

FOOD SCIENCE AND TECHNOLOGY

Lecture36

Lecture 36: Chemical Food Additives

Hello everyone. Namaskar. Now we are entering the eighth module of the course.



The banner features the NPTEL logo and the Indian Institute of Technology Kharagpur logo at the top. Below them, the text reads: "NPTEL ONLINE CERTIFICATION COURSES", "Food Science and Technology", "Professor H N Mishra", "Agricultural and Food Engineering Department", "Indian Institute of Technology Kharagpur". At the bottom, it specifies "Module 08 : Food Additives and Contaminants" and "Lecture 36 : Chemical Food Additives".

The next five lectures in this module will be devoted to food additives and contaminants. So, in today's lecture, we will study chemical food additives.



The slide is titled "Concepts Covered" and lists the following topics:

- Food additives
 - ✓ Definition and classification
- Criteria to be fulfilled by a chemical for use in a food
- Antioxidants and chelating agents
- Nutrient supplement
- Non-nutritive sweeteners

On the right side of the slide, there is a circular graphic with the text "Food Additives" and several small images of food products. At the bottom right, there is a small video inset showing Professor H N Mishra speaking. The bottom of the slide features the IIT Kharagpur logo and the text "IIT Kharagpur".

We will talk, in general, about what food additives are, their definition, and classification, and the criteria to be fulfilled by a chemical for use in food. Then we will talk about some specific additives like antioxidants and chelating agents, nutrient supplements, as well as non-nutritive sweeteners.

the FSSAI definition of a food additive. The maximum use level of an additive is the highest concentration found to be both functionally effective and safe in a food or food category, typically expressed as milligrams per kg of food. This level may not match the optimum or recommended use level, which varies by application under good food manufacturing practices and depends on factors like the intended technical effect, food type, processing, and handling conditions.

Criteria to be fulfilled by a chemical for use in a food

Why are chemicals used in foods?

- Chemicals may be added to foods to extend
 - Freshness**
 - Increase nutritional benefits**
 - Enhance taste**
 - Improve texture**
 - Maintain food safety**

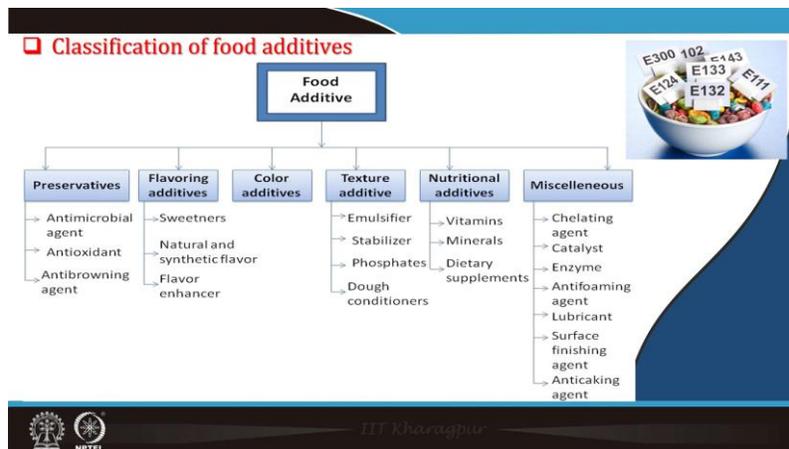
So, the criteria to be fulfilled by a chemical for use in food. So, I think you now have some hint as to why chemicals are used in food from the definition itself. So, obviously, as we discussed, chemicals may be added to foods to extend freshness, to increase nutritional value or provide nutritional benefits, enhance taste, improve texture, maintain food safety, and for many other purposes.

Criteria to be fulfilled by a chemical for use in a food (Contd...)

- The World Health Organization (WHO) and the Joint FAO/WHO Expert Committee on Food Additives (JECFA) assess food additives' safety to ensure they don't pose health risks to consumers.
- The criteria for approval include
 - Safety assessments**- The additive must undergo a JECFA safety assessment and toxicological tests on animals to determine a safe consumption amount.
 - Acceptable daily intake (ADI)**- An ADI is established to determine if the additive can be consumed without harmful effects.
 - Stability**- Data demonstrating the additive's stability under intended conditions of use is required, especially if it's sensitive to environmental factors.
 - Technological need**- There must be a justifiable technological need for the additive.
 - Consumer deception**- The additive must not mislead consumers or disguise the use of poor quality raw materials or undesirable practices.

