

# Introduction to Food Additives



# Food additives

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- There are over 2000 compounds approved as food additives in the US (list is continuously changing due to additions and deletions)
- Necessary for meeting the demands of a continuous, adequate supply of a substantial variety of food items

# Broad categories of food additives

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- Pesticide residues
- Unavoidable contaminants
- Colouring additives
- Intentional food additive to achieve a desired function

# Food Additives

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- **Functions**

- Enhance food appearance and consumer acceptance
- Improve shelf life
- Enhance nutrition
- Functional property provision & improvement (e.g. texture improvement)
- Aid in processing

# Food additives

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- Chemicals, both natural and synthetic, added intentionally to foods to bring desired change in physical, chemical and sensory properties
- Classified according to the functionality or desired purpose
- Antioxidants, preservatives, flavouring agents, colouring agents, emulsifiers

# Food additives

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- **Acids / Acidity regulators / Alkalis**
  - help to maintain a constant acid level in food. This is important for taste, as well as to influence how other substances in the food function. For example, an acidified food can retard the growth of some micro-organisms.
- **Anti-caking agents**
  - reduce the tendency of individual food particles to adhere and improve flow characteristics. For example, seasoning with an added anti-caking agent flows freely and doesn't clump together.

# Food additives

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- **Antioxidants**

- retard or prevent the oxidative deterioration of foods. For example, in fats and oils, rancid flavours can develop when they are exposed to oxygen. Antioxidants prevent this from happening.

- **Bulking agents**

- contribute to the volume of the food, without contributing significantly to its available energy. For example, sugar often contributes to the volume of lollies, while some low-joule foods need bulking agents added to them to replace the bulk normally provided by sugar.

<http://www.foodstandards.gov.au/>



# Food additives

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- **Colourings**
  - add or restore colour to foods. For example, icing mixture is coloured to make it more attractive on cakes.
- **Emulsifiers**
  - facilitate or maintain oil and water from separating into layers. For example, emulsifiers may be used in margarine to prevent oil forming a layer on top of the margarine.
- **Firming agents / Stabilisers**
  - maintain the uniform dispersion of substances in solid and semi-solid foods.

<http://www.foodstandards.gov.au/>



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# Food additives

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- **Flavour enhancers**
  - enhance the existing taste and/or odour of a food.
- **Foaming agents**
  - maintain the uniform dispersion of gases in aerated foods.
- **Gelling agents**
  - modify the texture of the food through gel formation.
- **Glazing agents**
  - impart a coating to the external surface of the food, for example a wax coating on fruit to improve its appearance.



# Food additives

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- **Humectants**
  - reduce moisture loss in foods. For example, glycerine may be added to icing to prevent it from drying out.
- **Preservatives**
  - retard or prevent the deterioration of food by micro-organisms, and thus prevent spoilage of foods.
- **Raising agents**
  - liberate gases, thereby increasing the volume of a food. Raising agents are often used in baked goods.

# Food additives

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- **Sweeteners**

- replace the sweetness normal provided by sugars in foods without contributing significantly to their available energy.

- **Thickeners**

- increase the viscosity of a food. For example, a sauce might contain a thickener to give it the desired consistency

# Use of food additives in Australia

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- Food Standards Australia New Zealand (FSANZ) is the regulatory body which evaluates for the following
  - Is the food additive safe (at the requested level in that particular food)?
  - Are there good technological reasons for the use of the food additive?
  - Will consumers be clearly informed about its presence?

