FOOD ADDITIVES

Introduction

- Food additives:
  - Intentional additives
  - Incidental additives

Intentional additives are added to food for specific purposes and are regulated by strict governmental controls.

FA Purposes

- To improve or maintain nutritional quality
- To enhance quality
- To reduce wastage
- To enhance consumer acceptability
- To improve keeping quality
- To make the food more readily available
- To facilitate preparation of the food

In many food processing techniques, the use of additives is an integral part of the method.

FA should not be used:

- To disguise faulty or inferior processes
- To conceal damage, spoilage
- To deceive consumer
- If the use entails substantial reduction of important nutrients
- If the amount is greater than minimum necessary to achieve the desired effect.

Intentional FA

- Complex substances such as proteins or starches that are extracted from other foods (e.g. caseinates for sausages)
- Naturally occurring, well-defined chemical compounds such as salt, phosphates, acetic acid and ascorbic acid.
- Substances produced by synthesis which may or may not occur in nature, such as coal tar dyes, synthetic beta carotene, antioxidants, preservatives and emulsifiers.

Regulation - CODEX

- CODEX has adopted the following basic principles for the addition of nutrients to foods:
  - Restoration – the addition to food of essential nutrients in the amounts lost during processing, storage and handling.
  - Nutritional equivalence of a substitute food – the addition to a new food of nutrients found in the traditional food.
  - Fortification – the addition of one or more essential nutrients to a food over and above the normally contained in the food, for the purpose of correcting a deficiency in the population.
  - Ensuring the appropriate nutrient composition of special purpose food – foods such as meal replacements and foods for special dietary use.

Vitamins

- Added vitamins are generally as stable as those that occur naturally.
- In order to estimate the extra amount of vitamins required to account for losses during processing and shelf-life of the product, some factors must be carefully considered, such as:
  - the nature of the product,
  - the method used in processing,
  - the packaging and the condition under which the product will be stored.

Vitamins

- All vitamin-fortified products should undergo stability testing in the development stage.
- The product should be stored under conditions which simulate or exceed conditions of normal use.
- For example, under accelerated testing conditions, the product is kept at 35^{o}C or 45^{o}C and 45% humidity for several weeks.
- Vitamin assay should be performed at time 0, at week 1, 2 weeks and at monthly intervals for three months.
- Along with potency testing, sensory testing also should be conducted.

Minerals

- Minerals are often added together with vitamins.
- When evaluating minerals for food enrichment, the following criteria should be considered:
  - Moisture content
  - Particle size compatibility
  - Solubility
  - pH
  - Odor/ color interaction with other components
  - Ease of mixing
  - Bioavailability
  - Safety
  - Application needs

Minerals

- Little loss of minerals occurs during processing.
- Adding minerals to food may occasionally cause taste, color, odor or stability problems.
- If the food product is dry, few stability problems will occur.
- However, in such high moisture foods as baked goods, cereals with fruits and beverages, minerals may severely affect vitamin and lipid stability.

Preservatives

- Increasing demand for convenience foods and reasonably long shelf-life of processed foods, therefore chemical food preservatives are indispensable.
- Long history of use common preservatives, such as sulfites, nitrate, and salt-have been used for centuries in processed meats and wine.
- The choice of an antimicrobial agent is based on a knowledge of the antimicrobial spectrum of the preservative, the chemical and physical properties of both food and preservative, the conditions of storage and handling, and the assurance of a high initial quality of the food to be preserved.

1. Benzoic Acid

- Benzoic acid (C_6H_5COOH) occurs naturally in many types of berries, plums, prunes and some spices.
- As an additive, it is used as benzoic acid or benzoate. The later is used more often because benzoic acid is sparsely soluble in water, while sodium benzoate is more soluble.
- Once in the product, some of the salt converts to the active form which is most active against yeast and bacteria, and least active against molds.

1. Benzoic Acid

- The undissociated form of benzoic acid is more effective antimicrobial agent. The optimum pH range from 2.5 to 4. this makes it an effective antimicrobial agent in high-acid foods, fruit drinks, cider, carbonated beverages, and pickles. It is also used in margarines, salad dressings, soy sauce and jams.
- Often benzoic acid is used in combination with sorbic acid or parabens.
- Level of use usually range from 0.05-0.1% by weight.