The World Health Organisation and the joint FAO-WHO expert committee on food additives, which is popularly known as JECFA, assess food additive safety to ensure they do not pose health risks to consumers. So, the criteria for approval of a chemical as a food

additive, as per JECFA, include, most importantly, a safety assessment. That is, the additive must undergo a JECFA safety assessment and toxicological tests on animals to determine a safe consumption amount. Then, the acceptable daily intake, that is, ADI. So, ADI is established to determine if the additive can be consumed without harmful effects. Then, stability data is taken into consideration; that is, the data demonstrating the additive's stability under intended conditions of use, processing, handling, etc., is required, especially if it is sensitive to environmental factors like oxygen, temperature, and so on. Then, there is a technological need, that is, the chemical must have a justifiable technological need for the additive. As a rule, one should avoid the use of any chemical in food, if the same benefit intended by the addition of a chemical, if the same benefit can be obtained by an economically viable physical process or method, then one should go for that. So, for the use of a chemical in food, there must be a sound, justifiable technological need and then another very important criterion is that it should not lead to deception of the consumers. That is, the additive must not mislead consumers or disguise the use of poor-quality raw materials, or it must not disguise faulty processing operations, etc. So, for that purpose, for example, if you have used excessive heating and the colour has degraded, the flavour has been lost. So, you can use certain colors to improve the. So, that should not be consumed; that should not be taken into account, okay? That is, it should not mislead consumers.



Then the classification of food additives may be. preservatives like antimicrobial agents, antioxidants, and anti-browning agents. It may be another class of flavouring additives, such as sweeteners, natural and synthetic flavours, flavour enhancers, etc. Then colour additives, texture additives, nutritional additives and apart from that, there are another miscellaneous group of additives like chelating agents, catalysts, enzymes, anti-foaming agents, surface finishing agents, anti-caking agents. So, there is a vast list of the purposes

or functional properties or other characteristics for which the chemicals can be used in food.

❖ **Functional classification of food additives**

Functional classes of additives	Definition	Sub-classes (Technological functions)
▪ Acid	✓ Increases the acidity and/or alkalinity of a food.	✓ Acidifier
▪ Acidity regulator	✓ Alters or controls the acidity or alkalinity.	✓ Acid, alkali, base, buffer, buffering agent, pH adjusting agent
▪ Anticaking agent	✓ Reduces the tendency of particles of food to adhere to one another.	✓ Anticaking agent, antistick agent, drying agent, dusting powder, release agent
▪ Antifoaming agent	✓ Prevents or reduces foaming	✓ Antifoaming agent

Functional classification of food additives (Contd...)

The other antioxidant prolongs the shelf life of food by protecting against deterioration caused by the oxidation of fat, such as fat rancidity, colour changes, flavour changes, etc., in the food. fat and fat products. So, here the technological subcategory may be an antioxidant synergist or sequestrant, etc.

▪ Colour retention agent	✓ Stabilizes, retains or intensifies the colour of a food.	✓ Colour fixative, colour stabilizer
▪ Emulsifier	✓ Forms or maintains a uniform mixture of two or more immiscible phases which surface as oil and water in a food.	✓ Emulsifier, plasticizer, dispersing agent, surface active agent, surfactant, wetting agent
▪ Emulsifying salt	✓ Rearranges cheese proteins in the manufacture of a processed cheese, in order to prevent fat separation.	✓ Melding salt, sequestrant
▪ Firming agent	✓ Makes or keeps tissues of fruit or vegetables firm and crisp, or interacts with gelling agents to produce or strengthen a gel.	✓ Firming agent
▪ Raising agent	✓ Substance or combination of substances which liberate gas and thereby increase the volume of dough.	✓ Leavening, raising agent

Functional classification of food additives (Contd...)

Then colour, colour modifier or colouring additives. So, it adds or restores color to a food. Flavour enhancers enhance the existing taste and or odour of a food. So, it may be a flavour enhancer, flavour modifier, or tenderiser. Then, a flour treatment agent is a substance added to flour to improve its baking quality or colour, particularly in wheat flour. There are certain chemicals that are used to improve its baking properties.

			Functional classification of food additives (Contd...)
▪ Antioxidant	✓ Prolongs the shelf-life of foods by protecting against deterioration caused by oxidation, such as fat rancidity and colour changes.	✓ Antioxidant, antioxidant synergist, sequestrant	
▪ Colour	✓ Adds or restores colour in a food.	✓ Colour	
▪ Flavour enhancer	✓ Enhances the existing taste and/or odour of a food.	✓ Flavour enhancer, flavour modifier, tenderizer	
▪ Flour treatment agent	✓ A substance added to flour to improve its baking quality or colour.	✓ Bleaching agent, dough improver, flour improver	
▪ Foaming agent	✓ Makes it possible to form or maintain a uniform dispersion of a gaseous phase in a liquid or solid food.	✓ Whipping agent, aerating agent	
▪ Gelling agent	✓ Gives a food texture through formation of a gel.	✓ Gelling agent	

So, the bleaching agent, dough improver, flour improver, etc. A foaming agent makes it possible to form or maintain a uniform dispersion of a gaseous phase in a liquid or solid food. So, here, subclasses may be whipping agents, aerating agents, etc. A gelling agent gives food texture through the formation of a gel.

