help to prevent the spoilage of food;
- know the permitted and non permitted chemical additives;
- discuss the general considerations required in the selection of food preservatives; and
- that apart from certain added preservatives there are some naturally occurring preservative factors in food.

6.1 INTRODUCTION

In Unit 1, you read about the various types of microorganisms that are important in the food industry. In this unit, we shall tell you how the spoilage of food can be prevented or delayed which are caused due to these microorganisms or some other chemical reactions. This unit highlights the various classes of chemical preservatives that have been approved for the use

in food and their use. The various aspects to be considered for the selection of chemical additives (food additives), their mode of action and the adverse reactions resulting due to the consumption of the additives is also elaborated in this unit. The unit also deals with the developed additives, namely acids, alcohol and bacteriocins.

6.2 USES OF VARIOUS FOOD ADDITIVES AND CHEMICAL PRESERVATIVES

For centuries, man has recognized the effects of food additives and has used whatever was available-marigold for colour, wood ashes for leavening, the lining of calf stomachs for cheese making etc. today, thousands of compounds are used as food additives, whose chemical identity and structure are known. The use of food additives is imperative in the complex and integrated society in which we live. Additives have provided protection against food spoilage during storage, transportation, distribution or processing. Also, with the present degree of urbanization, it would be impossible to maintain food distribution without the processing and packing and packing with which many additives are involved.

Additives permit the variety of foods that we deem desirable and which certainly are objectively important in maintaining important nutrition. Vitamins and minerals are important in maintaining good nutrition. Many of these chemical additives can be manufactured so that foods can be “fortified” or “enriched”.

There is then the need for the use of food additives to maintain the nutritional quality of food, to enhance the stability with resulting reduction in waste, to make food more attractive and to provide efficient aids in processing, packing and transport. The amount of food additives used should be kept to a minimum and it should conform to a standard of purity and be safe. Over 3000 different chemical compounds are used as food additives. They are categorized into different groups which will be discussed below.

According to WHO a food additive is defined as a substance or mixture of substances other than the basic foodstuff, which is present in food as a result of any aspect of production, processing, storage and packaging. The term does not include chance contaminants- thus the former refers to intentional food additive while latter is incidental un-intentional food additive.

Intentional food additives could be nutritive, freshness maintenance, sensory and processing aids; preservatives, antioxidants, emulsifiers, stabilizers, maturing agents, colours, special sweeteners, nutrient supplements, flavouring compounds and natural flavouring materials.

6.2.1 Types of Additives

- ***Acidity regulators***, used to alter and control the acidity or alkalinity levels for different desired effects, which can include preservation, added/altered tartness, colour retention and to assist raising agents.

- ***Acids***, used to control to what degree other substances function and/or to impart a sharp taste. Assists in the release of carbon dioxide in raising agents and can have a preservative effect.

- ***Anti-caking agents***, used to ensure the free flow in products such as dried milks, icing sugar and table salt.
- ***Anti-foaming agents***, used to reduce or prevent foaming (frothing) on boiling and to reduce scum forming.
- ***Antioxidants***, used to protect food against deterioration caused by exposure to air (oxidation), such as fat rancidity, flavour deterioration or colour changes.
- ***Bleaching agents***, used to artificially whiten flour.
- ***Buffers***, see acidity regulators.
- ***Bulking agents***, used to increase volume without significantly adding to the energy levels of the food. Normally used in diet foods but can also be used to pad out expensive ingredients. Not usually digested and acts as a source of dietary fibre (roughage).
- ***Carriers and carrier solvents***, used to modify a food additive (by dissolving, diluting or dispersing etc.), without changing its function, to enable easier use or handling.
- ***Emulsifiers***, used to aid in the formation and maintenance of the dispersion of two or more substances that would normally separate and not normally mix, such as oil and water. Milk, mayonnaise and salad dressings are typical oil in water emulsions, butter and margarine water in oil emulsions.
- *E*mulsifying salts, used to disperse protein so reducing the stringiness in cooked cheese.
- ***Firming agents***, used to make or retain firmness or crispness in fruit and vegetables and to strengthen gels.
- ***Flour improvers***, used to enhance the elastic properties and aid the development of dough. Also accelerates the effect of bleaching agents.
- ***Foaming agents***, used to provide a uniform dispersion of gas in a food.
- ***Gelling agents***, used to form a jelly so providing texture to a product.
- ***Glazing agents***, used to produce a protective coating or to impart a polish/sheen on the surface of a food such as confectionery or citrus fruit.
- ***Humectants***, used to retain moisture in foods by absorbing water from the air to prevent drying out.
- ***Modified starch***, used for various functions including adding texture, adding bulk, stabilizing and as a thickener.
- ***Packaging gases***, used to replace air in the packaging of foodstuffs susceptible to oxidation but not necessarily shown on food labels.
- ***Preservatives***, used to extend the shelf life of products by preventing the growth of microorganisms, which could otherwise cause food decay, and in some cases, food poisoning.

