Food Additives

Fahim shaltout

Professor of Meat Hygiene,

Faculty of Veterinary Medicine ,

Benha University

Egypt

Introduction

- Food additives can be divided into two major groups
  - Intentional additives
    - Chemical substances that are added to food for specific purpose
    - Are regulated by strict governmental controls
  - Incidental additives
    - We have little control over incidental or unintentional additives

Introduction

- The term food additive means any substance the intended use of which results, or may reasonably be expected to result,
- directly or indirectly in its becoming a component or otherwise affecting the characteristics of any food
- (including any substance intended for use in producing, manufacturing, packing, processing, preparing , treating, packaging, transporting, or holding food;

Introduction

- and in including any source of radiation intended for such use)
- Except that such a term does not include pesticides, colour, additives and substances for which prior sanction or approval was granted

Introduction

- The law thus recognizes the following three classes of intentional additives
  - Additives generally recognized as safe (GRAS)
  - Additives with prior approval
  - Food additives

Introduction

- Colouring materials and pesticides on raw agricultural products are covered by other laws
- The GRAS list contains several hundred compounds

Introduction

- *Toxicity* – is the capacity of a substance to produce injury
- *Hazard* – is the probability that injury will result form the intended use of the substance
- It is now well recognized that many components of our foods, whether natural or added, are toxic at certain levels, but harmless or even nutritionally essential at lower levels

Introduction

- The ratio between effective dose and toxic dose of many compounds, including such common nutrients as amino acids and salts, is the order of 1 to 100
- It is now mandatory that nay user of an additive must petition the government for permission to use the material and must supply evidence that the compound is safe

Intentional Additives

- Chemicals that are intentionally introduced to foods to aid in processing
- to act as preservatives
- or to improve the quality of the food – are called intentional additives
- Their use is strictly regulated by national and international laws

Intentional Additives

- The purpose of food additives
  - To improve or maintain nutritional value
  - 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

Intentional Additives

- The use of food additives is in effect a food processing method
- because both have the same objective – to preserve the food and/or make it more attractive
- In many food processing techniques, the use of additives is an integral part of the method, as is smoking, heating, and fermenting

Intentional Additives

- In the following situations additives should *not* be used:
  - To disguise faulty or inferior processes
  - To conceal damage, spoilage, or other inferiority
  - To deceive the consumer
  - If use entail substantial reduction in important nutrients
  - If the desired effect can be obtained by economical, good manufacturing practices
  - In amount greater than the minimum necessary to achieve the desired effects

Intentional Additives

- There are several ways of classifying intentional food additives
- One such method lists the following three main types of additives
- i) complex substances such as proteins or starches that are extracted form other foods
  - For example: the use of caseinate in sausages and prepared meats

Intentional Additives

- ii) naturally occurring, well-defined chemical compounds such as salt, phosphates, acetic acid, and ascorbic acid
- iii) substances produced by synthesis, which may or may not occur in nature, such as coal tar dyes, synthetic B-carotene, antioxidants, preservatives, and emulsifiers

Preservatives

- Preservatives or antimicrobial agents play an important role in today's supply of safe and stable foods
- Increasing demand for convenience foods and reasonably long shelf life of processed foods make the use of chemical food preservatives imperative
- Some of the commonly used preservatives – such as sulfites, nitrate, and salt – have been used for centuries in processed meats and wine

Preservatives

- The choice of antimicrobial agent has to be 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,
  - the assurance of a high initial quality of the food to be preserved

Benzoic Acid

- Benzoic acid occurs naturally in many types of berries, plums, prunes, and some spices
- As an additive, it is used as benzoic acid or as benzoate
- The latter is used more often because benzoic acid is sparsely soluble in water, and sodium benzoate is more soluble
- The undissociated form on benzoic acid is the most effective antimicrobial agent
  - pK_a of 4.2; optimum pH range is from 2.5 to 4.0

Benzoic Acid

- This makes it an effective antimicrobial in high-acid foods, fruit drinks, cider, carbonated beverages, and pickles
- It is also used in margarines, salad dressings, soy sauce, and jams

Parabens

- Parabens are alkyl esters of *p*-hydroxybenzoic acid
- The alkyl groups may be one of the following
  - Methyl, ethyl, propyl, Butyl, or heptyl
- Parabens are colourless, tasteless, and odorless (except the methyl paraben)
- They are nonvolatile and nonhygroscopic
- Their solubility in water depend on the nature of the alkyl group
  - The longer the alkyl chain length, the lower the solubility