# Recognising food additives

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- Code numbers are used to identify each additive on food labels, e.g.
  - Thickener (1422) - acetylated distarch adipate
  - Acidity regulator (270) - lactic acid
  - Acidity regulator (260) - acetic acid, glacial
  - Thickener (415) - xanthan gum
- List of code number is available at Food Standards Australia New Zealand (FSANZ) Web site

# Examples of functional properties in food processing

<u>Property/functionality</u>	<u>Ingredient</u>
Water binding	Protein, phosphates
Emulsification	Lecithin
Whippability	Albumin
Buffering	phosphates
Heat gelation	proteins
O <sub>2</sub> scavenging	BHA

# Food acidulants

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- Functions of food acidulants
  - pH control agents
  - Preservatives
  - Chelating agent/antioxidant synergist
  - Flavour adjuncts
  - Fortification
  - Viscosity and melting modifiers

# Food acidulants

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- **Inorganic**
  - Phosphoric and its derivatives
  - HCl and H<sub>2</sub>SO<sub>4</sub>
- **Organic**
  - Carboxylic acid
    - Mono-carboxylic - Acetic, propionic, lactic
    - Di-carboxylic - Succinic, fumaric, malic, tartic, adipic
    - Tri-carboxylic - citric
  - Phenolic acids - benzoic acid
  - Fatty acids - sorbic, caprylic, butyric
  - Lactones - ascorbic acid, gluconolactone
  - Amino acids - Lysine, cysteine, glutamic acid



# Acids

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- General attributes & functions
  - Reduction in pH
  - Buffering
  - Taste
  - Gel formation: pectin, casein, cultured dairy products
  - Chemical leavening

# Phosphates

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- **Classes**
  - Orthophosphates
  - Condensed phosphates
    - Polyphosphates (straight chain)
    - Metaphosphates (cyclic)

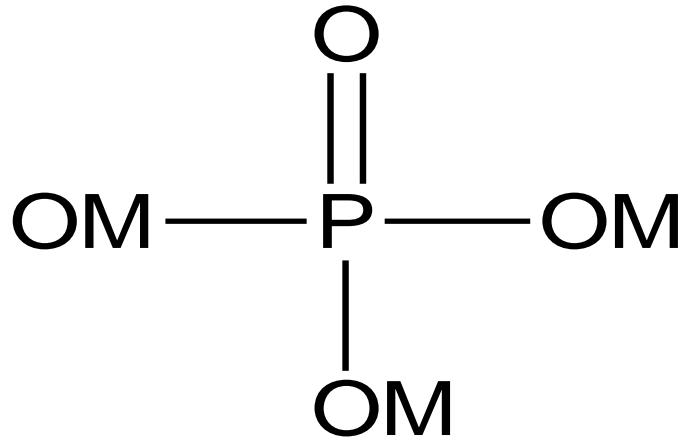
# Functions of phosphates

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- Sequestering agent
- Water holding capacity
- Stabilising emulsion
- Leavening
- Buffering