- ***Propellants***, a gas or volatile liquid used to expel foodstuffs from aerosols.
- ***Raising agents***, used to increase the volume of dough's and batters by promoting gas release (aeration).
- ***Releasing agents***, used to prevent foodstuffs sticking to machinery, molds, packaging etc. but not necessarily shown on food labels even though some may remain in the food.
- ***Sequestrants***, used to combine with trace metals in the environment to render them inactive.
- ***Stabilizers*** used to maintain the physical state of a food and to stabilize, retain or intensify the existing colour of a food, particularly emulsions, and therefore often used with emulsifiers.
- ***Sweeteners***, there are two different types of sweeteners:
    1. **Intense sweeteners** – these have a sweetness many times that of sugar and are therefore used at very low levels. They are used in products such as diet foods, soft drinks and table top sweeteners;
    2. **Bulk sweeteners** – these have a similar sweetness to sugar and are used at comparable levels. Unlike intense sweeteners they also provide bulk (although their main function is to provide sweetness). They are used in products such as sugar-free confectionery and foods for diabetics.
- ***Thickeners***, used to increase viscosity, modify texture and impart stability.

6.2.2 Role of Food Additives

Food additives help to enhance the consumer acceptability, help in maintaining or improving the nutritional quality, enhance stability or keeping quality by acting as antimicrobial agents with the resulting reduction in waste and prevention of chemical and biological deterioration, make food more attractive and provide sufficient aids in the food products for improving texture, colour and flavour, check spoilage by inactivating microorganisms and maintain safety of foods, facilitate preparation and help to improve palatability of the product.

It helps to enhance the shelf life of food or food products. It has been estimated that we consume about 5 kilograms of food additives as preservatives, colours, bleaches, flavours, emulsifiers and stabilizers every year in the food we eat. This not only results in extra work for our body to remove them, but frequently trigger asthma attacks; rashes; respiratory disturbances; hyperactivity in children, and in some people, an abnormal sensitivity to prescribed medications, particularly aspirin. Below are some common additives found in refined foods, and well-worth avoiding by those susceptible to their effects.

Acceptable daily intake (ADI) for various preservatives

Preservative	ADI (mg/kg body wt/day)
Acetic acid including its Na/K salts	No limit
Sodium diacetate	0-15
Benzoic acid including its Na/K salts	0-5
Formic acid	0-3
Hexamethylene tetramine	0-0.15
Para hydroxy benzoic acid esters	0-10
Lactic acid and its salts	No limit
Propionic acid and its salts	No limit
Natamycin/pimaricin	0-0.3
Na NO_3 and KNO_3	0-5
$NaNO_2$ and KNO_2	0-0.2
Sorbic acid including its Na/K/Ca salts	0-2.5
SO_2, Na_2 SO_3, $NaHSO_3$, Na/K metabisulphite	0-0.7

6.2.3 Preservatives

Preservatives are substances which are capable of inhibiting, retarding or arresting the process of fermentation, acidification or other decomposition of food or of masking any of the evidence of putrefaction but it does not include salt, sugar, vinegar, glycerol, alcohol, spices, essential oils etc. Sulphur dioxide (including sulphites) and benzoic acid (including benzoates) are among the principle preservatives used in the food processing industry. The permitted quantity of sulphur dioxide and benzoic acid is given in the following tables.