Parabens

- They differ form benzoic acid in that they have antimicrobial activity in both acid and alkaline pH regions
- The antimicrobial activity in parabens is proportional to the chain length of the alkyl group
- Parabens are more active against molds and yeast than against bacteria, and more active against gram-positive than gram-negative bacteria
- They are used in fruitcakes, pastries, and fruit fillings

Parabens

- Methyl and propyl parabens can be used in soft drinks
- Combinations of several parabens are often used in applications such as fish products, flavor extracts, and salad dressing

Sorbic Acid

- Sorbic acid is a straight-chain, *trans-trans* unsaturated fatty acid, 2,4-hexadienoic acid
- As an acid, it has a low solubility in water at room temp
- The salts, sodium, or potassium are more soluble in water
- Sorbates are stable in the dry form; the are unstable in aqueous solutions because they decompose through oxidation
- The rate of oxidation is increased at low pH, by increased temp, and by light exposure

Sorbic Acid

- Sorbic acid and other sorbates are effective against yeasts and molds
- Sorbate inhibit yeast growth in a variety of foods including wine, fruit juice, dried fruit, cottage cheese, meat, and fish products
- Sorbates are most effective in products of low pH including salad dressings, tomato products, carbonated beverages, and a variety of other foods
- The effective level of sorbates in foods is in the range of 0.05 to 0.30 percent

Sorbic Acid

- Sorbates are generally used in sweetened wines or wines that contain residual sugars to prevent refermentation
- At the levels generally used, sorbates do not affect food flavor
- However when used at higher levels, they may be detected by some people as an unpleasant flavor
- Sorbate can be degraded by certain microorganisms to produce off-flavors

Sulfites

- Sulfur dioxide and sulfites have long been used as preservatives
- Serving both as antimicrobial substance and as antioxidant
- Sulfur dioxide is a gas that can be used in compressed form in cylinders
  - It is liquid under pressure of 3.4 atm and can be injected directly in liquids
  - It can also be used to prepare solutions in ice cold water
  - It dissolves to form sulfurous acid

Sulfites

- Instead of sulfur dioxide solutions, a number of sulfites can be used .
- Because, when dissolved in water, they all yield active SO_2
- The most widely used of these sulfites is potassium metabisulfite
  - In practice, a value of 50 percent of active SO_2 is used

Sulfites

- When sulfur dioxide is dissolved in water, the following ions are formed:
  - $SO_2(gas) \rightarrow SO_2(aq)$
  - $SO_2(aq) \rightarrow H_2O \quad H_2SO_3$
  - $H_2SO_3 \rightarrow H^+ + HSO_3^-$
  - $HSO_3^- \rightarrow H^+ + SO_3^{2-}$
  - $2HSO_3^- \rightarrow S_2O_5^{2-} + H_2O$
- All of these forms of sulfur are known as free sulfur dioxide

Sulfites

- The bisulfite ion (HSO_3^-) can react with aldehydes, dextrins, pectic substances, proteins, ketones, and certain sugars to form addition compounds
- The addition compounds are known as bound sulfur dioxide
- Sulfur dioxide is used extensively in wine making
- and in wine acetaldehyde react with bisulfite
- Excess bisulfite reacts with sugars

Sulfites

- It is possible to classify bound SO_2 into three forms:
  - Aldehyde sulfurous acid
  - Glucose sulfurous acid
  - Rest sulfurous acid
    - Holds the SO_2 in a less tightly bound form
- Sulfites in wine serve a dual purpose
  - (1) antiseptic or bacteriostatic
  - (2) antioxidant

Sulfites

- These activities are dependant on the form of SO_2 present
- The various forms of SO_2 in wine are represented schematically .
- The antiseptic activity of SO_2 is highly dependent on the pH .
  - The lower the pH the greater the antiseptic action of SO_2
- The effect of pH on the various forms of sulfur dioxide is shown .

