UNIT 10 FOOD ADDITIVES

Structure

10.0 OBJECTIVES

After studying this Unit, you should be able to:

- define food additives;
- enlist different types of food additives;
- state the chemical properties and functions of food additives; and
- illustrate the use of food additives for various purposes in the food industry.

10.1 INTRODUCTION

How will cooked pulse without salt or spices and *kheer* without sugar taste? Certainly all of us will dislike it barring all those who may not be using these for some medical reasons. Can the food cooked and kept in open be consumed even after a day? We are well aware that it would get spoilt. What makes a common soft drink different from soda water? – Some flavoured substances besides a sweetener. Many more such questions as raised above and their answers make the content of the present unit.

You would agree that in today's busy life preserved cooked food has become a part and parcel of life for many of us as it saves our precious time and effort. The shelf life of these packed foods is enhanced by adding certain substances. Salt and sugar are two of the very common substances used for this purpose. Substances like salt, sugar and many others are not components of natural foods and are added to foods during its processing for a variety of reasons including taste, preservation, flavour, texture, etc. The substances which are added to natural foods from outside for protection against food spoilage, flavour and colour enhancement, texture improvement etc. are called **food additives**. Their usage is not a recent development. Salt has been used to

preserve meat and fish since ancient times. Spices have been employed since earliest recorded history to flavour and preserve foods. In other words, food additives seem to be a necessary part of modern society.

Though the use of food additives is well-accepted practice; there have been a number of concerns regarding the potential short-term and long-term risks of consuming these substances. These are to be used according to the regulation ascertained by Government agencies. In this unit, you will read about various types of food additives in terms of their properties, functions and importance in food industry along with the permitted additives as per the Food Adulteration Act and Rules (1954) prevalent in our country.

10.2 WHAT ARE FOOD ADDITIVES?

Food additives are the substances which are added to natural foods at various stages of food production, processing, storage, packing and preservation. According to the Food and Agriculture Organisation (FAO) and World Health Organisation (WHO),

The food additives are the non-nutritive substances added to foods, in small qualities, to improve its flavour, texture, appearance and storage properties.

According to another widely accepted definition,

Food additive is a substance or a mixture of substances, other than the natural foods which is present in food as a result of any aspect of production processing, storage or packing."

As you know, the preservation of food has an age old tradition and a number of substances e.g., smoke, alcohol, spices, sugar vinegar and salt etc. have been used for this purpose. These are not included in the list of food additives. Further, according to FAO and WHO, the nutritive substances like vitamins and minerals which are added in order to supplement and enrich the food are also excluded from the list of food additives. These organizations have formulated international standards for defining the quality of food additives, their permissible levels in foods and all other technological related issues.

The above definitions do not include the substances which get added to the food in the course of their agriculture production, food processing or packing. These are called **unintentional** or **incidental additives**. These are also called chance contaminants, for example, pesticides are one such type of compounds which get added to foods unintentionally and may be hazardous to health. Many a times, insect parts, and antibiotics added to animal feeds also show up in the food.

The additives which are added in the food deliberately to have a desired property and for a specific function are termed as **intentional additives.** Since some additives may have undesirable effects on the human health, their usage has to be controlled and one must adhere to the prescribed norms and standards while using them. Many food additives are classified as GRAS meaning '**Generally Regarded As Safe**' additives. The GRAS additives are supposed to be causing no harm for longer periods. In India the **Prevention of Food Adulteration Act and Rules**, 1954 are responsible for listing the additives permitted in different foods and their maximum permissible limits.

If you have interest in knowing the details of the Acts and Rules regarding various food additives you can browse the web site: **http:// mohfw.nic.in/pfa**

The various important applications of food additives in general are:

- to maintain nutritional quality of food
- to improve the nutritional quality of food by enriching and fortifying it with vitamins and minerals. You have read about this in Unit 9
- to protect against microbial growth in the food e.g. use of antioxidants, antimicrobial agents etc.
- to impart firmness to the food
- to retard or speed up chemical reactions in food
- to enhance stability of food resulting an increase in the shelf life of foods and the reduction in wastage of food. The waste is generated both by microbial and chemical causes and can be reduced by use of antimicrobial agents and antioxidants.
- to make food more attractive in the form of colouring agents, flavouring agents, emulsifiers, stabilizers, thickeners, clarifiers and bleaching agents
- to provide aids in processing, packing and transport of food. These include acids, alkalis, buffers, sequestrants and other types of chemicals.