2. Parabens

- Parabens are alkyl esters of *p*-hydroxybenzoic acid.
- The alkyl groups may be methyl, ethyl, propyl, butyl and heptyl.
- Parabens are colorless, tasteless, odorless, (except the methyl paraben), non-volatile and non-hygroscopic.
- Their solubility in water depends on the nature of alkyl group.
- They have antimicrobial activity in both acid and alkaline pH regions.

2. Parabens

- The antimicrobial activity of parabens is proportional to the chain length of the alkyl group. The shorter chain is often used due to their solubility.
- Parabens are more active against moulds and yeasts (0.5-1% by weight) than against bacteria, and more active against Gram-positive than Gram-negative bacteria.
- Parabens are used in fruitcakes, pastries, and fruit fillings. Methyl and propyl parabens can be used in soft drinks. Various combinations of several parabens can also be used in these and other foods.

3. Sorbic Acid

- Sorbic acid (C-C=C-C=C-COOH) is a straight chain, *trans-trans* unsaturated fatty acid, 2,4-hexadienoic acid.
- As an acid, it has low solubility in water at room temperature. The salts, sodium or potassium are more soluble in water.
- Sorbates are stable in the dry form; in aqueous solutions they decompose through oxidation.
- Sorbic acid and sorbates are effective against yeast and moulds.

3. Sorbic Acid

- Sorbates inhibit yeast growth in wine, fruit juice, dried fruit, cottage cheese, meat and fish products. Sorbates are usually used in sweetened wines or wines that contain residual sugars to prevent re-fermentation.
- Sorbates are most effective in products of low pH (up to pH 6.5).
- The effective level of sorbates in foods is in the range of 0.3 – 0.50%. At such levels, sorbates do not affect food flavor. When used at higher levels, they may be detected by some people as unpleasant flavor.
- Sorbates may also be degraded by certain microorganisms to produce off-flavors.

4. Sulfites

- Sulfur dioxide and sulfites have long been used as preservatives, serving both as antimicrobials and as antioxidants (used in wine in Roman times).
- Sulfur dioxide also can inhibit nonenzymatic browning and certain enzyme-catalyzed reactions.
- It dissolves to form sulfurous acid.
- Instead of sulfur dioxide solutions, a number of sulfites can be used when dissolved in water, they all yield active SO_2.

4. Sulfites

- The commonly used forms in foods: sulfur dioxide gas, Na/K/Ca salts of sulfite (SO_3^{2-}), bisulfite (HSO^{3-}) or metabisulfite ($S_2O_5^{2-}$).
- The most widely used are sodium or potassium metabisulfite → because they exhibit good stability toward autoxidation.
- All of water dissolved sulfur are known as free sulfur dioxide. The bisulfite ion (HSO_3^-) can react with aldehydes, dextrins, pectic substances, proteins, ketones, and certain sugars.

5. Nitrates & Nitrites

- They are known as curing agents, which produce the characteristic color and flavor of products such as bacon, ham.
- Nitrate can be reduced to nitrite, which is not desired in food.
- Both nitrates and nitrites have antimicrobial agents.
- Nitrate is used in the production of cheese to prevent gas formation by butyric acid-forming bacteria.
- Nitrite inhibits toxin formation by *C. botulinum*.

5. Nitrates & Nitrites

- Nitrite, which may react with secondary amines in food to form nitrosamines.
- The nitrosamines are powerful carcinogens, and they may be mutagenic and teratogenic.

6. Hydrogen Peroxide

- H_2O_2 is a strong oxidizing agent and is also useful as a bleaching agent. For example: in crude soya lecithin.
- H_2O_2 is used for the preservation of cheese milk.
- H_2O_2 decomposes slowly into water and oxygen. This process is accelerated by increased temperature and the presence of heavy metals and enzymes such as catalase and lactoperoxidase.
- Its antimicrobial action increases with temperature.

6. Hydrogen Peroxide

- When H_2O_2 is used for cheese making, the milk is treated with 0.02% H_2O_2 followed by catalase to remove H_2O_2.
- H_2O_2 is also used as component of the lactoperoxidase system, which generates antimicrobial compounds through the oxidation of thiocynate (SCN^-), naturally present in milk.
- H_2O_2 can be used for sterilizing food processing equipment and for sterilizing packaging material used in aseptic food packaging systems.

