UNIT 6 FOOD ADDITIVES

Structure

6.0 OBJECTIVES

After reading this unit, you should be able to answer:

- the definition of food additives;
- different types of food additives;
- their chemical properties and functions in foods; and
- their legal status for the purpose of adding to foods.

6.1 INTRODUCTION

Food additives have been used for centuries to enhance the quality of food products. Smoke, alcohol, vinegar, and spices were used more than 10,000 years ago to preserve foods. Along with the developments in Food Chemistry and Food preservation in the early 1900s, the use of food additives increased significantly. The demand for new, tasty, convenient, and nutritious foods continued to increase. As a result, by the early 1960s, over 2500 different chemicals were being used in foods in many developed countries.

Different people used to understand food additive in different ways. The widely accepted definition of food additive is:

> "a substance or mixture of substances, other than a basic foodstuff, which is present in a food as a result of any aspect of production, processing, storage, or packaging. The term does not include chance contaminants".

Food additives are substances intentionally added for specific functions. The number of additives being used in food today is very large. However, they can be classified into a few types based on their functional properties. They may include: 1) preservatives, 2) antioxidants, 3) acidulants, neutralizers and buffers, 4) colouring agents, 5) flavouring agents, 6) sweeteners 7) nutritional additives, and 8) miscellaneous additives.

The use of food additives is well-accepted practice but not without controversy. There have been a number of concerns regarding the potential short-term and long-term risks of consuming these substances. Based on the available scientific information on the toxicological status of each additive and the likely quantity of that additive consumed through a particular food, the maximum permissible limits (Acceptable Daily Intake, ADI) of additives have been stipulated. As you will be learning in subsequent units, each country has laid down its own food legislation and The Prevention of Food Adulteration Act (PFA) and Rules, 1954, in India lists the additives permitted in different foods and their maximum permissible limits. You will also be learning that our food standards are in the process of harmonisation with international food standards. Therefore, it is likely that the present list of permitted additives under PFA may increase in the near future. Keeping these points in mind, in this unit some important and versatile food additives are included even though some of them may not be permitted under PFA at present. The nutritional additives viz. vitamins and minerals have already been dealt with in the previous unit; they will not be included in this unit.

6.2 PRESERVATIVES

From prehistoric times humans have attempted to preserve food products from the deteriorative effects of microorganisms. Some chemical food preservatives like salt, nitrites and sulphites have been in use for many years. Even though newer packaging techniques, processing and storage methods are able to preserve foods without chemical preservatives, even today these chemicals play a significant role in protecting the food supply mainly because preservation using chemical preservatives is cheaper and more convenient.

Under PFA, 1954, preservatives are classified into Class I and Class II preservatives. Class I preservatives are also called natural preservatives. They are, 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.

Class II preservatives are, Benzoic acid and its salts, sulphurous acids and its salts, nitrates or nitrites, sorbic acid and its sodium, potassium and calcium salts, calcium or sodium propionates, lactic acid, sodium or calcium propionate, methyl or propyl parahydroxy benzoic acid, sodium diacetate and sodium potassium and calcium lactate.

Among the above preservatives, benzoates and sulphites are most widely used for preservation of fruit and vegetable products. Sorbates have been permitted for some products lately. Therefore, these and a few natural preservatives will be dealt with in this unit.

6.2.1 Class I Preservatives

1) *Salt (sodium chloride):* 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. The anti- microbial activity of sodium chloride is essentially related to its ability to reduce water activity (a_w) and create unfavourable conditions for microbial growth. As the water activity of the external medium is reduced, microbial cells are subjected to osmotic shock and rapidly lose water through plasmolysis. These results in the cells ceasing to grow and either die or remain dormant. Aside from the osmotic influence on microbial growth, other possible mechanisms include limiting oxygen solubility in the medium and toxicity of chloride ions.

   Sodium chloride-intolerant bacteria are inhibited by concentrations as low as 1%. Some bacteria like the lactic acid bacteria used in producing lactic fermented vegetables (you have learned in the units under 'Food fermentations') can tolerate from 6–15 % sodium chloride. In general, food borne pathogenic bacteria are inhibited by a water activity of 0.92 or less which is equivalent to sodium chloride concentration of 13%. That is why for salt curing, sodium chloride concentration of about 13% is commonly used.