			Functional classification of food additives (Contd...)
▪ Glazing agent	✓ A substance which, when applied to the external surface of a food, imparts a shiny appearance or provides a protective coating	✓ Coating, sealing agent, polish	
▪ Moisture retention agent	✓ Prevents food from drying out by counteracting the effect of a wetting agent atmosphere having a low degree of humidity.	✓ Moisture/water retention agent, wetting	
▪ Preservative	✓ Prolongs the shelf-life of a food by protecting against deterioration caused by agent, bacteriophage control agent, microorganisms.	✓ Antimicrobial preservative, antimycotic	
▪ Propellant	✓ A gas, other than air, which expels a food from a container.	✓ Propellant	

Then, a colour retention agent stabilises, retains, or intensifies the colour of food. It may be a colour fixative, colour stabiliser, etc. Then, an emulsifier forms and/or maintains a uniform mixture of two or more immiscible phases, such as oil and water, in food. So, in this subclass or subcategory, it may be an emulsifier, plasticiser, dispersing agent, surface-active agent, surfactant, wetting agent, and so on. Chemicals having these properties are considered in this group. Then, foaming agents. These make or keep tissues of fruit or vegetable firm and crisp, or they interact with gelling agents to produce or strengthen a gel. Raising agents are substances or combinations of substances which liberate gas and thereby increase the volume of the dough. These are used in the bakery industry as leavening agents, raising agents, and so on.

A glazing agent is a substance which, when applied to the external surface of food, imparts a shiny appearance or provides a protective coating. So, here: coating agent, sealing agent, polish, etcetera. Moisture retention agents prevent food from drying out by counteracting the effect of a wetting agent. or wetting atmospheres with a low degree of humidity. So, here: moisture or water retention agents, wetting, and so on. Preservatives prolong the shelf life of food by protecting against deterioration caused by agents such as microorganisms, bacteria, bacteriophages, control agents, and so on. In this category, there may be antimicrobials, preservatives, antimycotics, etcetera. A propellant is a gas, other than air, which expels food from a container.

Functional classification of food additives (Contd...)	
<ul style="list-style-type: none"> Stabilizer 	<ul style="list-style-type: none"> Makes it possible to maintain a uniform dispersion of two or more immiscible retention agent, foam stabilizer substances in a food
<ul style="list-style-type: none"> Sweetener 	<ul style="list-style-type: none"> A non-sugar substance which imparts a sweet taste to a food sweetener.
<ul style="list-style-type: none"> Thickener 	<ul style="list-style-type: none"> Increases the viscosity of a food.
	<ul style="list-style-type: none"> Binder/firming agent Sweetener, artificial sweetener, nutritive Thickening agent, texturizer, bodying agent

Then, stabilisers are another group of functional food additives. Stabilizers make it possible to maintain a uniform dispersion of two or more immiscible retention agents, foam stabiliser substances, in a food. So, your binder or firming agents may be of their technical class. Sweeteners, particularly non-nutritive or non-sugar substances, impart a sweet taste to a food, such as artificial sweeteners, non-nutritive sweeteners, and so on. Then, thickeners increase the viscosity of a food. So, thickening agents, texturisers, bodying agents, and so on. So, now I have given you a brief overview of the major functional classes of food additive applications, their purposes for use in food, and their technical justification and subclasses. Now, let us take one by one some important classes of food additives. We will cover a few in this lecture and the rest in the next lecture. So, first we will discuss antioxidants and chelating agents, a very important group of functional food additives or chemicals that extend shelf life or provide other functionalities.

Antioxidants and chelating agents

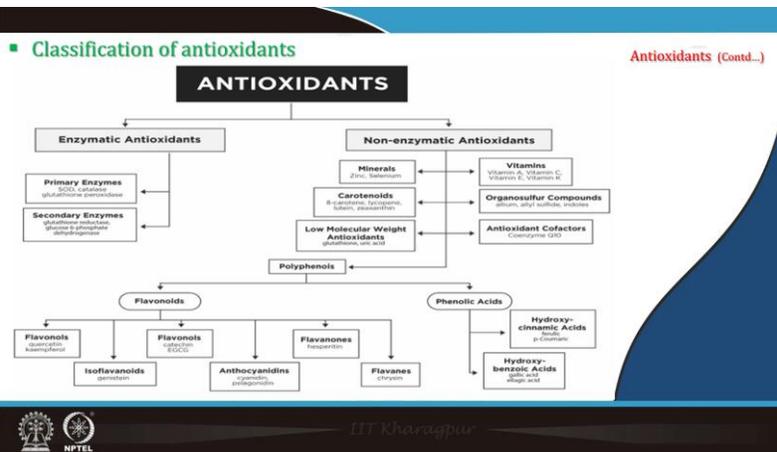
Antioxidants

- Antioxidants are substances that serve as a defense against free radicals, which are byproducts of metabolism or result from environmental factors like air pollution.
- Free radicals can damage cells by altering DNA or cell membranes, leading to oxidative stress and an increased risk of chronic diseases.
- Antioxidants neutralize free radicals, safeguarding cells.
- Prolongs the shelf-life of foods by protecting against deterioration caused by oxidation.



Dr. Kharaschia

So, first let us talk about antioxidants. In earlier classes, we also discussed antioxidants and the oxidation of fats. So, these antioxidants are substances that serve as a defence against the oxidation of fats, particularly free radical formation. These free radicals are byproducts of metabolism or result from environmental factors like air pollution. So, these free radicals can damage cells by altering DNA or cell membranes, leading to oxidative stress and an increased risk of chronic diseases. So, we have seen the details of the mechanism, etc., how the oxidation of fats takes place in the earlier class, what free radical formation is, its mechanism, and all those things. So, antioxidants basically neutralise free radicals and therefore safeguard cells. They prolong the shelf life of foods, particularly fats and oils or food containing significant amounts of fats, by protecting against deterioration caused by oxidation.