Sulfites

- Sulfurous acid inhibits molds and bacteria and to a lesser extent yeasts
- For this reason, SO_2 can be used to control undesirable bacteria and wild yeasts in fermentations without affecting the SO_2-tolerant cultured yeasts
- The undissociated acid is 1 000 times more active than HSO_3^- for *Escherichia coli*, 100 to 500 times for *Saccharomyces cerevisiae*, and 100 times for *Aspergillus niger*

Sulfites

- The amount of SO_2 added to foods is self-limiting because at levels from 200 to 500 ppm the product may develop an unpleasant off-flavor
- The acceptable daily intake (ADI) is set at 1.5 mg/kg body weight
- Because large intakes can result consumption of wine, there have been many studies on reducing the use of SO_2 in wine making
- Although some other compounds (sorbic acid and ascorbic acid) may partially replace SO_2 there is no satisfactory replacement for SO_2 in wine making

Sulfites

- The use of SO_2 is not permitted in foods that contain significant quantities of thiamine, because this vitamin is destroyed by SO_2
- SO_2 are used in
  - Wine, meat products
  - Dried fruits, dried vegetables
- Because SO_2 is volatile and easily lost to the atmosphere, the residual levels may be much lower than the amounts originally applied

Nitrates & Nitrites

- Curing salts, which produce the characteristic colour and flavor of products such as bacon and ham, have been used throughout history
- Curing salts have traditionally contained nitrate and nitrite
  - The discovery that nitrite was the active compound was made in about 1890
  - Currently, nitrite is not considered to be an essential component in curing mixtures
  - It is sometimes suggested that nitrate may be transformed into nitrite, thus forming a reservoir for the production of nitrite

Nitrates & Nitrites

- Both nitrates and nitrites are thought to have antimicrobial action
- Nitrate is used in the production of Gouda cheese to prevent gas formation by butyric acid-forming bacteria
- The action of nitrate in meat curing is considered to involve inhibition of toxin formation by *Clostridium botulinum*, an important factor in establishing safety of cure meat products

Nitrates & Nitrites

- Major concern about the use of nitrite was generated by the realization that secondary amines in foods may react to form nitrosamines .
- The nitrosamines are powerful carcinogens, and they may be mutagenic
- It appears that very small amount of nitrosamines can be formed in certain cure meat products

Nitrates & Nitrites

- There appears to be not suitable replacement for nitrite in the production of cured meats such as ham and bacon
- The ADI of nitrite has been set at 60 mg per person per day
- It is estimated that the daily intake per person in Canada is about 10 mg
- There has been dramatic declines in the residual nitrite levels in cured meat products
- This reduction of nitrite levels by about 80 percent has been attributed to lower ingoing nitrite, increased use of ascorbates, improved process control, and altered formulations Nitrates & Nitrites

Nitrates & Nitrites

- The nitrate-nitrite intake from natural sources is much higher than that from processed foods
- Its estimated that the nitrate intake from
  - 100 g of processed meat might be 50 mg
  - and from 100 g of high-nitrate spinach, 200 mg

Hydrogen Peroxide

- Hydrogen peroxide is a strong oxidizing agent and is also useful as a bleaching agent
- It is used for the bleaching of crude soya lecithin
- The antimicrobial action of of hydrogen peroxide is used for the preservation of cheese milk
- Hydrogen peroxide decomposes slowly into water and oxygen
  - This process is accelerated by increased temp
  - The presence of catalysts such as catalase, lacto-peroxidase and heave metals

Hydrogen Peroxide

- Its antimicrobial action increases with temp
- When hydrogen peroxide is used for cheese making, the milk is treated with 0.02 percent hydrogen peroxide followed by catalase to remove hydrogen peroxide
- Hydrogen peroxide can be used for sterilizing food processing equipment and for sterilizing packaging material used in aseptic food packaging systems

Sodium Chloride

- Sodium chloride has been used for centuries to prevent spoilage of foods
- Fish, meats and vegetables has been preserved with salt
- Today, salt is used mainly in combination with other processing methods
- The antimicrobial activity of salt is related to its ability to reduce the water activity (a_w) thereby influencing microbial growth

Sodium Chloride

- Salt has the following characteristics:
  - It produces an osmotic effect
  - It limits oxygen solubility
  - It changes pH
  - Sodium and chloride ions are toxic
  - Salt contributes to loss of magnesium ions
- The use of sodium chloride is self-limiting because of its effect on taste

Bacteriocins - Nisin

- Nisin is an antimicrobial polypeptide produced by some strains of *Lactococcus lactis*
- Nisin-like substances are widely produces by lactic acid bacteria
- These inhibitory substances are known as becteriocins
- Nisin has been called an antibiotic, but this term is avoided because nisin is not used for therapeutic purposes in humans or animals
- Nisin-producing organisms occur naturally in milk