Sequestrant: An agent that removes ions from solution

Today, a very large number of additives are being used in food industry. On the basis of their functional properties, these can be classified into the following types.

- Preservatives
- Antioxidants
- Acidulants, neutralizers and buffers
- Colouring agents
- Flavouring agents
- Sweeteners
- Miscellaneous additives.

In the following sections, you will read about these different types and categories of the food additives and their uses. Before proceeding further, try to answer the following questions.

Check Your Progress Exercise 1

Note: a) Compare your answers with those given at the end of the unit.

1) Fill in the blanks with appropriate words.

   a) The substances which are added to natural foods during the production processing, storage or packing are called……..

   b) Definition of food additives does not include the …… added unintentionally to foods.

   c) ……. and …….are the food additives used for maintaining the nutritional value of food.

10.3 PRESERVATIVES

Salt has been used as a preservative since the beginning of recorded history. Pickling of fruits and vegetables and salting of fish and meat are widely practiced

You are well aware that foods are subject to spoilage due to contamination by microbes. As the contamination depends upon the temperature besides moisture as one of the factors, we have been using a conventional method of keeping the food material in the refrigerator to slow down this process. However, this method will not work when storage for a longer time is required. We may need to use some chemical preservatives for this purpose. Though a large number of preservatives are available, for economical and convenience reasons, salt, nitrites and sulphites have been in use for many years. The antimicrobial activity of sodium chloride is essentially related to its ability to reduce water activity (a_w) and create unfavourable conditions for microbial growth. Further, though newer packaging techniques, processing and storage methods are available that can preserve foods without chemical preservatives, chemicals play a significant role in protecting the food supply, again for convenience and economy.

On the basis of their mode of action, the preservatives can be grouped into three types. These are **antimicrobials** that inhibit growth of bacteria, yeasts, or molds for example sorbates that inhibit most of the species of yeasts, moulds and of some bacteria; **antioxidants** that slow down the air oxidation of fats and lipids that cause rancidity. For example preservatives like *tert*-butylhydroquinone (TBHQ), stop the chemical breakdown of food that happens in the presence of oxygen; and the third group which blocks the natural ripening and enzymatic processes in foodstuffs. For example, the browning the exposed surface of cut apple due to the enzyme phenolase can be checked by acids like citric acid and ascorbic acid (vitamin C) that inhibit the enzyme by making the pH uncomfortably low for it. Sulphur dioxide serves all the three functions, which makes it along with the related sulphites as an important constituent of a number of household products.

Sulphur dioxide and several sulphites have GRAS status.

Class I and Class II Preservatives

Under the prevention of food adulteration Act (PFA) rules, 1954, preservatives are classified into Class I and Class II preservatives. **Class I preservatives**, also called **natural preservatives** include common salt, sugar, dextrose (glucose), spices, vinegar or acetic acid, honey, and vegetable oils. There is no restriction to the addition of Class I preservatives to any food. Brewed and synthetic vinegar (dilute acetic acid) are widely used as antimicrobials in vinegar pickles. Acetic acid is more effective against yeasts and bacteria than moulds. Only acetic, lactic and butyric bacteria are markedly tolerant to acetic acid. Like most of the preservatives, acetic acid is also more effective at lower pH. Sugar and spice also help in preserving foods. Like salt, sugar also acts by reducing the water activity of the medium to inhibit the growth of microorganisms. Many chemical substances in spices like terpenes have been shown to have antimicrobial properties.

Generally, 1-2 % acetic acid is sufficient to inhibit most of the organisms.

Class II preservatives are those which can be added in foods as specified by regulations and not otherwise. These can be added in foods as specified by regulations include, benzoic acid, sulphurous acid and their salts, nitrates, nitrites, sorbic acid and its sodium, potassium and calcium salts, lactic acid, propionic acid**,** sodium or calcium propionate, methyl or propyl-parahydroxy benzoic acid, sodium diacetate and sodium, potassium and calcium lactate. Of these, benzoates and sulphites are most widely used for preservation of fruit and vegetable products; however, recently sorbates have been allowed for some products.

Benzoic acid is found naturally in cranberries, plums, prunes, cinnamon, cloves and most berries. It is a strong antimycotic agent. Most yeasts and moulds can be controlled using 0.05–0.1% benzoic acid. Control of many bacteria requires much higher concentration. Due to low solubility of benzoic acid in water, sodium benzoate salt is preferred.

Antimycotic: An agent inhibiting the growth of fungi.

Benzoic acid is permitted in several products like squashes, syrups, crushes, fruit juices, jams, jellies, marmalade, beverages, pickles and tomato products.