Food additives and their usage concentrations

Food additives	Concentration (%)	Foods
Antioxidant: Butylated Hydroxy Anisole (BHA)	Not exceeding 0.02% of the total fat content and 0.01% of the finished product 0.02	*Rasogolla* and *Vadas* Whole and partially skimmed milk powder Margarine
Colours	0.02	Most foods
Flavour: Monosodium glutamate	0.05	Meat product, soup powder
Anticaking agent: Aluminium silicate	2	Table salt, onion powder, garlic powder, soup powder
Sweetening agent: Saccharin	100 ppm	Carbonated non-alcoholic drinks
Sequestrant: Ethylene Diethyl Tetra Amino Acetic Acid (EDTA)	33-800 ppm	Canned carbonated beverages, salad dressings and margarine

Classes of preservatives

CLASS I:

Common salt, sugar, dextrose, spices, vinegar or acetic acid, honey

CLASS II:

Benzoic acid and its salts, sulphur dioxide and the salts of sulphurous acid, nitrites and nitrates, sorbic acid and its salts, propionic acid and its salts, lactic acid and its salts.

Sulphur dioxide

Sulphur dioxide and its derivatives have been extensively used in foods as a food preservative. It acts both as an antioxidant and reducing agent and prevents enzymatic and non-enzymatic reactions, leading to microbial stability. The common used forms are sulphur dioxide gas and sodium, potassium and calcium salts of sulphite, bisulphite or metabisulphite. It is like a biocidal and biostatic agent and is more active against bacteria than molds and yeasts.

Sulphite or metabisulphite sprays or dip with or without added citric acid provides effective control of enzymic browning in pre-peeled and pre-sliced potatoes, carrots, mushroom and apples.

Sodium benzoate

It was the first chemical preservative permitted in foods by the FDA, and it continues in wide use today in a large number of foods. Benzoates have greatest activity at low pH. As used in acidic foods, benzoates act essentially as a mold and yeast inhibitor.

In foods such as fruit juices, benzoates may impart disagreeable tastes at the maximum level of 0.1 per cent. The taste has been described as being ‘peppery ‘or burning.

Permitted quantity of benzoic acid in food

Processed food	Permitted quantity of Benzoic Acid (ppm)
Non-alcoholic wines, squashes, crushes, fruit syrups, cordials, fruit juices and barley water (to be used after dilution)	600
Jams, marmalades, canned cherry, fruit jelly	200
Sweetened mineral water and sweetened ready to serve beverages	120
Brewed ginger beer	120
Pickles and chutneys	250
Tomato and other sauces	750
Danish tinned caviar	50
Tomato puree and paste	750
Syrups and sherbets	600
Fat spread	1000

Quantity of sulphur dioxide permitted in food

Processed food	Permitted quantity of SO_2 (ppm)
Sausages and sausage meat containing raw meat, cereals and condiments	450
Fruit, fruit pulp or juice for conversion into jams or crystallized glace or cured fruit or other products	
a) cherries	2000
b) straw berries and raspberries	2000
c) other fruits	1000
Fruit juice concentrate	1000
Dried fruits	
Apricots, peaches, apples, pears and other fruit	2000
Raisins and sultanas	750
Other non-alcoholic wines, squashes, crushes, fruit syrups, cordials, fruit juices and barley water (to be used after dilution)	350
Jams, marmalade, preserves, canned cherry and fruit jelly	40
Crystallized glaced or cured fruit	150
Fruit and fruit pulp not otherwise specified in the schedule	350
Plantation white sugar, cube sugar, dextrose, jaggery or *misri*	70
Khandsari(s) and *Bura*	150
Refined sugar	40
Corn flour and similar starches	100
Corn syrup	450
Canned *Rossogulla*	100
Gelatine	1000
Beer	70
Cider	200
Alcoholic wines	450
Sweetened mineral water/ready to serve beverages	70
Pickles and chutneys made from fruits or vegetables	100
Dehydrated vegetables	2000
Syrups and sherbets	350
Dried ginger	2000
Hard boiled sugar confectionery	350
Dry mixes of *Rossogulla*	100