   The inhibitory effect of sodium chloride is dependent on several factors particularly pH. As acidity increases, less sodium chloride is required to inhibit microbial growth.

2) *Acetic acid:* Synthetic vinegar (dilute acetic acid) and brewed vinegar are widely used as acidulants and antimicrobials. Vinegar pickles are common in our country.

   Acetic acid is more effective against yeasts and bacteria than moulds. Only acetic, lactic and butyric bacteria are markedly tolerant to acetic acid. As is the case with most other preservatives, acetic acid is also more effective at lower pH. Generally, 1-2 % acetic acid is sufficient to inhibit most of the organisms.

3) *Sugar and spices:* They also have preservative effects in many food products. The main function of sugar is to reduce the water activity of the medium thus inhibiting the growth of microorganisms. Many chemical substances in spices (terpenes) have been shown to have antimicrobial properties.

6.2.2 Class II Preservatives

As mentioned above, there are a number of chemicals having preservative action. However, only a few of them are permitted for use in foods. So, what are the factors to be considered in selecting a preservative for a food?

How to select a preservative?

Firstly the effectiveness of the preservative against different types of spoilage organisms must be known. This along with the knowledge of the common spoilage organisms associated with the product will allow the selection of the correct preservative for the product. Secondly, the physico-chemical properties of both the preservative and the product should be known. The ionisation and solubility characteristics of the preservative in the product as well as the pH of the product are important factors. Finally, the safety and legality of the preservative chosen must be known.

Benzoic acid and benzoates: 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. Benzoic acid is sparingly soluble in water (0.27% at 18^{o}C). As sodium benzoate has higher solubility (66% at 15^{o}C), it is mostly used for preservation. Benzoates are most effective at low pH (pH 2.5–4.0) because the undissociated form is the effective antimicrobial agent.

Benzoic acid is permitted in several products like squashes, syrups, crushes, fruit juices, jams, jellies, marmalade, beverages, pickles and tomato products. You will be learning its maximum permissible limits in these products in the course on different products. Benzoic acid and its sodium and potassium salts have been generally recognised as safe (GRAS).

Sulphur dioxide and sulphites: 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 nonenzymatic browning in a variety of food products.

Sulphur dioxide is a colourless, non-flammable gas with a suffocating odour. It dissolves readily in water to produce sulphurous acid (H_2SO_3). Sulphur dioxide and its salts (bisulphites and metabisulphites) exist in a pH – dependent equilibrium in solution.

As the pH decreases, the proportion of the undissociated H_2SO_3 increases. As in the case of benzoic acid, the undissociated sulphurous acid has more antimicrobial activity than the dissociated ions.

Sulphurous acid inhibits yeasts, moulds and bacteria. However, yeasts and moulds are less sensitive than bacteria. That is the reason why sulphur dioxide is used at low concentrations (about 100 ppm) during grape juice fermentation to control the growth of other microorganisms and facilitate growth of yeast. Sulphur dioxide and sulphites are permitted under PFA for a number of products like fruit pulps, squashes, syrups, crushes, cordials, wines, RTS beverages, and dehydrated fruits and vegetables. Sulphur dioxide is also used as an antibrowning agent. Fruits are exposed to fumes of burning sulphur before drying to prevent browning and also insect and microbial attack. Sulphite solutions are also used as dip solution for vegetables before drying or dehydration.

Sulphur dioxide and several sulphites have GRAS status. However, sulphites cannot be used in meats and in foods that are sources of the vitamin thiamine. As sulphites have strong bleaching action on plant pigments like anthocyanins, they should not be used for preserving such products. It has been found that sulphites show allergic responses in certain individuals, such as steroiddependent asthmatics. This has led to ban of use of sulphites on raw fruits and vegetables in many countries.

Sorbic acid and sorbates: 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). It is a trans-trans, unsaturated monocarboxylic fatty acid.