Antioxidants can again be classified into two major categories. One is enzymatic antioxidants like primary enzymes or secondary enzymes; others may be non-enzymatic antioxidants.

which may include minerals, vitamins, carotenoids, low molecular weight substances, antioxidant co-factors, or polyphenols. In the earlier class, we again discussed polyphenols, particularly flavonoids and phenolic acids, and how important they are. They have health-promoting activities, and one of their major functions is antioxidant properties, it is their antioxidant properties.

Antioxidants (Contd...)

- **Natural antioxidants**
 - ✓ Natural antioxidants either are synthesized in human body through metabolic process or are supplemented from other natural sources.
 - ✓ This is further divided into two categories.
- **Enzymatic antioxidants**

Enzymatic antioxidants are uniquely produced in the human body and can be subdivided into primary and secondary antioxidant.

Primary antioxidants <ul style="list-style-type: none"> ✓ Superoxide dismutase ✓ Catalase ✓ Glutathione peroxidase 	Secondary antioxidants <ul style="list-style-type: none"> ✓ Glutathione reductase ✓ Glucose-6-phosphate dehydrogenase
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So, let us talk about natural antioxidants. In earlier lectures, we also discussed something about natural pigments and flavoring materials, etc., which have antioxidant properties. So, natural antioxidants are either synthesized in the human body through metabolic processes or supplemented from other natural sources. So, this is further divided into two categories: one is enzymatic antioxidants, that is, enzymatic antioxidants are uniquely produced in the human body and can be subdivided into primary and secondary antioxidants. So, the primary antioxidants may be superoxide dismutase, catalase, glutathione peroxidase, etc. Secondary antioxidants include glutathione reductase, glucose-6-phosphate, and dehydrogenase.

Antioxidants (Contd...)

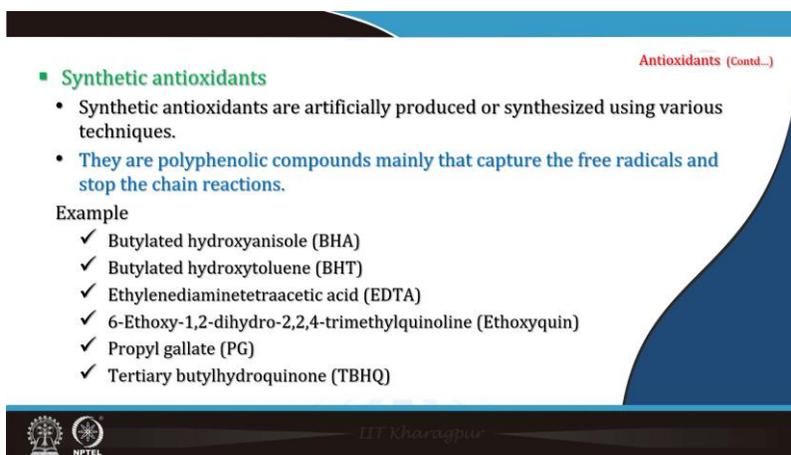
- **Non-enzymatic antioxidants**

They are a class of the antioxidants which are not found in the body naturally but are required to be supplemented for the proper metabolism.

Minerals <ul style="list-style-type: none"> ✓ Iron (Fe) ✓ Magnesium (Mg) ✓ Selenium (Se) ✓ Copper (Cu) ✓ Zinc (Zn) ✓ Manganese (Mn) 	Vitamins <ul style="list-style-type: none"> ✓ Vitamin A ✓ Vitamin C ✓ Vitamin E Carotenoid <ul style="list-style-type: none"> ✓ β-carotene ✓ Lycopene ✓ Lutein ✓ Zeaxanthin 	Polyphenols <ul style="list-style-type: none"> ✓ Flavonoid ✓ Phenolic acids ✓ Gingerol ✓ Curcumin 	Other antioxidants <ul style="list-style-type: none"> ✓ Albumin ✓ Ceruloplasmin ✓ Hepatoglobin ✓ Transferrin ✓ Bilirubin ✓ Uric acid ✓ Coenzyme Q
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Non-enzymatic antioxidants are a class of antioxidants that are not found in the body naturally. But they are required to be supplemented for proper metabolism. Examples here include minerals like iron, magnesium, selenium, copper, zinc, manganese, and vitamins like vitamin A, vitamin C, vitamin E, and carotenoids like beta-carotene, lycopene, lutein, and zeaxanthin. Polyphenols such as flavonoids, phenolic acids, gingerol, curcumin, and other antioxidants like albumin, hepatoglobin, transferrin, bilirubin, uric acid, and coenzyme Q, etc. So, there are several compounds which have the property. They are non-enzymatic compounds, but they have antioxidant properties.



Antioxidants (Contd...)