6.2.4 Acidulants

Sour or acidic taste of a food is attributed to the acidic components present in the food. Many processed foods and beverages, however, need the addition of acids to impart characteristic taste and flavour to the final food product. The intensity of sourness and ability to reduce pH vary among the organic group of acidulants in the decreasing order as follows:

Fumaric > tartaric > malic > acetic > citric > lactic > gluconic acid

Commonly used acidulants include acetic, adipic, citric, fumaric, lactic, malic, phosphoric and tartaric acids. Citric acid is the most versatile and widely used food acidulant.

Main foods in which acidulants occur or added to food

Acid	**Main food**
Acetic acid	Pickles, sauces, relishes, fermented vegetables and fruits, vinegar, wheat bread, cheeses and creams, apple juice, grapefruit juice.
Adipic acid	Beet juice, guava, papaya, raspberry, pork fat, dairy foods, gelatine and desserts, puddings, beverages, jams and jellies, snack foods, condiments
Citric acid	Oranges, lemons, grapefruit, black currants, gooseberries, pineapple, raspberries, strawberries
Fumaric acid	Confectionery, powdered gelatines, desserts, cheese cake, jams, and jellies
Glucono-delta-lactone	Cured meats, frankfurters, salami, sausages, dessert mixes, bakery mixes, processed cheese, fish products, spice preparation
Lactic acid	Fresh meat, yogurt, cheese, bread, pickles, sauces, relishes, fermented foods, buttermilk, wines, beer
Malic acid	Watermelon, plum, apple, cherry, peach, pear, grape, gooseberry, pineapple
Phosphoric acid	Cola beverages, jams and jellies, bread dough, cake, flour
Tartaric acid	Grapes, tamarind, pineapple, mulberries, gherkins, wines

Check Your Progress Exercise 1

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Define food additives. What are intentional and unintentional food additives?

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2. Briefly discuss the functions of food additives.

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6.2.5 Control of Psychotropic Contamination in Food

Increasingly all types of consumers are demanding minimally processed foods that are high in quality, nutritionally superior and easy to prepare. Food processors have met this demand by developing refrigerated foods with extended shelf life. The most important bacteriological problem in processed food products today is deterioration due to contamination by psychophilic microbes, as storage at low temperature is favourable for the growth of high levels of psychrotrops. Psychotrophs are bacteria, yeasts and molds that grow although slowly, at refrigeration temperature (below 7°C) but grows optimally at temperatures above refrigeration, e.g. 25-30°C. Their maximum growth temperature is 30-35^{o}C. Several pathogens such as *Aeromonas hydrophila*, *Clostridium botulinum*, *Listeria* spp., *Yersinia enterocolitica*, some strains of *Bacillus cereus*, enteropathogenic *Escherichia coli* and *Vibrio parahaemolyticus* can grow at refrigeration temperature. These bacteria may enrich in food during cold if storage times are long enough. Some of these pathogens can cause illness when even few cells are ingested.

The control of psychrophiles in food products should start from the very beginning of raw material procurement up to processing and storage of the finished product. The following steps are of considerable importance. Processors need to select high-quality raw materials with low levels of microorganisms, especially psychrophiles. Fabrication of raw materials by using clean and sanitized machinery and equipments into finished products

under hygienic conditions is also important. Apart from this regular check on quality of water supply and proper chlorination of water used in the food industry should be done. Appropriate use of salt and other ingredients which reduces the a_w to 0.98 or below will lengthen the lag phase of most bacteria and will further reduce the rate of any subsequent growth. Most recent studies have shifted to the use of lactic acid bacteria that produces bactericidal chemicals called bacteriocins to slow or inhibit the growth of psychrophiles organisms. By lactic acid bacteria a wide variety of food borne pathogens are either inhibited or killed, and many spoilage organisms are affected in similar ways, especially Gram-negative psychrophiles.