Enzymes

- Minor constituents manufacture of foods, but play major role in food.
- Enzymes that are naturally present in foods may change the composition of those foods.
- Desirable and undesirable enzyme-catalyzed changes in foods.
- Some enzymes are used as indicators in analytical methods; e.g. alkaline phosphates is used in the test for pasteurisation of milk.
- They are also used as processing aids, e.g., rennet in cheese

Enzymes

Enzyme	Food	Purpose of action
Amylases	Baked goods	Increase sugar content for yeast fermentation
Cellulase	Brewing	Hydrolysis of complex carbohydrates cell walls
Lactase	Ice cream	Prevent crystallization of lactose, which results grainy, sandy texture

Enzymes

Enzyme	Food	Purpose of action
Pectic enzymes	Chocolate-cocoa Wine	Hydrolysis activity during fermentation of cocoa Clarification
Protease	Baked goods	Softening action in dough, cut mixing time, improvement in texture, loaf volume.
Lipase	Cheese (useful) Cereals (deteriorative)	Ageing, ripening, and general flavor characteristics. Over-browning of oat cakes, discoloration of wheat bran

Enzymes

Enzyme	Food	Purpose of action
Peroxidase (useful)	Vegetables	Detection of effectiveness of blanching
Peroxidase (deteriorative)	Vegetables	Off-flavor
Catalase	Milk	Deterioration of H_2O_2 in cold pasteurization

Enzymes

- Choosing enzymes for food application must consider several factors:
  - The source, form and legal status of the enzymes.
  - Availability of supply of consistent quality.
  - Convenient of usage; immobilized or soluble enzymes.

  The use of immobilized enzyme allows easier process control, removal of enzyme from products, reusability and hence reduction in cost. The drawbacks include diminishing of substrate, the growth of microbes and waste disposal.

Emulsifiers-Classification

- Based on charge:
  - Anionic: surfactants that carry a negative charge on the active portions of the molecule.
  - Cationic: surfactants that carry a positive charge on the active portions of the molecule.
  - Non-ionic: Uncharged molecule having lipophilic and hydrophylic parts.
  - Amphoteric: surfactant species that can be either cationic or anionic.
  - Zwitterionic: both positive and negative charge may be present in the surface active portion.

Emulsifiers-Classification

- Based on hydrophylic – lipophylic balance (HLB)
- Based on solubility
- Based on functional groups: saturated/ unsaturated acids, alcohols, ethylene oxide, etc.

Emulsifiers-Emulsification

- All emulsifiers are surface active agents, which can promote emulsification of oil and water phases because they possess both hydrophilic and lipophilic groups within the same molecule.
- Emulsifiers with low hydrophilic to lipophilic ration value (HLB value) stabilize water in oil emulsions, whereas emulsifiers with high HLB value stabilize oil in water emulsions.
- Each system requiring an emulsifier has an optimum HLB value.

Emulsifiers-Emulsification

- This HLB value can be used as an indicator of the most suitable emulsifier for that particular system.
- However, the chemical type of the emulsifier also is important in achieving emulsion stability.

Emulsifiers-Dispersion

- Dispersions of solids, liquids and gasses depend on the reduction of interfacial energy by a surface – active agent. The disperse systems can involve all three principle phases.

Type	Internal phase	External phase
Emulsion	Liquid	Liquid
Foam	Gas	Liquid
Aerosol	Liquid / Solid	Gas
Suspension	Solid	Liquid

Emulsifiers

Behavior of surfactant in water	HLB range
No dispersibility in water	1 – 4
Poor dispersion	3 – 6
Milky dispersion after vigorous agitation	6 – 8
Stable milky dispersion	8 – 10
Translucent to clear dispersion	10 – 13
Clear solution	13+

Emulsifiers

- Sorbitan monostearate
- Polysorbate 60
- Lecithin
- Polyglyserol ester of FA
- Mono and di-glyceride lactylated
- Milk proteins

Hydrocolloids

- Hydrocolloids are water-soluble polymers with an ability to thicken or gel aqueous systems (thickening and gelling agents).
- They can be classified according to origin, isolation method, function, texture, gelling time.