Bacteriocins - Nisin

- Nisin can be used as a processing aid against gram-positive organisms
- Because its effectiveness decreases as the bacterial load increases, it is unlikely to be used to cover unhygienic practices
- Nisin is a polypeptide with a molecular weight of 3 500, which is present as a dimer of molecular weight of 7 000
- It contains some unusual sulfur amino acids, lanthionine and B-methyl lanthionine

Bacteriocins - Nisin

- It contains no aromatic amino acids and is stable to heat
- It has been used effectively in preservation of processed cheese
- It is also used in the heat treatment of nonacid foods and in extending the shelf life of sterilized milk

Acids

- Acids as food additives serve a dual purpose
  - Acidulants
  - Preservatives
- Phosphoric acid is used in cola soft drinks to reduce the pH
- Acetic acid is used to provide tartness in mayonnaise and salad dressings
- Similar functions are served by organic acids
  - Citric acid, tartaric, malic, lactic… acids.

Acids

- Straight-chain carboxylic acids, propionic and sorbic acids, are used for their antimicrobial properties
- Propionic acid is mainly used for its antifungal properties

Antioxidants

- Food antioxidants in the broadest sense are all of the substances that have some effect on preventing or retarding oxidative deterioration in foods
- They can be classified into a number of groups:

Antioxidants

- i) ***Primary antioxidants***
  - Terminate free radical chains and function as electron donors
  - They include the phnolic antioxidants, butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) tertiary butyl hydroquinone (TBHQ), propylgallate (PG) and natural synthetic tocopherols

Antioxidants

- ii) Oxygen scavengers
  - Can remove oxygen in a closed system
  - Most widely used compounds are Vit C, and related substances, ascorbyl palmitate, and erythorbic acid (the D-isomer of ascorbic acid)
- iii) Chelating agents or sequestrants
  - They remove metallic ions, especially copper and iron, that are powerfull pro-oxidants
  - Citric acid is widely used for this purpose
  - Amino acids and ethylene diamine tetraacetic acid (EDTA) are examples of chelating agents

Antioxidants

- iv) Enzymatic antioxidants
  - Can remove dissolved head space oxygen, such as glucose oxidase
  - Superoxide dismutase can be used to remove highly oxidative compounds from food systems
- v) Natural antioxidants
  - Present in many spices and herbs
  - Rosemary and sage are the most potent antioxidant spices

Antioxidants

- The active principles in rosemary are carnosic acid and carnosol .
- Antioxidants from spices can be obtained as extracts or in powdered form

- Sometimes the antioxidant are incorporated in the packaging materials rather than in the food itself

Emulsifiers

- With the exception of lecithin, all emulsifiers used in foods are synthetic
- They are characterized as ionic or nonionic and by their hydrophile/lipophile balance (HLB)
- All the synthetic emulsifiers are derivatives of fatty acids
- Lecithin is the commercial name of a mixture of phospholipids obtained as a byproduct of the refining of soybean oil

Emulsifiers

- Crude soybean lecithin is dark in colour and can be bleached with hydrogen peroxide or benzoyl peroxide
- The emulsifying properties, especially HLB, are determined by the chain length and unsaturation of the fatty acid chain
- Hydroxycarboxylic and fatty acid esters are produced by esterfying organic acids to monoglycerides
- This increases their hydrophilic properties

Emulsifiers

- Organic acids used are
  - Acetic, citric, fumaric, lactic or tartaric acid
- Acetic acid esters can be produced from mono- and diglycerides by reaction with acetic anhydride or by transesterification
- They are used to improve aeration in food high in fat content and to control fat crystallization

Emulsifiers

- Sucrose fatty acid esters can be produced by esterification of fatty acids with sucrose, usually in a solvent system
- When the level of esterification in increases to over five molecules of fatty acid, the emulsifying property is lost
- At high levels of esterification the material can be used as a fat replacer because it is not absorbed or digested and therefor yields no calories

Bread improvers

- To speed up the aging process of wheat flour, bleaching and maturing agents are used
- Benzoyl peroxide is a bleaching agent that is frequently used
  - Other compounds – including the oxides of nitrogen, chlorine dioxide, nitrosyl chloride, and chlorine – are both bleaching and improving (maturing) agents

Bread improvers

- Improvers used to ensure that dough will ferment uniformly and vigorously include
  - Oxidizing agents: Potassium bromate, potassium iodate, calcium peroxide
- There may be small amounts of other inorganic compounds in bread improvers
  - Including ammonium chloride, ammonium sulfate, calcium sulfate…
- Most of these bread improvers can only be used in small quantities, because excessive amounts reduce quality

Thank you

Fahim shaltout