Thus the effective control of microbial contaminants must begin on the farm and be followed through to the retail store. Clean equipment and packages, use of approved food additives and chemical preservatives of Generally Recognized As Safe (GRAS) status in proper concentration, limited time of storage, low holding temperatures for raw materials and the finished product, effective laboratory control and attention to good manufacturing practices which will slow the outgrow of psychrophiles will help the food plant to produce with good yield, good flavour, long shelf –life and high sales appeal.

6.3 GENERAL CONSIDERATIONS IN THE SELECTION OF CHEMICAL FOOD PRESERVATIVES

Antimicrobial preservatives added to foods can be grouped as follows:

1. *Those added preservatives not defined as such by law:* natural organic acids (lactic, malic, citric etc.) and their salts, vinegar, sodium chloride, sugars, spices and their oils, wood smoke, carbon dioxide and nitrogen
2. *Substances generally recognized as safe (GRAS) for addition to foods:* propionic acid and sodium and calcium propionate, caprylic acid, sorbic acid and its salts, sulphur dioxide, sodium nitrite
3. *Chemicals considered to be food additives*, which would include all that are not included in the first two categories
4. *Chemicals proved safe and approved by the Food and Drug Administration*

6.3.1 Desirable Properties of Food Preservatives

There are seven requirements for food preservatives:

- No toxicity problems.
- Microbiocidal rather than microbiostatic properties.
- Must be stable in foods (especially if only microbiostatic).
- The spectrum of activity should correspond to the spectrum of microorganisms likely to appear in the food.
- Must not stimulate the development of resistant strains of microorganisms.
- Chemicals used therapeutically are not recommended as food additives.
- An assay procedure should be available.

Categories of Antimicrobial Food Additives Added to the Food:

Following chemicals and biochemicals are used in food preservation:

- Naturally present or formed in the food, chemicals added to the food, bacteriocins e.g. lactoperoxidase, lysozyme, lactoferrin, nisin etc.
- Chemicals with antimicrobial properties of salts of organic acids, like citric, benzoic, propionic and ascorbic. Chemical preservatives (sulphur dioxide and sulphites, parabens etc.), nitrites and nitrates.
- Chemicals with multifunctional properties added to the food, one property being antimicrobial e.g. spices and essential oils, salt, sugar, antioxidants, vinegar etc.

6.3.2 Mode of Action of Food Additives

- Alteration of cell wall permeability.
- Alteration of colloidal nature of protoplasm.
- Damage of the cell wall.
- Damage of proteins.
- Inhibition of enzyme activity.
- Disruption of cytoplasmic membrane.
- Bacteriostatic or bactericidal action.
- Interference with synthetic processes.

6.3.3 Factors Affecting the Antimicrobial Activity of Food Additives

Many factors must be considered for the selection of a specific antimicrobial food additive for a specific food. These factors are as follows:

- Physical and chemical properties of the antimicrobial agents (such as water solubility, hydrophobic lipophyllic balance, boiling point, ability to ionize and potential interaction with food constituents). The activity of the antimicrobials is reduced as a result of reaction with lipids, proteins or carbohydrates.
- Composition of food, its pH/ acidity and nutritional value.
- Type of preservation system other than chemicals used in the food.
- Characteristics and number of microorganisms.
- Initial contamination by microbes prior to preservation/processing.
- Type and concentration of chemical used.
- Time and temperature of food storage.
- Cost and toxicity of the antimicrobial.

6.3.4 Precautions to be taken for Using Food Additives

- Food additives must be thoroughly tested before use. Foods containing physical hazards such as stones, seeds, glass fragments or metal pieces must be thoroughly checked.
- FDA approved food additives should be used. Improper use of some of them may prove to be harmful to human health.