- **Synthetic antioxidants**
 - Synthetic antioxidants are artificially produced or synthesized using various techniques.
 - They are polyphenolic compounds mainly that capture the free radicals and stop the chain reactions.

Example

- ✓ Butylated hydroxyanisole (BHA)
- ✓ Butylated hydroxytoluene (BHT)
- ✓ Ethylenediaminetetraacetic acid (EDTA)
- ✓ 6-Ethoxy-1,2-dihydro-2,2,4-trimethylquinoline (Ethoxyquin)
- ✓ Propyl gallate (PG)
- ✓ Tertiary butylhydroquinone (TBHQ)

NPTEL

Dr. Khanna

Then, synthetic antioxidants. Synthetic antioxidants are artificially produced or synthesized using various techniques. They are mainly polyphenolic compounds that capture free radicals and stop chain reactions. The major synthetic antioxidants used by the fat and oil industry include butylated hydroxyanisole and butylated hydroxytoluene. Ethylenediaminetetraacetic acid, popularly known as EDTA, then 6-ethoxy-1,2-dihydro-2,2,4-trimethylquinoline, commonly known as ethoxyquin, then propyl gallate, tertiary butylhydroquinone, and so on. So, these are the major synthetic antioxidants used by the food industry.

Mechanism of antioxidants action

- They function by interrupting the free radical chain mechanism involved in lipid oxidation.
- **Effective in small concentration (0.01-0.02%).**
- Mixed antioxidants sometimes act synergistically.

Ascorbic acid (Ascl) → Ascorbate (AscH) → Ascorbate radical (Asc•) → Dehydroascorbate (Asc2)

Antioxidant + Free Radical → Paired Electron + Non-radical

Antioxidants (Contd...)

- Vitamin C, changes to the ascorbate radical by donating an electron to the lipid radical in order to terminate the lipid peroxidation chain reaction.
- The pairs of ascorbate radicals react rapidly to produce one molecule of ascorbate and one molecule of dehydroascorbate.

Dr. Kharaschia

So, let us briefly discuss the mechanism—how these antioxidants work. So, basically, in the free radical, you know that there is an unpaired electron in the outermost orbital. So, these antioxidants donate electrons to the free radical, and they make the unpaired electron a paired electron, meaning they function by interrupting the free radical chain mechanism involved in lipid oxidation. That is, when they donate an electron, the free radical becomes a non-radical compound. So, these antioxidants are effective in small concentrations, maybe 0.01 to 0.02 percent by weight, and mixed antioxidants often act synergistically; that is, if two antioxidants are used together, the effectiveness of each is improved. So, vitamin C changes to the ascorbate radical by donating an electron to the lipid radical to terminate the lipid peroxidation chain reaction, as you can see here in this chemical reaction. So, the pairs of ascorbate radicals react rapidly to produce one molecule of ascorbate and one molecule of dehydroascorbate. So, the radical compounds are converted into non-radical compounds.

Chelating agents

- Chelating agents or sequestrants are compounds that form complexes with metal ions.
- **When metallic ions are released through hydrolysis or degradation, they are free to participate in reactions that lead to food discoloration, oxidative rancidity, turbidity, and flavor changes.**
- The chelating agents are organic macromolecules which, owing to several functional groups, are able to establish more than one chemical bond with the metal ion, stabilizing it and increasing its solubility.

Metallic ion + Chelating agent → Metallic chelate

Dr. Kharaschia

The other class is the chelating agents. So, the chelating agents are also commonly known as sequestrants; they are compounds that form complexes with metal ions. Again, in the earlier lecture when we were talking about micronutrients, particularly the minerals, we discussed the chelate, how the minerals form chelates, that is, a metal ion. Plus, certain chelating agents, the complex coordination compounds, result in what is called metal chelates. So, when these metallic ions are released through hydrolysis or degradation or by such other reactions, they are free to participate in reactions that lead to food discolouration, oxidative rancidity, turbidity and flavour changes. So, the chelating agents are organic molecules which, owing to several functional groups, are able to establish more than one chemical bond with the metal ion stabilizing it and increasing its solubility.

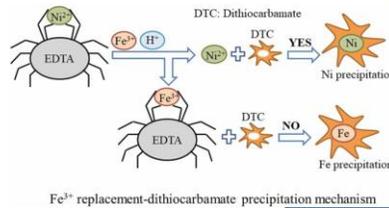
Chelating agents (Contd...)

- Chelators used in the food industry include
 - ✓ Sorbic acid
 - ✓ Polycarboxylic acids (Citric, malic, tartaric, oxalic, and succinic acids)
 - ✓ Polyphosphates (ATP and Pyrophosphates)
 - ✓ Macromolecules (Porphyrins, proteins)
 - ✓ EDTA
- Other chelating agents, which are capable of inhibiting polyphenol oxidase, are
 - ✓ Diethyldithiocarbonate
 - ✓ Sodium azide and 2-mercaptobenzothiazole
 - ✓ Mercaptobenzthiazol, Dimercaptopropanol
 - ✓ Potassium methyl xanthate
- Citric acid and derivatives, phosphates and salts of ethylene-diamine tetra-acetic acid (EDTA) are the most popular chelating agents used in foods.