The acid is a white crystalline powder and is slightly soluble in water (0.16% at 20^{o}C). The potassium salt, which is highly soluble in water (58.2% at 20^{o}C), is mostly used as the preservative. However for preservation of oils like corn oil, the acid is used because the salt is practically insoluble.

In the case of sorbic acid also, the undissociated acid has the highest antimicrobial activity. Therefore, sorbic acid is also more effective at low pH. However the dissociated acid also shows microbial action, though of a lower order. At pH above 6, the dissociated acid is responsible for more than 50% of the inhibition observed. This is the reason why sorbates are preferred for products like chapatti and cheese.

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 chapatties and fat spreads. Sorbic acid and potassium sorbate have GRAS status.

Nitrites: 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.

Nitrites are white or pale yellow hygroscopic crystals. Sodium nitrite is quite soluble in water. Nitrite has a strong inhibitory action against *Clostridium botulinum* and several other microorganisms. It is more effective below neutral pH (below 7.0). Along with salt, nitrite exhibits stronger antimicrobial action.

Biologically derived antimicrobials

Antimicrobial substances (antibiotics) produced by microorganisms have been known for many years. However, some of these substances are allowed for food use only in recent years. Nisin, and natamycin have been permitted in some foods.

Nisin is a polypeptide produced by *Steptrococcus lactis* (now called *lactococcus lactis*). The solubility of the compound depends on the pH of the medium. It is more soluble in acidic pH and almost insoluble in neutral pH.

Nisin has a narrow spectrum affecting only gram-positive bacteria, including lactic acid bacteria, streptococci, bacilli, and clostridia. It generally does not inhibit gram-negative bacteria, yeasts or moulds. The antimicrobial action of nisin is pH dependent, increases as the pH decreases. It is effective at very low concentrations of the order of 0.04–2.0 ppm. Nisin has been permitted in packaged coconut water and canned rasagolla under PFA.

Natamycin: It is produced by the bacterium *Streptomyces natalensis*. The compound has a large lactone ring which is substituted with one or more sugar residues. Natamycin is primarily effective against yeast and moulds and is ineffective against bacteria, viruses and actinomyces. Natamycin is also effective at very low concentrations of the order of 5-10 ppm. Natamycin has been permitted for surface treatment of hard cheese.

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 additive.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

2. How are preservatives classified under PFA? List the Class I preservatives.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

3. List the permitted (PFA) Class II preservatives. What are the functions of sulphites in foods?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

6.3 ANTIOXIDANTS

Antioxidants play important role in preserving fats, oils and fatty foods. You have already learnt the chemistry of oils and fats. They are essentially fatty acid esters of glycerine. The fatty acids can be either saturated or unsaturated. The unsaturated fatty acids in fats and oils can undergo oxidation during storage leading to rancidity development. Along with rancidity development, vitamin destruction, discolouration and even toxic effects are possible.

Lipid oxidation is often referred to as an autocatalytic reaction. It is a complex reaction, which once initiated will become a chain reaction. Food antioxidants are substances that are able to inhibit or interfere with the autoxidation reaction fundamental to glyceride oxidation. In simple terms, they get oxidised in preference to the fats and oils.

You have already learnt 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. 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.

The most widely used phenolic antioxidants for fats and oils are i) butylated hydroxy anisole (BHA), ii) butylated hydroxy toluene (BHT), iii) propyl gallate and iv) tert-butyl hydroquinone (TBHQ).

Butylated hydroxy anisole (BHA): BHA is a white, waxy solid that is usually tableted to minimize caking during storage. It is readily soluble in glycerides and organic solvents and insoluble in water and has a distinct phenolic odour. BHA is quite stable during normal processing and storage of fatty foods. Therefore, it is considered to have good carry-through effect. However, being volatile at high temperatures, BHA may be lost partially during deep fat frying.

Butylated hydroxy toluene (BHT): BHT is a white, crystalline solid. It is also soluble in glycerides, and insoluble in water. It has a fair degree of carry-through effect but partially lost by volatilisation at high temperatures. BHT is less effective as an antioxidant than BHA.