- Use of additives should not be permitted if:
  - They fail to serve the interest of consumers.
  - They are used to mark the effect of faulty processing and handling techniques.
  - They are used to deceive the consumers.
  - Their use results in a significant reduction in the nutritive value of the foods.
  - Additives should be used in a controlled way so as to maximize benefits and prevent abuses.

Status of some additives and Acceptable Daily Intake (ADI)

Material	**Status**
Amaranth (red azo dye)	Carcinogenic, but still WHO/FAO-prescribed an ADI* for Amaranth
Saccharin	Bladder cancer. However, still permitted in soft drinks to the extent of 100ppm. WHO/FAO-prescribed ADI from 2.5-5.0 mg/kg of body weight.
Cyclamate	Bladder cancer. WHO/FAO-prescribed ADI of 4 mg/kg of body weight for cyclamate.
Brominated vegetable oil	Banned in India and UK
Hydrogen peroxide	Used for extending shelf life of milk, is repeatedly turned down on grounds that it would have undesirable consequences on milk collection practices.
Gallate, Phenols	Permitted in most countries, but in India there use required specific permission that is not granted.
Nitrates and nitrites	Give rise to nitrosamine, which are carcinogenic but still used in our country within the permissible limit.
Sulphites	Banned in USA

*ADI-Acceptable Daily Intake (mg/kg body weight/day)

6.3.5 Adverse Effects of Using Food Additives

Although these additives are regarded as GRAS (generally recognized as safe), their increased used may also lead to various health problems viz. acidity, dyspepsia, digestive disorders etc.

Food additive name	Often used in	Common reactions
Tartrazine (colour)	drinks, cakes, snacks, ice-cream, confectionery	asthma; hyperactivity; aspirin sensitivity
Sunset yellow (colour)	drinks, packet soups, dessert, biscuits, confectionery, ice-cream	hyperactivity; allergies; aspirin sensitivity
Cochineal (colour)	cakes, confectionery, ice-cream	hyperactivity
Azorubine (colour)	packet soups, sauces, jams, desserts (jellies)	asthma; hyperactivity; aspirin sensitivity
Indigotine (colour)	tablets, capsules, ice cream, biscuits	nausea; skin rashes; allergies; high blood pressure
Brilliant blue (colour)	tinned peas, bacon-flavoured snacks	hyperactivity
Caramel (colour)	drinks, sauces, soups, cakes, pickles, vinegar	hyperactivity
Benzoic acid (preservative)	confectionery, cheeses,	asthma; hyperactivity;
Sulphur dioxide (preservative)	beer, wine, soft drinks, dried fruit, cordials	asthma; hyperactivity
Sodium bisulphite (preservative)	wine, beer, soft drinks, juices, cordials	asthma; destroys vitamin B1; hyperactivity
Sodium nitrite (preservative)	cured meats, some cheeses	hyperactivity; adverse reactions in children; potentially carcinogenic
Propyl gallate (antioxidant)	oils, margarine, salad dressings	gastric and skin irritant
Tert-butyl hydroquinone (antioxidant)	fats, oils, margarine, packet chips	nausea; delirium
Butylated hydroxyanisole (antioxidant)	fried snacks, soft drinks, edible oils, margarine, chewing gum	hyperactivity; asthma; adverse reactions; allergies; increases cholesterol levels
Carageenan (thickener) (emulsifier)	ice-cream, jellies, cake decorations, cheese, salad dressings	allergies; intolerances
Mannitol (emulsifier)	ice cream, confectionery, low calorie foods	allergies; diarrhoea, nausea
Monosodium glutamate (MSG) (flavour enhancer)	prepacked meals, snacks, Chinese cooking	hyperactivity; asthma; adverse reactions; allergies; aspirin sensitivity

Disodium 5' ribonucleotide (flavour enhancer)	flavoured crisps, instant noodles, party pies	skin rashes; not easily broken down by body
Aspartame (sweetener)	diet drinks, diabetic confectionery, ice cream	allergies; headaches; nervous disorders

6.4 DEVELOPED AND ADDED PRESERVATIVES

Developed preservatives include those synthesized naturally, by various microorganisms during fermentation and growth and metabolism.