Sulphur dioxide and its various salts have a long history of use dating back to the times of the ancient Greeks. They have been used extensively as antimicrobials and to prevent enzymatic and non-enzymatic browning in a variety of food products. Sulphurous acid inhibits yeasts, moulds and bacteria. Sulphur dioxide and sulphites are permitted under PFA for a number of products like fruit pulps, squashes, syrups, crushes, cordials, wines, beverages, and dehydrated fruits and vegetables. Sulphur dioxide is also used as an anti-browning agent.

Sorbic acid and its sodium, potassium and calcium salts are collectively known as **sorbates**. Sorbic acid is present in some berries like berries of the mountain ash berry (rowanberry). These sorbates inhibit most of the species of yeasts and moulds. Several species of bacteria are also inhibited by sorbates. At present under PFA, sorbates are permitted for only a few fruit and vegetable products. They include jams, jellies, marmalades, glazed or candied fruits, fruit bars, fruit juice concentrates and prunes. Some of the other products include cheese, flour confectionary, smoked fish, preserved chapattis and fat spreads. Sorbic acid and potassium sorbate have GRAS status.

Nitrites have been used in meat curing for many centuries. For meat curing, nitrite is used along with a mixture of salt, sugar, spices, and ascorbate. Nitrite contributes to the development of the characteristic colour, flavour, and texture improvement and preservative effects. Nitrite has a strong inhibitory action against *Clostridium botulinum* and several other micro-organisms.

Nitrites and nitrates are the food industry's primary chemical defense against the bacterium *Clostridium botulinum*. They also impart a pink, fresh hue to cured meat.

Antimicrobial substances (antibiotics) produced by microorganisms have been known for many years. These are the products of the defence system of the microbes themselves generated when they compete with each other for space and nutrients. Some of these, like nisin, and natamycin, the cheese preservatives called **bacteriocins** have been allowed in some foods only in recent years.

Some other potential natural preservative sources include honey, milk, and even dried plums.

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) Categorise the following food additives into class I and class II preservatives.

Benzoic acid, Glucose, Vegetable oils, Lactic acid, Salt, Vinegar, Sorbic acid, Honey, Propionic acid.

……..

……..

……..

10.4 ANTIOXIDANTS

Lets us recall what we have learnt about autooxidation of fats and oils while studying Unit 7 on lipids. The unsaturated fatty acids in fats and oils can undergo oxidation during storage leading to the development of rancidity i.e., the characteristic off-flavours indicating the spoilage of oils and fats. The oxidative processes may also cause vitamin destruction, discolouration and even some toxic effects. Food antioxidants are substances that are able to inhibit or interfere with the autooxidation reaction. In other words, they get oxidized in preference to the fats and oils and thus prevent the oxidation of the latter.

It was explained in the previous Unit that tocopherols present in many vegetable oils have antioxidant property. Similarly, ascorbic acid and lecithin have antioxidant properties. However, the major antioxidants commercially used in foods, fats and oils are phenolic compounds and are generally referred to as **phenolic antioxidants**. The most widely used phenolic antioxidants for fats and oils are i) butylated hydroxy anisole (BHA), ii) butylated hydroxy toluene (BHT), iii) propylgallate and iv) *tert*-butyl hydroquinone (TBHQ).

Certain metals like iron and copper present in foods are strong catalysts of fat oxidation and may react with antioxidants to cause discolouration. Food acids like citric acid have the ability to bind these metals. Therefore, the antioxidants are usually added along with citric acid.

Browning of cut fruits and vegetables is due to enzymatic oxidation of phenolic substances.

The antioxidants are perhaps the most widely used among the food additives. They are used in vegetable oils, meat products, confections and chewing gums, cereal products like breakfast cereals, bakery products etc. Use of the antioxidants in fruit and vegetable products though limited, is of considerable commercial importance. Some of them include fruit nuts like walnut, almonds, cashew nuts; citrus oils, dehydrated potato products like powder, flakes and granules.

Under PFA, all the above mentioned phenolic antioxidants except BHT have been permitted with restrictions. Additionally, lecithin and ascorbyl palmitate are also permitted for specific food products.

10.5 ACIDULANTS

As the name indicates acidulants are food additives that may lower the pH of any food. Since the microbial spoilage of food is inhibited at low pH, acidulants find an application as an antimicrobial agent. Acidulants contribute a variety of functional properties that lead to the enhancement of food quality by imparting desired flavours and taste to it. Most of the acidulants used in food are organic acids and their salts. For example, the commonly used acidulants in foods are acetic, ascorbic, citric, lactic, malic and tartaric acids and their salts. Inorganic acids like phosphoric acid is also used extensively in cola type beverages.