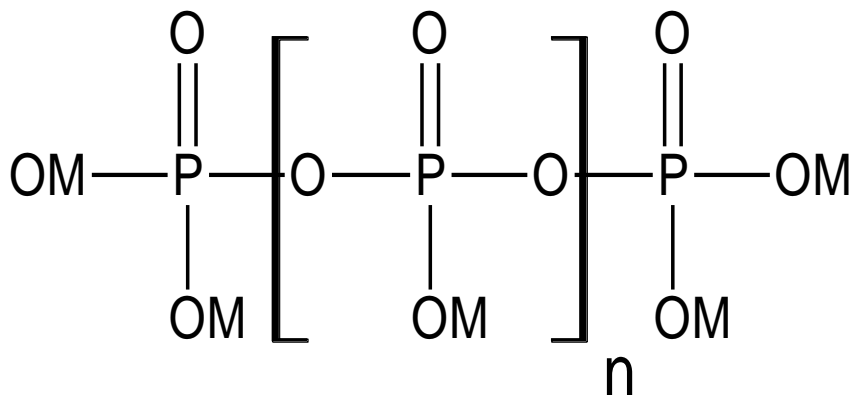
# Orthophosphates

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Orthophosphates

# Polyphosphates



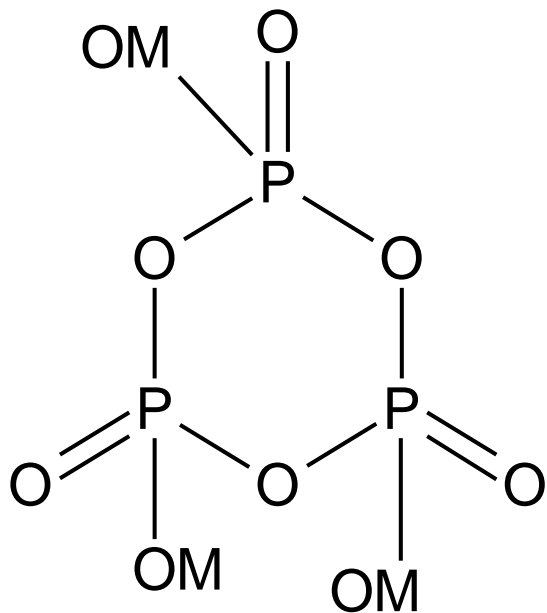
n=0 pyrophosphate

n=1 triphosphate

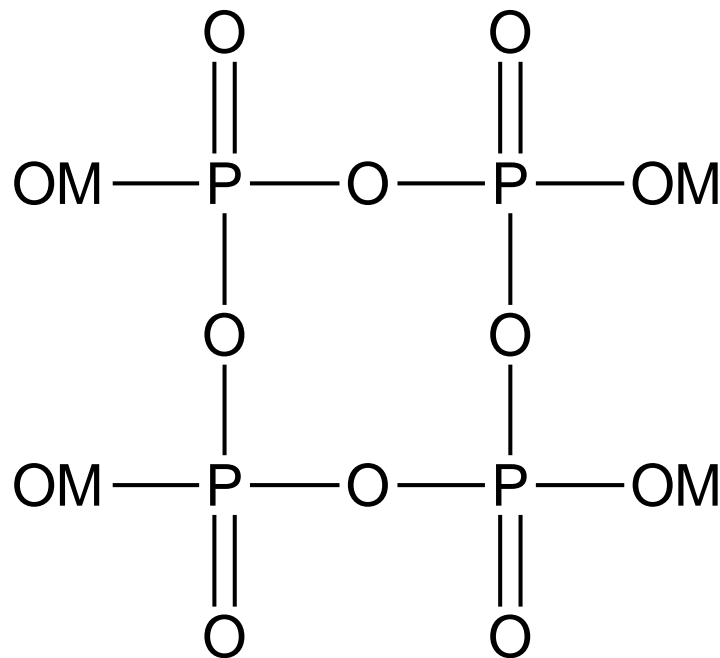
n>1 long chain phosphate

Straight chain polyphosphates

# Polyphosphates

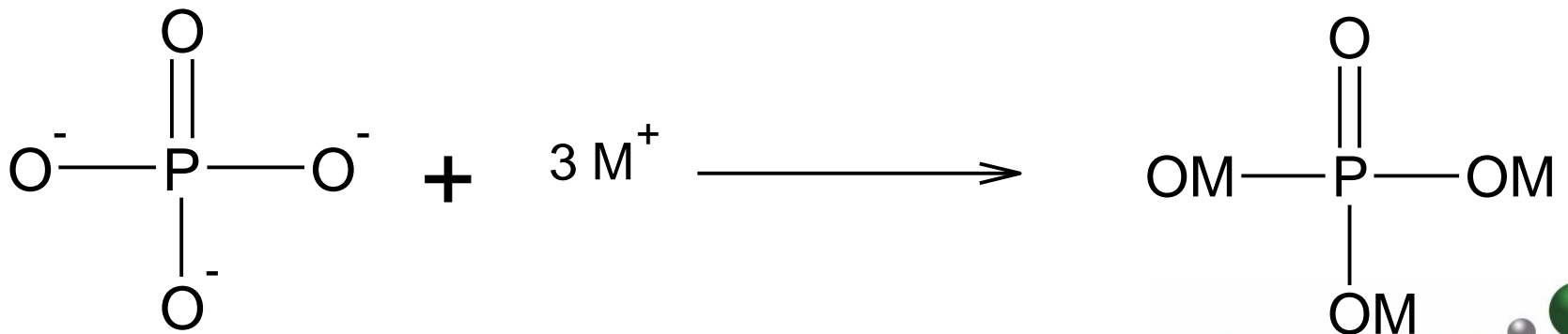


Cyclic metaphosphates



# Phosphate-sequestering

- Sequestering action is due to phosphate acting as an anion to bind cations which are metals in the presence of other complexing or precipitating anions



# Phosphate-sequestering

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- Action depends on
  - pH (higher the pH lesser is sequestering)
  - Long chain phosphates are stronger anion than short chain or orthophosphates



# Phosphate-Water holding capacity

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- Used in processed meat, poultry, seafood for retaining juiciness and tenderness
- Combination of phosphates are utilised for optimum functionality, eg sodium tri-polyphosphates and sodium dexta-meta-phosphates are used together

# Phosphate-Water holding capacity

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- Phosphates are hydrolysed to pyrophosphates, which are active principles to control WHC
- Functions
  - Increasing pH
  - Increase in ionic strength
  - Sequestering of metal ions

# Phosphate-WHC in meat products

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- Mechanism in meat products
  - Phosphates and chlorides cause interfibrillar volume to expand due to
    - Depolymerisation of myosin filament
    - Dissociation of actomyosin complex

# Phosphate:emulsion stabiliser

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- Used in processed cheese to stabilise emulsion of butterfat in protein-water matrix
- Na salts of orthophosphate are often used

# Phosphate: emulsion stabiliser

Phosphate	Use