So, the factor chelators used in the food industry include popular ones such as sorbic acid, polycarboxylic acids, or polymers of citric, malic, tartaric, oxalic, succinic acid, etc. Polyphosphates or even macromolecules like porphyrins, proteins and EDTA. Other chelating agents which are capable of inhibiting polyphenol oxidase are diethyldithiocarbonate. Sodium azide, 2-mercaptobenzothiazole, mercaptobenzthiazol, dimercaptopropanol, potassium methyl xanthate, and so on. So, citric acid and derivatives, phosphates, and salts of ethylene diamine tetraacetic acid are the most popular chelating agents used in the food industry.

■ Mechanism of action of chelating agents

- Chelating agents are not anti-oxidants.
- They serve as scavengers of metals which catalyze oxidation.
- However, they are anti-oxidant synergists.
- Citric acid and its esters in propylene glycol solution are effective synergists in lipid systems.
- Polyphosphates and EDTA are used as chelating agents in canned sea foods.
- EDTA is a chelating agent permitted for use in the food industry as a chemical preservative.



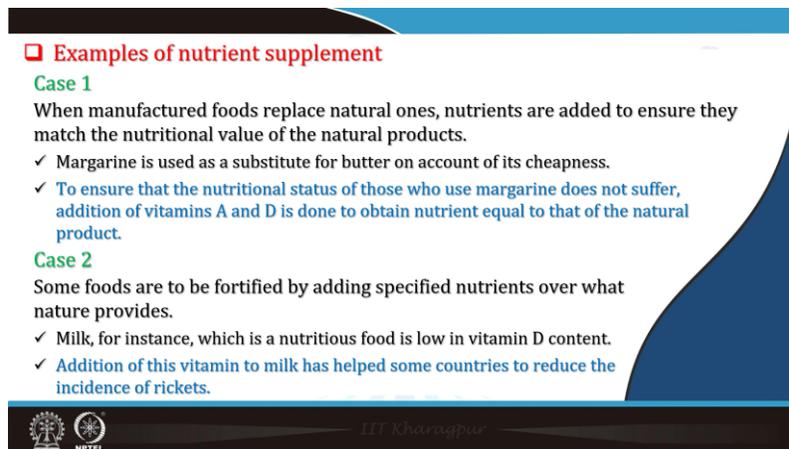
So, the mechanism of action of chelating agents means that these chelating agents are not antioxidants, but they serve as scavengers of metals, which catalyse oxidation because if there is a metal, it will increase the rate of the oxidation reaction. So, the chelating agents bind the metal, catch hold of the metal, as you can see here in this figure, which has been shown, that is, Fe³⁺ replacement dithiocarbamate precipitation mechanism. So, the chelating agents serve as scavengers of metals, which catalyse oxidation. However, they are antioxidant synergists; that is, in the presence of chelating agents, the effectiveness of antioxidants is increased. Citric acid and its ester in propylene glycol solution are effective synergists in lipid systems. Polyphosphates and EDTAs are used as chelating agents in canned seafood. EDTA is a chelating agent permitted for use in the food industry as a chemical preservative.

Nutrient supplement

- The term nutritional additives can be used to mean the addition of vitamins, minerals, amino acids, fatty acids, as well as other pure chemical compounds to food in order to improve or maintain the nutritional quality of foods.
- Nutrient supplements restore values lost in processing or storage, or ensure higher nutritional value.
- When foods are processed, there may be loss of some nutrients. Additives may be added to restore the original value.
For example, when wheat is milled in such a way as to remove the brown-coloured part of the grain, which is rich in vitamins and minerals.
- To restore the nutritive value, thiamine, nicotinic acid, iron and calcium, are added to the flour.
Similarly, vitamin C is added to canned citrus fruits to make up the loss of the vitamin during processing.

Then, let us talk about another major group of food additives. Chemical additives are included in the category of nutrient supplements. So, the term nutritional additive or nutrient supplement can be used to mean the addition of vitamins, minerals, amino acids,

fatty acids, as well as other pure chemical compounds in food in order to improve its nutritional value or maintain the nutritional quality of the food. Nutrient supplements restore values lost in processing or storage, or ensure higher nutritional value, such as fortification, restoration, or supplementation, which are terms which are used many times in this category. There is a loss of certain nutrients when foods are processed. or even others like colours, etc. So, additives may be used to restore the original value, which is lost during processing. So, that process is called restoration. For example, wheat, when milled, is processed in such a way as to remove the bran or colored part of the grain. So, the bran is mostly rich in vitamins and minerals. So, sometimes during the milling process, vitamins and minerals are added to the rice. That is, the rice bran contains a rich amount of minerals, vitamins, etc. But during the polishing process, when bran is removed, these are all micronutrients. which are present in the bran, they are removed. So, the rice is fortified with vitamins, minerals, etc., to increase its value. So, there are several other examples. So, to also restore the nutritive value, thiamine, nicotinic acid, iron, and calcium are added to the flour. Even vitamin B₁₂, folic acid, and iron are added to rice as well as wheat flour, etc. Also, vitamin C is added to canned citrus fruits to make up for the loss of vitamins during processing, okay. Then, let us take one or two case studies for the nutrient supplement.