Propyl gallate: Propyl gallate is the n-propyl ester of 3,4,5- trihydroxy benzoic acid or gallic acid. It is a white to light grey powder. It has low oil solubility and significant water solubility. Though it has very good antioxidative properties, due to its heat-labile nature; it has very little carry-through properties especially under alkaline conditions encountered in baked foods. Therefore, propyl gallate is used in combination with other antioxidants like BHA thus providing the combined effects of improved storage stability and carry-through protection.

tert-Butyl hydroquinone (TBHQ): TBHQ is a white to light tan crystalline solid noted for its effectiveness in increasing the storage stability of fats and oils. It is moderately soluble in fats and oils, and only slightly soluble in water. Unlike the other phenolic antioxidants, it does not form coloured compounds with metal ions in foods like iron, which is an advantage. TBHQ provides good carry-through protection to fried foods.

Applications of phenolic antioxidants

As mentioned earlier, among the food additives, perhaps the antioxidants are the most widely used. 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 phenolic antioxidants **except BHT** have been permitted with restrictions. Additionally, lecithin and ascorbil palmitate are also permitted for specific food products.

6.4 ACIDULANTS

Acidulants contribute a variety of functional properties that lead to the enhancement of food quality. Most of the acidulants used in food are organic acids. The organic acids and their salts commonly used in foods are acetic, ascorbic, citric, lactic, malic and tartaric acids. Inorganic acids like phosphoric acid is also used extensively in cola type beverages. Organic acids like citric, malic and tartaric acids are widely distributed in pants. Ascorbic acid, which is vitamin C, is also of plant origin. Lactic acid as the name implies is derived from milk. Since some aspects of acetic and ascorbic acids were already covered elsewhere, they are not specifically discussed here.

Citric acid is perhaps the most widely used organic acid. It is a tricarboxylic acid abundantly present in citrus and many other fruits. Even though it used to be produced from citrus fruits, at present most of the commercial citric acid is manufactured by fermentation. Citric acid is a white crystalline powder, easily soluble in water. Commercial citric acid is available as the monohydrate. It is hygroscopic in nature. Therefore, citric acid is not very suitable for use in dry food formulations.

Malic acid is 2-hydroxybutanoic acid, which is a dicarboxylic acid. It is the major acid in apples and mango. It is a crystalline white powder, easily soluble in water. Synthetic malic acid is available commercially. Since it is not hygroscopic, malic acid is preferred for use in dry food formulations.

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

General functions of acidulants

The proper selection of an acid is dependent on which property or combination of properties of the acid is desired as well as its cost. Some of the general functions are given below.

- *Flavouring agents:* They intensify certain tastes and flavours, mask undesirable tastes
- *Buffering action:* The salts of organic acids, especially the sodium salts control the pH of food during various stages of processing as well as of the finished products.
- *Preservation:* By reducing pH, prevent growth of microorganisms and the germination of spores, which lead to spoilage and food poisoning.

- *Sequestering:* Bind metal ions and enhance the function of antioxidants.
- *Viscosity modifiers:* Like in dough, consequently modifying the shape and texture of baked foods.
- *Meat curing agent:* Together with other curing components, enhance colour, flavour and preservative action.

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

6.5 COLOURING AGENTS

Food colouring agents (colourants) may often be considered simply of cosmetic in nature, but the role they play is actually very important. You will be learning more about this quality attribute of food in a subsequent unit.

The addition of colourants to foods in order to make them more attractive is not a new invention. Extracts of spices and vegetables were used for the purpose as early as 1500 B.C. The advent of the use of food colourants in the late 1800s and early 1900s was unfortunately accompanied by their misuse in food adulteration, 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.

Development of synthetic dyes became a boon to the food industry because these colourants were superior to natural extracts in tinctorial strength (colour intensity), number of shades, stability, and easy availability and was cheap. However, safety is the most important aspect of synthetic food colours. Extensive toxicological studies have been carried out on these colourants in different countries. While many of the colourants have been found to be harmful, a few others appeared to be safe for use depending on various factors like the quantity of the colourant consumed. Besides, the test methods followed in different countries varied, which have resulted in much scientific and political debate. Consequently, colourants considered safe in one country may not be considered safe in another country. The toxicological studies are revealing newer information and hence the regulatory status of the colourants used in countries throughout the world is in a state of flux. One common observation is that the number of permitted synthetic colourants is decreasing year by year.