Sequestrants combine with metals forming complexes with them and making them unavailable for other reactions. They can have antioxidant properties.

In general acidulants are used as flavouring agents, buffering agents, preservatives, sequestrants, viscosity modifiers and meat curing agents.

Some commonly used acidulants are given below.

Citric acid, a tricarboxylic acid abundantly present in citrus and many other fruits is perhaps the most widely used organic acid. Though earlier it used to be produced from citrus fruits, presently fermentation is employed for most of the commercial citric acid production. It is used in carbonated soft drinks.

Malic acid (2-hydroxybutanoic acid), a dicarboxylic acid is the major acid in apples and mango. It is a nonhygroscopic white crystalline powder, easily soluble in water and finds application in dry food formulations. Synthetic malic acid is available commercially.

Tartaric acid a dicarboxylic acid found predominantly in grapes and tamarind. It is a white crystalline water soluble solid, usually extracted from the argol sediment formed during fermentation of grapes. It finds application in baking powder and effervescent 'health salts'.

Most of the food acidulants are permitted under PFA with certain restrictions.

10.6 COLOURING AGENTS

The colours do not have anything to do with the nutritive value of foods but the specific colouring of a given food item does affect its acceptability. Many a times colours are added to restore the natural colour of the food which is lost in food processing or sometimes these are used just to give the food an attractive look. Food colouring agents called **colourants** may often be considered simply of cosmetic in nature, but the role they play is actually very important. We may say that the colour of foods is a measure of its quality to a certain extent. For example an orange if has a brown colour, will not be acceptable in the first instance.

The use of colourants to foods to make them more attractive is not new. Extracts of spices and vegetables were used for the purpose as early as 1500 B.C. However, the advent of the use of food colourants in the late 1800s and early 1900s was unfortunately accompanied by their misuse. These were used as adulterants, frequently to disguise food of poor quality. Some of these deceptive practices included colouring of pickles with copper sulphate; cheese with vermillion and red lead; tea with copper arsenite, lead chromate and indigo; and candy and turmeric with lead chromate, red and white lead and vermillion.

The colouring agents used in food are natural as well as synthetic in their origin. Let us read about these in the following subsections.

10.6.1 Natural Colourants

The natural colourants are extracted from the seeds, flowers and some insects. Some examples are spinach juice for green and marigold flower for yellow colour. A few of the natural colourants are discussed below.

Anthocyanins*:* Anthocyanins are the intense red and blue water-soluble pigments occurring in many fruits, vegetables and flowers like strawberries, cranberries, raspberries, blueberries, grapes (blue), Jamun and some flowers. Due to their structure, anthocyanins exhibit most intense colour below a pH of 3.5 and thus are suited for acidic foods only. Further, these easily undergo discolouration in the presence of amino acids, phenolic sugar derivatives etc. and are bleached by ascorbic acid and sulphites.

Some common natural colourants

1. Beta carotene
2. Beta – apo -8'-carotenal
3. Methyl and ethyl ester of beta-apo-8'-carotenoic acid
4. Canthaxanthin
5. Chlorophyll
6. Riboflavin (lactoflavin)
7. Caramel
8. Annatto
9. Saffron
10. Curcumin (or turmeric)

Carotenoids*:* Carotenoids are responsible for the yellow, orange and red pigments in a number of plants and animal foods. Carotenoids are classified into three groups. i) Carotenes – These are hydrocarbons containing β-ionone rings and possess vitamin-A activity for example, β-Carotene present in carrots, chillies, soybean. ii) Lycopenes – the carotenoids devoid of β-ionone rings and do not possess vitamin-A activity. Lycopene is present in tomato, apricot, watermelon, and red guavas. iii) Xanthophylls –the oxygenated derivatives of carotene. These do have β-ionone rings, but do not possess vitamin-A activity. These are present in papaya, orange peel, and yellow maize. iv) α-Carotenes – similar to β-carotene in its biological activity.

Structurally, carotenoids are polyenes composed of isoprene units. These are fat soluble, fairly heat stable and are stable in the pH range of 2–7. However, during processing of fruits and vegetables, partial loss of carotene takes place. Due to their structure, carotenoids are very sensitive to oxidation therefore, synthetic β -carotene is marketed in forms that confer protection from oxidation i.e., these are oxidized in preference to the item being protected. Ascorbic acid can protect β-carotene by serving as an antioxidant.