Polyphosphate eg Na-acid pyrophosphates and Na-hexametaphosphates	Processed cheese-smooth texture and melt down with no fat separation
Alkaline pyrophosphates	Soft texture & low melting point
Acid phosphates & polyphosphates	Hard texture & high melting point

# Phosphates-leavening

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- Reaction with bicarbonates to produce  $\text{CO}_2$  in leavened bakery products
- Anhydrous mono-calcium phosphate, dicalcium phosphate dihydrate, sodium aluminium phosphate & sodium acid pyrophosphates are most common

# Classification of food colourants

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- Subject to certification
  - Azo
    - FD&C Red 40, FD&C Yellow No. 5 & 6, Orange B, Citrus Red No. 2
  - Triphenylmethane
    - FD&C Blue No. 1, FD&C Green No.3
  - Xanthene
    - FD&C Red No. 3
  - Sulfonated Indigo
    - FD&C Blue No. 2

# Classification of food colourants

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- Exempt from certification
  - Non-synthetic (natural)
    - Annatto extract, Anthocyanins, Betalains, Chlorophylls, Caramel, Cochineal extract (carmine), Paprika, Turmeric, Saffron, Carrot oil, Carthamus yellow, Corn endosperm oil, Cottonseed flour, Dried algae meal, Fruit & vegetable juices, Grape colour extract, Grape skin extract, Lutein
  - Synthetic (nature identical)
    - Beta-carotene, Beta-apo-8'-carotene, Canthaxanthin, Riboflavin, Ferrous gluconate
  - Inorganic
    - Titanium dioxide, Ultramarines, Iron oxides and hydroxides, Calcium carbonate, Silver, Gold, Aluminium

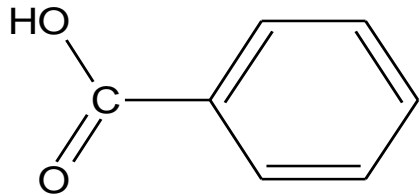


# Antimicrobials

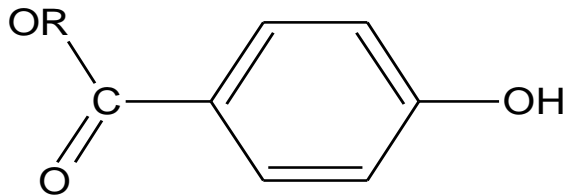
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- Benzoic acid and its salts
- Sorbic acid and its salts
- Propionic acid and its salts
- Esters of p-hydroxybenzoic acid
- Sulphur dioxide and sulphites
- Carbon dioxide
- Others
  - Dimethyl & diethyl dicarbonates
  - Epoxides
  - Hydrogen peroxide