Hydrocolloids

Structure	Characteristics	Examples
Linear	Not more than two copolymerized sugar units. High viscosity. Unstable solutions. Difficult to dissolve. Risk of precipitation after gelation.	Cellulose, amylose, pectin, carrageenan, alginate, agar.
Single branch	Sugar units condensed with carbon groups other than C1 or C4	Dextrane

Hydrocolloids

Structure	Characteristics	Examples
Substituted linear	Numerous short branches often consisting of only one sugar unit in length	Guar gum
Branch on branch	Slide chains on side chains. More viscous than linear. Typically, two or more types of sugar make up the polysaccharides. Excellent adhesive properties.	Amylopectin, gum arabic

Sweeteners

- The same taste and functional characteristics as sucrose
- Low caloric density on a sweetness equivalency basis.
- Non-cariogenicity
- Metabolized normally or excreted unchanged
- No allergenic, mutagenic, carcinogenic or other toxic effects in the body.
- Chemical and thermal stability
- Compatibility with other food ingredients
- Economically competitive with existing sweeteners.

Sweeteners

- Sweeteners may be nutritive, as they are the hydrogenated sugars, also known as sugar alcohols or polyols, or can be non-nutritive as are the intense sweeteners.
- They can be synthesized or extracted form natural sources.
- Intense sweeteners contribute no bulk, viscosity or texture to foods and beverages, and must be mixed with nutritive sweeteners, or some other bulking agent when these properties are required.

1. Polyols

- Sugar alcohols, which are functionally similar to sucrose, and are bulking agents.
- Sorbitol, mannitol and xylitol are naturally occuring like sucrose.
- They have technical benefits including increased chemical stability and affinity for water, without altering the sweetening power, and a reduced tendency to crystallise.
- The physiological benefits are that sugar alcohols have low cariogenicity. They are suitable for inclusion in products for diabetics.

1. Polyols

- Xylitol has about the same sweetness as sucrose.
- The other sugar alcohols are less sweet and need supplementation with intense sweeteners to be comparative to sucrose.
- Sugar alcohols add texture and mouth feel properties to foods and drinks since they are bulking agents.
- Many sugar alcohols, xylitol and sorbitol particularly, impart a cooling sensation in the mouth because they absorb heat as they dissolve.
- All have pleasant, sweet taste profile with no after-taste.

2. Saccharine

- Sachharine was accidentally discovered in 1879.
- It is synthesized from toluene, and has a chemical formula of $C_7H_5NO_3S$.
- It is usually available as the sodium salt and sometimes as calcium salt.
- It is the most widely used sugar due to its high stability, and low cost.
- But it has disadvantage of a bitter metallic after taste.

2. Saccharine

- Saccharin is not metabolized in the body, but it is excreted unchanged.
- Bladder tumor have been associated with saccharine intake.

3. Aspartame

- It is discovered accidentally in 1965, while synthesizing a product for ulcer therapy.
- Aspartame is dipeptide methyl ester, composed of two amino acids (phenylalanine and aspartic acid).
- It has a very agreeable sweet taste but is unstable under certain conditions.
- It is one of the most thoroughly tested FA.
- The safety of aspartame's component amino acids, and of its metabolite (methanol) has been questioned.

3. Aspartame

- However, toxicity is always dose-related and large safety margins has been reported with regard to amounts likely to be consumed in the human diet.
- Analysis of adverse reactions and clinical data suggests that aspartame is remarkably safe.
- Warning on product packaging are necessary to alert sufferers of phenylketonuria who have to control the amount of phenylalanine in their diets.

4. Acesulfame -K

- It is a potassium salt derived from acetoacetic acid, with a chemical formula of $C_4H_4NO_4KS$ and has molar mass of 201.2.
- This sweet-tasting compound was discovered accidentally in 1967.
- No adverse reactions in the body to the consumption of acesulfame-K have been found.
- The Join FAO/WHO Expert Committee on Food Additives (JECFA) allocated an ADI of 0.9 mg/kg of bw in 1983, having found that acesulfame-K was neither mutagenic nor carcinogenic, and with no other toxicological problems.

4. Acesulfame -K

- It is not metabolized in the body, is excreted rapidly and completely, and thus has no caloric value and it is suitable for diabetics.
- It is also considered to be non-cariogenic, since the acute oral toxicity of acesulfame-K use is extremely low.

Diskusi

- 1. Sebutkan 15 jenis kelompok BTM. Berikan penjelasan fungsi masing-masing BTM, contoh-contohnya dari setiap jenis dan seringnya diaplikasikan pada produk apa?
- 2. Untuk jenis pengawet, jelaskan jenis-jenis pengawet, efektivitasnya (pada kondisi dan produk apa) dan bagaimana bisa mengawetkan bahan/produk pangan (mekanisme pengawetan).