Betalains: Betalains are found in plants such as red beets, amaranthus flowers, bougainvillea, cactus fruits etc. Betalain colours range from red to yellow. The red beet is the most common commercial source of these pigments.

Chlorophylls*:* Chlorophylls, the most abundant naturally occurring plant pigments, are the green and olive green pigments in green plants. These are soluble in alcohol, diethyl ether, benzene, acetone etc. but insoluble in water. Some metal ions like iron, zinc and copper react with chlorophyll and the green colour becomes brighter. In alkaline pH, the colour of chlorophyll is better retained. Chlorophylls are heat sensitive and during processing of fruits and vegetables containing chlorophyll, the green colour is lost and turns olive green. When vegetables containing chlorophyll is cooked, the central magnesium atom is replaced by hydrogen atom and loses its colour forming pheophytin.

Curcumin is the main colourant (yellow) in the oleoresin obtained from turmeric (*Curcuma longa*). Curcumin is fat-soluble, has good tinctorial strength, but exhibit slight sensitivity to light, air and pH.

Paprika oleoresin is the extract of mild capsicum (*Capcicum annum*) and is orange red to deep red in colour. Like curcumin, paprica oleoresin is also water insoluble. Paprika and turmeric oleoresins are available in various standardized forms.

Saffron is generally stable toward light, oxidation and pH and has a high tinctorial strength.

Annatto is the color used in butter and cheese and is obtained from a plant – Bixa Orellana -

10.6.2 Synthetic Colourants

The colourants derived from synthetic dyes are called **synthetic colourants**.

Synthetic colourants were earlier manufactured from coal tar derivatives and the gelatin desserts, candies and bakery goods were coloured with them. Although the colourants were highly purified before they were added to foods, the negative connotation of their association with coal tar resulted in much unfavourable publicity. As a result, synthetic colourants are no longer

manufactured from coal tar derivatives but instead are developed from highly purified petrochemicals.

In fact the development of synthetic dyes came as a boon to the food industry because these colourants were superior to natural extracts in terms of their colour intensity, number of shades, stability, easy availability above all they were quite cheap. However, it also brought in a new aspect of the safety in focus. The toxicological studies have shown that many of the colourants are in fact harmful; though a few appear to be safe for use depending on the quantity consumed. To add to the woes, these assessments of toxicity also vary and colourants considered safe in one country may not be considered safe in another country. More so with further studies, the status of the colourants used in countries throughout the world is in a state of flux the number of permitted synthetic colourants is decreasing year by year. Some of the permitted synthetic colourants are given in Table 10.1.

Table 10.1: Common Synthetic Food Colours

S. No.	Common Name	Shade	Chemical class
1.	Ponceau 4R	Red	Azo
2.	Carmoisine	Red	Azo
3.	Erythrosine	Red	Xanthene
4.	Tartrazine	Yellow	Pyrazolone
5.	Sunset yellow FCF	Yellow	Azo
6.	Indigo carmine	Blue	Indigoid
7.	Brilliant blue FCF	Blue	Tri-aryl methane
8.	Fast green FCF	Green	Tri-aryl methane

The above list shows that the permitted synthetic colourants belong to five chemical classes viz. azo, xanthene, pyrazole, indigoid and triarylmethane. These colours water-soluble and are more resistant to chemical reaction, pH and heat compared to natural colourants.

Check Your Progress Exercise 3

Note: a) Compare your answers with those given at the end of the unit.

1) Fill in the blanks with appropriate words.

   a) The antioxidants in foods prevent the ……..reactions of fats and oils.

   b) BHA is an example of a ……..antioxidant.

   c) The food additives which help to lower the acidity and increase the pH of foods are called ……...

   d) Yellow, orange and red colour to food is imparted by …….. which are …… colouring agents.

10.7 FLAVOURING AGENTS

Flavour like colour has no nutritional value but has a great bearing on acceptance of foods and therefore, has enormous commercial importance. Some studies have indicated that taste can alter intestinal absorption of glucose

and fat metabolism. Flavour is defined in several ways, according to one such definition the flavour is, "**the sensation produced by a material taken in the mouth, perceived principally by the senses of taste and smell, and also by general pain, tactile and temperature receptors in the mouth".**

Flavouring agents include flavourings and flavour enhancers. The former are added in foods to produce flavours or modify the existing ones, while the latter include the additives which intensify the flavours which are already present and are weak in nature. During the early days, people used spices, herbs, vinegar, smoke, honey etc. To enhance or modify the flavour of foods. Along with the developments in synthetic chemistry and analytical techniques like gas chromatography and mass spectrometry, there was a spurt in synthetic flavour compounds and identification of the flavour compounds in various foods and processed products. Besides this these are also of great importance in the drug industry. For making the medicines favourable to the patients often the former is coated with flavours. Many medicines with their usual taste could cause vomiting or nausea therefore these are camouflaged with suitable flavouring agents.