The regulatory status of several natural colourants is less severe mainly because they are mostly extracted from edible plant sources. Another class of colourants are called **nature-identical** colourants. They are those identical counterparts of naturally occurring pigments. Some examples of nature-identical colourants are β -carotene, canthaxanthine, and β -apo-8'-carotenal. Their regulatory status is similar to natural colourants.

Under PFA, the following natural and synthetic colours are permitted at present with restrictions on their maximum levels and the specific food products.

Natural colouring matters

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

Synthetic food colours

Sl.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	Triaryl methane
8.	Fast green FCF	Green	Triaryl methane

6.5.1 Natural Food Colourants

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. Anthocyanins are composed of an aglicone (anthocyanidin) esterified to one or more sugars and may be acylated. The sugars may be glucose, rhamnose, galctose, xylose and arbinose. Grape skin and elderberries are good commercial sources of anthocyanin pigments.

The anthocyanin double ring benzopyran structure is very reactive. The compounds are easily ionised and tend to become colourless above pH 4.5. They exibit their most intense colours below pH 3.5. Therefore, these colourants are only suited for acidic foods. Anthocyanins easily undergo discolouration in the presence of amino acids, phenolic sugar derivatives etc. They are also bleached by ascorbic acid and sulphites.

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. Ex. β-Carotene present in carrots, chillies, soybean. ii) Lycopenes – These are carotenoids not having β-ionone rings and do not possess vitamin-A activity. Lycopene is present in tomato, apricot, watermelon, and red guavas. iii) Xantohphylls – These are oxygenated derivatives of carotene. These have β-ionone rings, but do not possess vitamin-

A activity. They are present in papaya, orange peel, and yellow maize. iv) α-Carotene – This is similar to β-carotene in its biological activity.

Chemically carotenoids are poly –enes composed of isoprene units. They are fat soluble and fairly heat stable. During processing of fruits and vegetables, partial loss of carotene takes place. They are stable at pH 2–7. As a result of their chemical structure, which contains conjugated double bonds, carotenoids are very sensitive to oxidation. Ascorbic acid can protect β -carotene by serving as an antioxidant. "Nature-identical" synthetic β -carotene is marketed in forms that confer protection from oxidation.

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. Betalains are sensitive to pH, light and heat. These compounds are most stable at pH 4 – 5. Because of the carbohydrates present in betalains, the colourants tend to impart beet flavour to the food.

Production of colourants like anthocyanins and betalains by tissue culture technique offers the advantage of a more reliable supply of the colours independent of plant variability and elimination of the strong undesirable plant flavours.

Chlorophylls: Chlorophylls, the most abundant naturally occurring plant pigments, are the green and olive green pigments in green plants. Chlorophylls are obtained from a wide variety of sources and they are mixture of 2 compounds namely chlorophyll a and chlorophyll b present in the ratio of 3a: 1b in plants. They belong to a group of important biological pigments called porphyrins, which include haemoglobin, and is composed of four pyrole rings held together. Magnesium is located in the centre of the molecule.

Chlorophylls 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 brown. When vegetables containing chlorophyll is cooked, the central Mg atom is replaced by hydrogen atom and loses it's colour forming pheophytin. Chlorophylls may be stabilized by replacement of the magnesium ion in the compound with copper.

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

Paprika oleoresin, which is orange red to deep red, is the extract of mild capsicum (*Capcicum annum*). 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.

6.5.2 Synthetic Colourants

Synthetic colourants, also known as coal tar dyes or aniline dyes were earlier manufactured from coal tar derivatives. 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.

As can be seen from the table above, the permitted synthetic colorants belong to five chemical classes viz. azo, xanthene, pyrazole, indigoid and triarylmethane. You may notice that all together there are three red, two yellow, two blue and one green colour permitted under PFA. All these colours are water-soluble. As mentioned earlier, these colours are more resistant to chemical reaction, pH and heat compared to natural colourants.