Examples of nutrient supplement

Case 1
When manufactured foods replace natural ones, nutrients are added to ensure they match the nutritional value of the natural products.

- ✓ Margarine is used as a substitute for butter on account of its cheapness.
- ✓ To ensure that the nutritional status of those who use margarine does not suffer, addition of vitamins A and D is done to obtain nutrient equal to that of the natural product.

Case 2
Some foods are to be fortified by adding specified nutrients over what nature provides.

- ✓ Milk, for instance, which is a nutritious food is low in vitamin D content.
- ✓ Addition of this vitamin to milk has helped some countries to reduce the incidence of rickets.

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Case study number 1: When manufactured foods replace natural ones, nutrients are added to ensure that they match the nutritional value of the natural product. So, here, margarine is used as a substitute for butter on account of its cheapness. So, to ensure that the nutritional status of those who use margarine does not suffer, additives like vitamin A and D are added to the margarine in order to make it nutritionally equivalent to that of natural butter. Some foods are to be fortified by adding specified nutrients over what nature provides.

Like milk, for example, isortified with vitamin D. It is a nutritious food, but milk is low in vitamin D. So, vitamin D may be added from outside to fortify it or to increase the amount of vitamin D. And this helps it is done in some country to reduce the incidence of rickets, etc.

□ Nutritional additives and their commercial forms

Nutritional compound	Commercial form
▪ Vitamin A	✓ Vitamin A is available in pure form by chemical synthesis as vitamin A palmitate or the acetate, or recovered from molecularly recovered fish oil.
▪ Carotenoids	✓ Beta carotene is available as red crystals or crystalline powder.
▪ Vitamin D	✓ Commercially available forms include fat soluble crystals for use in high fat content foods and encapsulated, stabilized versions of the fortificant
▪ Vitamin E	✓ DL- α -Tocopherol, D- α -Tocopherol concentrate, Tocopherols concentrate, mixed, D- α -Tocopheryl acetate, DL- α -Tocopheryl acetate, D- α -Tocopheryl acetate concentrate and D- α -Tocopheryl acid succinate.
▪ Vitamin C	✓ L-Ascorbic acid is white or slightly yellow crystals or powder. ✓ Ascorbate is available in vitamin tablets and many multivitamin supplements.
▪ Thiamine	✓ Thiamin mononitrate and thiamin hydrochloride is available as white to yellowish white crystals, or crystalline powder.

Then, nutritional additives and their commercial forms I have summarised briefly in this table, which includes vitamin A it is available in pure form by chemical synthesis as vitamin A palmitate or the acetate are recovered from molecularly recovered fish oil. Carotenoids like beta carotene is available as red crystals or crystalline powder. Vitamin D is commercially available in the form of fat-soluble crystals for use in high-fat content foods, as well as encapsulated, stabilised versions of the fortificants are also available. Similarly, vitamin E comes in various forms like DL alpha tocopherol, D alpha tocopherol concentrates, tocopherol concentrate, mixed D alpha tocopheryl acetate, D alpha tocopheryl acetate concentrate or D alpha tocoperyl acid succinate, etc. This vitamin E is available for use as a nutrient supplement. Similarly, vitamin C is available as L-ascorbic acid, which is white or slightly yellow crystalline or powder. Ascorbate is available in vitamin tablets and many multivitamin supplements. Similarly, thiamine, thiamine mononitrate and thiamine hydrochloride are available as white to yellowish crystals or crystalline powders. So, these are some of the micronutrients, such as vitamins or carotenoids, etc., which are available commercially for use in food.

Similarly, even vitamin B6 is available commercially in the form of pyridoxine hydrochloride. Vitamin B9, also known as folic acid, is a yellow or yellowish-orange, odourless crystal or crystalline powder.

Nutritional additives and their commercial forms (Contd...)

Nutritional compound	Commercial form
▪ Vitamin B ₆	✓ It is available commercially in the form of pyridoxine hydrochloride.
▪ Vitamin B ₉	✓ Folic acid is a yellow or yellowish orange, odorless crystal or crystalline powder.
▪ Vitamin B ₁₂	✓ Cyanocobalamin are dark red crystals or amorphous or crystalline powder.
▪ Calcium	✓ Calcium phosphate monobasic, Calcium phosphate tribasic, Calcium acid pyrophosphate, Calcium carbonate, Calcium glycerophosphate, Calcium oxide, Calcium lactobionate, Calcium pyrophosphate, Calcium phosphate dibasic and Calcium sulphate.
▪ Magnesium	✓ Magnesium gluconate, Magnesium phosphate dibasic, Magnesium phosphate tribasic and Magnesium sulphate.
▪ Iron	✓ Ferric ammonium citrate, Ferric phosphate, Ferric pyrophosphate, Ferric fumarate, Ferric gluconate, Ferric lactate, Ferric sulphate.