6.4.1 Acids Produced during Fermentation

Food fermentations may serve either or both of two purposes: (1) to produce new and desired flavours and physical characteristics and hence a different food product and (2) to help preserve the food. The preservatives produced in foods by microbial action are the most part acids (chiefly lactic) and alcohol. One or more additional preservative agents, such as low temperature, heat, anaerobic conditions, sodium chloride, sugar or added acid, nearly always supplement the preservative effect of these substances.

Developed acidity plays an important part in the preservation of sauerkraut, pickles, green olives, fermented milk, cheese and certain sausages and in various fermented foods of plant origin. Development of full amount of acidity from the sugar available may be permitted in the pickle and green olive fermentations, or the fermentation may be stopped by chilling or canning before the maximum acidity is attained in other fermentations. The approximate acidity developed in some of these products, expressed as lactic acid, is sauerkraut, 1.7 per cent: dill pickles and green olives, 0.9 per cent and fermented milks, 0.6 to 0.85 per cent.

6.4.2 Alcohol

The alcohol content of beer, ale, fermented fruit juices and distilled liquors has a preservative effect but was not produced primarily for that purpose.

6.4.3 Bacteriocins

Many natural products have been found to have efficient preservative effect and their application in food is catching up fast due to the increased awareness about their nutritional and health benefits. These are termed as bio-preservatives as they act on harmful spoilage and pathogenic microbes and prevent their growth in foods.

Bacteriocins constitute an important segment of these biopreservatives. Technically speaking, the bacteriocins are proteinaceous antimicrobial compounds that kill or inhibit closely related bacteria and also are capable of exhibiting a wide inhibitory spectrum against spoilage and pathogenic bacteria. Various microorganisms such as the lactic acid bacteria (comprising species of *Lactobacillus, Lactococcus, Leuconostoc* and *Pediococcus*) and species of *Corynebacterium, Propionibacterium, Enterococcus, Bacillus* and *Escherichia* have been reported to produce bacteriocins or bacteriocin-like inhibitory substances. Lactic acid bacteria have been shown to produce sufficient quantities of bacteriocins in various cultured and fermented food preparations

(*dahi*, yogurt, cheese etc.) to prevent the growth of harmful bacteria. Alternatively the purified bacteriocin preparation can also be added directly to the food. So far, researchers have extensively tried out only two bacteriocins, namely nisin and pediocin as biopreservatives in various food systems of which nisin is the only bacteriocin that has been approved as GRAS food additives.

Nisin is a well known and most widely used bacteriocin produced by *Lactococcus lactis* subsp. *lactis* (formerly *Streptococcus lactis*). It has been used in processed cheese, pasteurized milk, flavoured milk and various other dairy products, in addition to canned foods and alcoholic beverages. The recommended doses of nisin used vary from 100-150 IU/g depending on the type of food. Nisin has sporostatic activity. This results in significant energy savings in canning processes by way of low heat application. So it is useful for the non-thermal preservation of foods. Nisin also has a great potential for use in brewing industry. It also finds application in low pH foods. In many European countries nisin has affirmed GRAS status in 1998 by Food and Drug Administration (FDA) for use as an antimicrobial agent.

Besides nisin, several other bacteriocins produced by lactic acid bacteria include pediocin PA-I and pediocin AcH produced by *Pediococcus acidilacti*, sakacin A from *Lactobacillus sake*, plantaricin from *Lactobacillus plantarum*, acidophilicin LA-I from *Lactobacillus acidophilus* and helveticin J produced by *Lactobacillus helveticus* and so on. The Pediococci, which are used as starter cultures in certain vegetable and meat fermentations, have also been the subject of recent investigation with regard to their bacteriocin-producing ability.

Advantages of using bacteriocins: The bacteriocins offer several advantages over the preservatives that are presently being used in several foods. They do not have any ill effect on the health of the consumer so they are safe to use and the inhibitory effect of bacteriocins on the growth of microorganisms exhibits the potential to inactivate microorganisms in foods.