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. What is the function of an antioxidant in foods?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

2. List two natural and three phenolic antioxidants.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

3. Describe the general functions of acidulants in foods?

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

4. List the synthetic colours permitted in foods under PFA.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………

6.6 FLAVOURING AGENTS

Flavour like colour of foods has a great bearing on acceptance of foods and therefore, has enormous commercial importance. It apparently has no nutritional value although some studies have indicated that taste can alter intestinal absorption of glucose and fat metabolism. Flavour is defined in several ways. One definition is: "**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".**

Food flavours is a very vast subject. You will be learning sensory perception and analysis of flavour in a subsequent unit. In this section you will learn some essential aspects of the chemistry and application of food flavourings.

During the early days, people used spices 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. The role of sensory analytical techniques in flavour research is very significant. One major finding was that most of the food flavours were due to a combination of a number of chemical compounds and only in a few cases, one single compound was responsible for the characteristic flavour of a food. Few examples are menthol in peppermint, benzaldehyde in bitter almond, citral in lime peel, amyl acetate in ripe banana, cinnamaldehyde in cinnamon etc. Therefore, it became apparent that creation of a food flavour is not an easy task. However, with a combination of art and scientific know-how, today a large number of flavour formulations are available. It is an extremely large industry. Food flavourings are classified into three groups.

1. *Natural flavours and natural flavouring substances:* They are flavour preparations and single substances respectively acceptable for human consumption, obtained exclusively by physical means from vegetable, sometimes animal raw materials, either in their natural state or processed, for human consumption.

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

3. *Artificial flavouring substances:* They are those substances, which have not been identified, in natural products intended for human consumption either processed or not.

The natural flavours include spice oleoresins and oils, essential oils like citrus oils; fruit aroma concentrates like apple aroma concentrate etc. As indicated earlier, the number of synthetic flavour substances is extremely large. Therefore, instead of listing the permitted flavouring substances, only those, which are not permitted, are specified under PFA. In this connection it is important to note that the concentrations of the flavour chemicals in natural or synthetic flavours to impart the desired flavour perception are extremely low, of the order of parts per million or parts per billion. As they have self-limiting property, maximum permissible limits are not stipulated.

6.7 SWEETENERS

Sweetness is one of the important taste sensations. The importance of sweetness is reflected in huge production of sugar (sucrose) world over. Sucrose is not consumed only for its sweetness. It also has many functional properties in foods like a bulking agent, texture modifier, and preservative.

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 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. This has resulted in development of sucrose alternatives.

There are two types of sucrose alternatives viz. nutritive and non-nutritive sweeteners. Nutritive sweeteners also called calorie sweeteners are usually carbohydrates or carbohydrate derivatives. Non-nutritive sweeteners include a range of natural products and some synthetic chemicals.

6.7.1 Nutritive Sweeteners

You have already learnt about glucose, glucose syrup, fructose and high fructose syrup and their relative sweetness in an earlier unit. In this section you will be learning about a few other nutritive sweeteners.

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 half the sweetness of sucrose.

As 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 6-0-β-D-glucopyranosyl-Dglusitol and 1-0-β-D-glucopyranosyl-D-mannitol. Isomalt is produced by the enzymatic transglucosidation of sucrose to isomaltulose and hydrogenation. It is of about half the sweetness of sucrose. It 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.

6.7.2 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.

Saccharin is a general name used for saccharin, sodium saccharin and calcium saccharin. Chemically saccharin is 1,2-benzisothiazol-3 (2H)-one-1, 1-dioxide. 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.

Available toxicological information does not conclusively implicate saccharin for any serious health hazard. The Acceptable Daily Intake (ADI by WHO) of saccharin is fixed at 2.5 mg/Kg body weight. However, as more and more research results accumulate, safer alternates for saccharin is bound to emerge.

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 synthesized from cyclohexylamine by sulphonation. 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 noncalorie 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. Its ADI value is 11 mg/Kg body weight.

Aspartame: 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.