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Vitamin B₁₂, cyanocobalamin, is dark red crystals or amorphous or crystalline powder. Calcium is available commercially in calcium phosphate monobasic, calcium phosphate tribasic, calcium acid pyrophosphate, calcium carbonate, calcium glycerophosphate, calcium oxide, calcium lactobionate, calcium pyrophosphate, calcium phosphate dibasic, calcium sulphate, and so many other forms. So, magnesium is available as magnesium gluconate, magnesium phosphate dibasic, magnesium phosphate tribasic, and magnesium sulphate. Iron is available in the form of ferric ammonium citrate, ferric phosphate, ferric pyrophosphate, ferric fumarate, ferric gluconate, ferric lactate, ferric sulfate, and so on. So, this vitamin B₉, folic acid, vitamin B₁₂, cyanocobalamin, and iron, that is in the form of ferric pyrophosphate. These are the three micronutrients permitted for use in wheat flour and rice as a fortification measure to control the prevalence of iron deficiency anemia in the country.

Non-nutritive sweeteners

- Non-nutritive sweeteners are also known as synthetic sweeteners.
- They have less than 2% of the calorific value of sucrose for equivalent unit of sweetening capacity.
 - **Saccharin**
 - ✓ It is about 300 times sweeter than sucrose in concentrations up to the equivalent of a 10 % sucrose solution. They have bitter after taste.
 - **Cyclamate**
 - ✓ About 30 times sweeter than sucrose but have little of the after-taste.
 - ✓ Widely used in soft drinks, low-calorie liquid foods, and dietetic forms of foods.
 - **Acesulfame K**
 - ✓ It is about 200 times sweeter than sugar.
 - ✓ Used in baked goods, chewing gum, gelatin desserts, and soft drinks.

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So, non-nutritive sweeteners are also synthetic sweeteners. They have less than 2 percent of the calorific value of sucrose for an equivalent unit of sweetening capacity. Some of the major non-nutritive sweetener compounds include saccharin, cyclamate, that is S L F M K, and so on. Saccharin is about 300 times sweeter than sucrose in concentrations up to the equivalent of a 10 percent solution of sucrose. That is, if you take a 10 percent solution of sucrose and a 10 percent solution of saccharin, saccharin will be 300 times sweeter than sucrose. However, saccharin has a bitter aftertaste. Cyclamate is about 30 times sweeter than sucrose but has little or no aftertaste, unlike saccharin. Cyclamate is widely used in soft drinks, low-calorie liquid foods, and dietetic forms of foods. Acesulfame K is about 200 times sweeter than sugar. It is used in baked goods, chewing gums, gelatin desserts, and soft drinks.

Non-nutritive sweeteners (Contd...)

- **Aspartame**
 - ✓ It is 180 times sweeter than sucrose.
 - ✓ Used in "Diet" foods, soft drinks, drink mixes, gelatin desserts, and low-calorie frozen desserts.
- **Neotame**
 - ✓ Latest FDA approved non-nutritive sweetener that is between 8,000 and 13,000 times sweeter than sucrose.
 - ✓ Not yet widely used in food products.
- **Sucralose**
 - ✓ Derived from table sugar (sucrose).
 - ✓ Used in baked goods, beverages, gelatin, and frozen dairy desserts.
- **Glycyrrhiza glabra**
 - ✓ Ranging in sweetness from 10 to 3,000 times of sucrose.
 - ✓ Used in tobacco products, confectioneries and beverages.

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Aspartame is 180 times sweeter than sucrose and it is used in diet foods, soft drinks, drink mixes, gelatin desserts, and low-calorie frozen desserts. Neotame is the latest FDA-approved non-nutritive sweetener, which is between 8,000 and 13,000 times sweeter than sucrose. However, it is not yet widely used in food products. Sucralose is derived from table sugar, which is sucrose. It is used in baked goods, beverages, gelatin, and frozen dairy desserts. Glycyrrhiza glabra, also known as licorice, ranges in sweetness from 10 to 3,000 times that of sucrose and it is used in tobacco products, confectioneries, and beverages.

Summary

- Food additives are substances added to food to enhance its quality, safety, and shelf life.
- Food additives must be safe for consumption, effective in their intended use, and not alter the food's nutritional value adversely.
- Antioxidants and chelating agents prevent oxidation and spoilage, extending shelf life (e.g. ascorbic acid, EDTA).
- Nutrient supplements are added to enrich foods with essential nutrients (e.g. vitamins, minerals) to prevent deficiencies.
- Non-nutritive sweeteners provide sweetness without added calories (e.g. aspartame, sucralose), often used in low-calorie and diabetic-friendly products.



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So, now I would like to summarize that different chemicals or biochemicals are used as food additives to enhance their quality, safety, and shelf life. However, food additives must be safe for consumption, they should be effective in their intended use, and they should not alter the food's nutritional value or other characteristics. Antioxidants and chelating agents prevent oxidation and spoilage, extending the shelf life of fats and oils in such foods. Nutrient supplements are added to enrich foods with essential nutrients as well as to prevent deficiencies. Non-nutritive sweeteners provide sweetness without added calories. Examples include aspartame, sucralose, etc., and they are often used in low-calorie and diabetic-friendly products.

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So, these are the references that were used in this lecture.



I thank you all for your patience. Thank you.