Food flavourings are classified into three groups.

1) **Natural flavours and natural flavouring substances***:* These are flavour preparations and single substances respectively acceptable for human consumption. These are obtained exclusively by physical means from vegetable, sometimes animal raw materials, either in their natural state or processed for human consumption. Some of the foods contain single compounds giving flavour e.g., menthol in peppermint, benzaldehyde in bitter almond, citral in lime peel, amyl acetate in ripe banana, cinnamaldehyde in cinnamon etc. The natural flavours include spice oleoresins and oils, essential oils like citrus oils; fruit aroma concentrates like apple aroma concentrate etc.

2) **Nature-identical flavouring substances***:* These are the substances chemically isolated from aromatic raw materials or obtained synthetically, they are chemically identical to substances present in natural products intended for human consumption, either processed or not.

3) **Artificial flavouring substances***:* These are the substances, which have not been identified in natural products and are intended for human consumption whether processed or not.

10.8 SWEETENERS

Sweetness is one of the important taste sensations. The importance of sweetness is reflected in huge production of sugar (sucrose) world over. Like any other carbohydrate, sucrose is also a nutrient providing energy to the human system. Over the years, sucrose has been implicated in obesity development and associated diseases and also with dental caries. Besides, diabetes has become a common disease among large sections of the population. As a result there is a general trend towards reducing energy intake in the form of sugars. This has resulted in development of sucrose alternatives or artificial sweeteners. There are two types of sucrose alternatives viz. nutritive and nonnutritive sweeteners. Nutritive sweeteners also called **calorie sweeteners** are usually carbohydrates or carbohydrate derivatives. Nonnutritive sweeteners include a range of natural products which are not carbohydrates in nature and some synthetic chemicals.

10.8.1 Nutritive Sweeteners

You have already learnt about glucose, glucose syrup, fructose and some other carbohydrates and their relative sweetness in Unit 6 of this block. A few other nutritive sweeteners are discussed below.

Sorbitol: Sorbitol is a six carbon sugar alcohol that was originally found in the berries of mountain ash. It is chemically produced from glucose for commercial use. It is highly soluble in water (72% at 25^{o}C). Sorbitol has about half the sweetness of sucrose. Since it has a much lower caloric content compared to sucrose, sorbitol is used as a sweetener for diabetic foods, sugar-free candies and chewing gums.

Xylitol: Xylitol (xylit) is a pentiol found in most fruits and berries as well as xylan (a polysaccharide) containing plant materials. It is also produced by microbiological methods. Xylitol is a crystalline substance, having good water solubility (64% at 25^{o}C). It has sweetness and caloric content equal to sucrose. However, because xylitol is absorbed slowly, it does not cause increase in blood glucose level as glucose or sucrose. Therefore, it is used in diabetic foods also.

Isomalt*:* Isomalt is also called hydrogenated isomaltulose. It is an equimolar mixture of 6-O-β-D-glucopyranosyl-D-glusitol and 1-O-β-D-glucopyranosyl-D-mannitol. It is of about half the sweetness of sucrose and is stable in acid and alkaline media under conditions normally occurring in food processing. It has no impact on blood sugar. Isomalt is used as a sugar substitute in confectionaries, chewing gum, soft drinks and desserts.

10.8.2 Non-nutritive Sweeteners

Saccharin*:* Saccharin was synthesised way back in 1879. During the two world wars, the use of saccharin as a sweetener increased due to the scarcity of sugar and became an accepted sweetener for special dietary and dietetic foods even though its safety has repeatedly been questioned. It was at the centre of controversy when it was shown that rats got urinary cancer after being fed with saccharin. But it was later related to too high a dose saccharine. Nowadays it is unlikely to get such a dose as saccharine is used only in processed drinks like coffee and food. However, saccharine should be avoided by pregnant or breastfeeding women.

The Acceptable Daily Intake (ADI by WHO) of saccharin is fixed at 2.5 mg/Kg body weight.

Saccharin and sodium saccharin are white crystalline powders soluble in water. They are about 500 times sweeter than sucrose. It has good stability during cooking and baking of food products but leaves a slight bitter metallic aftertaste. It is permitted as a sweetener in several countries including India with restrictions.