Aspartame provides 4 Kcal/g energy. Aspsrtame provides sugar like sweetness in foods, but under certain moisture, temperature and pH conditions, it is hydrolysed 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. Soft drinks are usually sweetened with a mixture of saccharin and aspartame.

Available evidence suggests that normal consumption of aspartame is safe because consumption of asprtame from foods is far below any suspected toxic levels. Its ADI value is fixed at 40-mg/Kg body weight. The use of asprtame is permitted in many countries including India.

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.

The available toxicological data on acesulfame K do not show any serious safety implications. The ADI value is fixed at 9-mg/Kg body weight. Its use as a sweetener is permitted in some countries including India with restrictions.

6.8 MISCELLANEOUS ADDITIVES

The number of substances in this category though very large, is not used extensively in fruit and vegetable products. Therefore, only a few of them will be dealt with in this section. 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. They include different types of gums (you have learnt under 'carbohydrates'), esters of fatty acids, lecithin, ester gums (glycerol esters of wood rosin) 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. 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.

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

Check Your Progress Exercise 3

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

1. Differentiate between natural and nature-identical flavouring substances.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

2. What is the difference between nutritive and non-nutritive sweeteners? Give three examples of each.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

3. Give one example each for Firming agent, Anticaking agent and Clarifying agent.

    ……………………………………………………………………………………

    ……………………………………………………………………………………

    ……………………………………………………………………………………

    ……………………………………………………………………………………

6.9 LET US SUM UP

A large number of additives are used in foods for different functions. Some are used as preservatives, which prevent microbial spoilage while antioxidants preserve food against oxidative deterioration. Acidulants have dual roles of preservation as well as imparting the desired taste. Colourants and flavouring agents are added essentially to enhance the acceptability of foods. There are also other additives having functions like texture modification, clarification, imparting free flowing characteristics to food powders etc.

All the food additives are not free from suspected health hazards. Therefore, their use in foods is restricted by food legislations.

6.10 KEY WORDS

Additive	:	Substance added intentionally
Class I preservatives	:	Natural preservatives
Class II preservatives	:	Chemical preservatives
Antioxidant	:	Substance, which prevents oxidation
Nutritive sweeteners	:	Sweeteners having calorific value.

6.11 ANSWERS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress Exercise 1

1. Your answer should include the following points:

    - Other than basic foodstuff
    - Added, not chance contaminant

2. Your answer should include the following points:

    - Class I and class II preservatives
    - Salt, sugar, spices, vinegar etc.

3. Your answer should include the following points:

   - Benzoates, sulphites, sorbates etc
   - Antimicrobial, anti browning

Check Your Progress Exercise 2

1. Your answer should include the following points:

   - Inhibit autoxidation of glycerides
   - Get oxidised in preference to fats and oils

2. Your answer should include the following points:

   - Tocopherols, ascorbic acids
   - BHA, BHT, TBHQ

3. Your answer should include the following points:

   - PH reduction
   - Buffering
   - Flavouring

4. Your answer should include the following points:

   - Ponceau
   - Carmoisine
   - Erythrosine
   - Sunset yellow etc

Check Your Progress Exercise 3

1. Your answer should include the following points:

   - Natural flavouring substances isolated by physical means
   - Chemically identical to natural substances but chemically isolated from aromatic substances or synthetically prepared

2. Your answer should include the following points:

   - Calorie sweeteners
   - Sucrose, glucose, fructose etc
   - Non calorie sweeteners
   - Synthetic
   - Saccharin, cyclamate, aspartame, acesulfame K

3. Your answer should include the following points:

   - Calcium chloride
   - Tri calcium phosphate
   - Gelatine

6.12 SOME USEFUL BOOKS

1. Larry Branen, A., Michael Davidson, P., and Seppo Salminen (1990) (Eds.) Food Additives, Marcel Dekker, Inc., New York and Basel.

2. Owen R. Fennema (1976) Principles of food science, Part I- Food Chemistry, Marcel Decker Inc.; New York.

3. Meyer L.H. (1969) Food Chemistry, Van Nostrand Reinhold Company, New York, Cincinnati, Toronto, London, Melbourne.

4. Ranganna, S. (2000) Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.