Check Your Progress Exercise 2

Note: a) Use the space below for your answer.
b) Compare your answers with those given at the end of the unit.

1. Define bacteriocins. Give a few examples and possible uses.

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2. What are the desirable characteristics of food additives?

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3. List down the mode of action of food additives.

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6.5 LET US SUM UP

Chemical additives that control microorganisms are not only a technological and functional tool in hands of food technologists but also aid in restoring the nutrients lost through processing. The availability of chemical/food additives has allowed the production of numerous out-of-season foods and a variety of new food products. Additives have increased the development of convenience foods, snack foods, low-calorie and health promoting (functional) foods, exotic foods and a variety of food substitutes. The present day consumer demands high quality, convenient and minimally processed foods. Some products can be formulated with ingredients such as organic acids, chemical preservatives, nitrite, bacteriocins, high concentrations of salt, carbon dioxide etc. that are barriers to microbial growth and can also inhibit there growth due to their antibacterial and antifungal properties. The role of chemical additives thus, becomes all the more important, hence to be selected judiciously, keeping in view their toxicological and biochemical role in food, before they are recommended and they have become an integral part of food industry for day to day life for the production of various processed products. They help to assure a food supply with the safety, variety, appeal, wholesomeness and affordability we have become accustomed to.

6.6 KEY WORDS

Food Additive **:** Food additive is defined as a substance or mixture of substances other than the basic foodstuff, which is present in food as a result of any aspect of production, processing, storage and packaging. The term does not include chance contaminants.

Bacteriocin **:** Proteinaceous antimicrobial compounds that kill or inhibit closely related bacteria and also are capable of exhibiting a wide inhibitory spectrum against spoilage and pathogenic bacteria.

Nisin **:** Widely used bacteriocin produced by *Lactococcus lactis* subsp. *lactis* (formerly *Streptococcus lactis*).

GRAS **:** Substances generally recognized as safe

ADI **:** The Acceptable Daily Intake (ADI) is defined as an estimate of the amount of a food additive, expressed on a bodyweight basis that can be

ingested on a daily basis in the diet over a lifetime without appreciable risk to health. "Without appreciable risk" means the practical, in view of the actual level of knowledge, certainty that no harm will result, even after a lifetime of exposure to the chemical additive concerned. The ADI is usually given as a range of 0-x milligrams per kilogram of bodyweight per day.

6.7 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1.
   - Food additive is a substance or mixture of substances other than the basic foodstuff, which is present in food as a result of any aspect of production, processing, storage and packaging.
   - Intentional food additives are added deliberately to food and could be nutritive, freshness maintaining, sensory and processing aids; preservatives, antioxidants, emulsifiers, stabilizers, maturing agents, colours, special sweeteners, nutrient supplements, flavouring compounds and natural flavouring materials.
   - Unintentional food additives are chance contaminants, which may get incorporated into food during any step of processing and are not desirable.

2. Food additives help to:
   - Enhance consumer acceptability.
   - Help improve or maintain the nutritional quality.
   - Enhance stability and prevent deterioration.
   - Make food more attractive and palatable.
   - Maintain the safety of foods.

Check Your Progress Exercise 2

1.
   - Bacteriocins are proteinaceous antimicrobial compounds produced by bacteria that kill or inhibit closely related spoilage and pathogenic bacteria eg: Nisin, Pediocin, Acidophillin etc.
   - They are used in processed cheese, pasteurized milk, flavoured milk and various other dairy products, canned foods and alcoholic drinks, brewing industry etc.

2. Food additives should be non-toxic, economical, must be stable in foods, should be microbiocidal rather than microbiostatic, should have broad antimicrobial spectrum, must prevent growth of resistant strains and an assay procedure should be available to detect them.

3. Action of food additives is by:
    - Altering cell wall permeability of bacteria.
    - Altering its protoplasm.
    - Damaging proteins and cell wall.
    - Inhibition of enzyme activity of cell.
    - Disruption of cell membrane and interfering with cell synthesis processes.

6.8 SOME USEFUL REFERENCES

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