Cyclamates*:* Although sodium cyclamate was synthesized in 1937, its actual use as a sweetener started only in 1950. Cyclamates is a group name used for cyclamic acid, sodium cyclamate and calcium cyclamate. They are not found in nature. Cyclamates are stable at high temperatures, are easily soluble in water. They are about 30 times sweeter than sucrose and can be used as a non-calorie sweetener in a variety of products. Some times it is used as a mixture along with saccharin. Cyclamates are not without safety questions. Therefore its usage is only allowed with restrictions like most other non-nutritive sweeteners. The use of cyclamates is not permitted under PFA.

The ADI value of cyclamates is 11 mg/kg body weight.

The ADI value is fixed at 40-mg/kg body weight.

Aspartame (Nutrasweet*):* Aspartame was discovered only in 1960. It is the methyl ester of L-aspartyl-L-phenylalanine. Aspartame is produced from the amino acids phenylalanine and aspartic acid. It is an odourless white crystalline powder, slightly soluble in water and almost 150-200 times sweeter than sucrose. Since 1981, it has been used in innumerable food items and diet soft drinks as it is devoid of any carbohydrates, calories, proteins or fats. Aspartame provides 4 Kcal/g energy. It provides sugar like sweetness in foods, but under certain moisture, temperature and pH conditions, it is hydrolyzed and loses its sweetness. Therefore, aspartame is more suitable for dry products or as a table top sweetener although it is widely used in soft drinks, dairy products etc. Like saccharine, aspartame has also been implicated in a number of health related issues but these have not been proved to be correct beyond doubt. However, person with 'phenylketonuria' disorder must avoid it.

The body doesn't process this sweetener.

Acesulfame K: Acesulfame K is one of the most recently introduced (1967) non-nutritive sweeteners. Acesulfame K is the potassium salt of 6-methyl-1,2,3-oxathizine-4(3)-one-2,2-dioxide. It is a white crystalline powder, freely soluble in water, non hygroscopic and 150-200 times sweeter than sucrose. Acesulfame K is used in soft drinks, chewing gum and as a table-top sweetener. More food applications are being investigated.

Sucralose (Splenda*)* - is produced by chlorinating sugar and is comparable to aspartame in terms of it not containing any fat, protein, calorie or carbohydrates and also in not influencing the blood sugar level. This is about 600 times sweeter than sucrose and finds applications in soft drink, candy bars and many other food products.

Rebiana is another non-nutritive sweetener derived from the herb **stevia** of the sunflower family. Stevia extracts are 250-300 times sweeter than sucrose. These are heat stable pH stable and non-fermentable. Rebiana is used as a natural sweetener for the diabetics.

10.9 MISCELLANEOUS ADDITIVES

The number of substances in this category is very large; however, these are not used extensively in fruit and vegetable products. Only a few additives of this category are being dealt with over here. They include emulsifiers and stabilizers, firming agents, anticaking agents, clarifying agents etc.

Emulsifying and stabilizing agents: are essentially used for emulsifying and stabilizing dispersions of oils and fats in aqueous media. Emulsifiers are used to obtain a stable mixture of liquids that other wise would not mix or would separate easily. They include different types of gums esters of fatty acids, lecithin, ester gums (glycerol esters of wood rasin), some synthetic emulsifiers. The emulsifiers were in use since the early 19th century; however, they were produced at the industrial scale only after 1950s. Now there are large varieties of emulsifiers in the market, margarine, mayonnaise, butter and espresso being the most common. Emulsifiers are also used in manufacturing high quality bread, shiny surfaced non-waxy chocolates, and toffees with lower stickiness to teeth, soft chewing gums, light creamy ice creams, and sausages etc.

Firming agents like calcium chloride are used to firm the texture of canned fruits and aluminium sulphate added to pickles.

Anticaking agents are used to impart free flowing properties to dry products as these prevent particles from adhering to each other. Examples are silicates in

potato flakes, dehydrated vegetable powders, cocoa powders, salt; tricalcium phosphate in spices, and fruit powders; and starches in icing sugar etc.

Humectants are moisture retention agents they are used to control viscosity and texture, bulking, retention of moisture, reduction of water activity and retention of softness.

Clarifying agents are used to clarify fruit juices and wines and chill proofing of beer. Gelatin is a typical example of a clarifying agent.

Curing agents are used to preserves (cure) meals, give them desirable colour and flavour. Sodium nitrite is one most widely used curing agent for meat products.

Check Your Progress Exercise 4

Note: a) Compare your answers with those given at the end of the unit.

1) Match the contents given in column A and B correctly.

	Column A		**Column B**
a)	Firming agent in pickles	i)	Sodium nitrite
b)	Curing agent for meats	ii)	Benzaidenyde
c)	Flavouring compound in bitter	iii)	Cyclamates
d)	An example of a nonnutritive sweetener	iv)	Aluminium sulphate

10.10 LET US SUM UP

The components of foods are very important for the growth of the living beings. However, human beings are more particular of the taste and appearance of food and have explored the ways to improve food quality by ways of food additives. Food additives are the substances not present in foods but are added to these for improving food quality.

There are two types of substances other than the usual food components. These are intentional and unintentional or incidental. The former are added deliberately to the foods while the later get added to the food during its production and processing.

The intentional or the food additives are added for various reasons. These are to improve texture, enhance the shelf life, improve flavours, prevent food from auto-oxidation, regain the colour lost during processing, bring firmness to food, emulsify, clarify and many more.

Although the methods of food preservation, colouring and flavouring etc, have been prevalent for ages using natural foods, yet due to the development of newer methods and ways, synthetic food additives have come into use. Synthetic sweetener, saccharin, is one of the most common example and there are many more. However all the food additives should be added according to the regulations in order to prevent any harm.

10.11 KEY WORDS

Preservatives : Substances capable of retarding or arresting the deterioration of food; examples are **sulphur** dioxide, **benzoic acid**, specified **antibiotics, salt, acids**, and essential oils.

Acceptable Daily Intake (ADI) : The amount of a food **additive** that could be taken daily for an entire life-span without appreciable risk. Determined by measuring the highest dose of the substance that has no effect on experimental animals, then dividing by a safety factor of 100.

Non-nutritive Sweeteners : Non-nutritive sweeteners, also called sugar substitutes or artificial sweeteners, do not provide calories and will not influence blood sugars. These include: saccharin, cyclamate, aspartame, sucralose and acesulfame potassium.

Oleoresin : In the preparation of some spices such as pepper, ginger, and capsicum, the aromatic material is extracted with solvents which are evaporated off, leaving behind thick oily products known as oleoresins.

Emulsifier : Surface-active agent that promotes the formation of an emulsion

10.12 TERMINAL QUESTIONS

1) What is the main purpose of adding preservatives to foods? What are their types?
2) Name three types of phenolic antioxidants used for fats and oils and their food applications in general.
3) What is meant by natural and nature-identical flavouring substances?
4) Differentiate between nutritive and nonnutritive sweeteners. Illustrate your answer with suitable examples.
5) Give the main function of each of the following as a food additive.
   a) Tartaric acid
   b) Lecithin
   c) Gelatin
   d) Anthocyanin

10.13 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1) a) incidental additives b) chance contaminants c) vitamin, minerals

Check Your Progress Exercise 2

1) Class I preservatives: glucose, vegetable oils, salt, vinegar

   Class II preservatives: benzoic acid, lactic acid, sorbic acid , propionic acid.

Check Your Progress Exercise 3

1. a) auto-oxidation b) phenolic c) acidulants d) carotenoids, natural.

Check Your Progress Exercise 4

1) a) iv)
   b) i)
   c) ii)
   d) iii)

10.14 ANSWERS TO TERMINAL QUESTIONS

1) Foods undergo spoilage due to the microbial contamination of food. Preservatives function to preserve food by checking the growth of microbes. There are two types of preservatives; type I preservatives and type II preservatives. The former have no restrictions of use while the later are to be used under certain regulations.
2) BHA, BHT, TBHQ and propylgallate are the most widely used phenolic antioxidants. The antioxidants interfere or inhibit the auto-oxidation reaction.
3) Natural flavouring substances are flavouring substances acceptable for human consumption, obtained from vegetables, animal raw materials either in their natural state or processed.
4) Nature identical flavouring substances are chemically isolated from aromatic raw materials or obtained synthetically.
5) Nutritive sweeteners are the calorie sweeteners which are usually carbohydrates or carbohydrate derivatives e.g., glucose fructose, sucrose etc.
6) Nonnutritive sweeteners are the sweeteners which belong to the class of natural products, non-carbohydrate in nature and some synthetic chemicals e.g., saccharin, cyclamates, aspartame etc.
7) i) Acidulant
   ii) Emulsifying Agent
   iii) Clarifying agent
   iv) Colouring agent

10.15 SOME USEFUL BOOKS

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