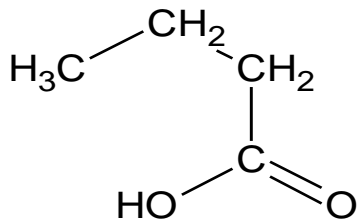
## Antimicrobial short chain acid derivatives



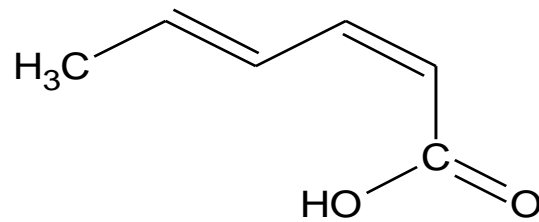
Benzoic acid



Paraben



Propionic acid



Sorbic acid

# Benzoic acids

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- Naturally found in berries *e.g.* cranberries (ca 5%)
- Effective
  - against most microorganisms, particularly yeasts, bacteria
  - Ineffective against molds
- Opt activity 2.5-4 pH

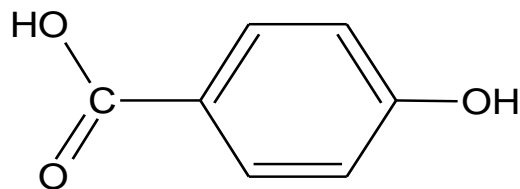
# Benzoic acids

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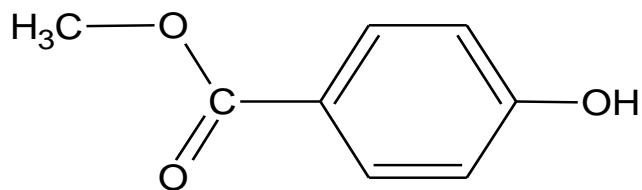
- Used as preservative in jams, jellies & preserves, fruit juices
- Use in combination with sorbic acid and parabens
- Safe in low amounts

# Parabens

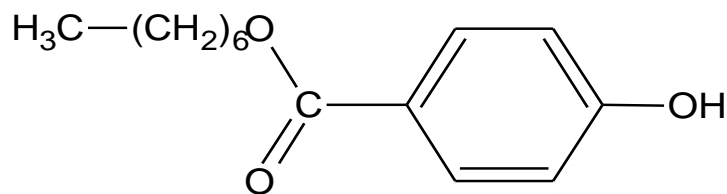
- Group of alkyl esters of p-hydroxy benzoic acid



p-hydroxybenzoic acid



Methyl paraben



Heptyl paraben

# Parabens

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- Used in baked products, soft drinks, beer, olives, pickles, jams, jellies & syrups
- Effective against yeasts & moulds (0.05 to 0.1% by wt)
- Ineffective against gram -ve bacteria
- Active at neutral pH

# Parabens

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- Remain un-dissociated at higher pH
- Efficiency depends on
  - Increase in chain length
  - Increase in chain length reduces the water solubility
- Safe as hydrolysed and excreted in urine

# Sorbic acid

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- Short chain monocarboxylic acid are Antimycotic, effective against yeast & moulds
- Used in cheese, baked products, fruit juices, pickles or applied on the packaging material



# Sorbic acid

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- Contributes little flavour at conc up to 0.3% by wt
- Activity
  - Decreases as pH increases, effective at 6.5
  - Against mould is due to inability to metabolise the diene aliphatic structure which interferes with the cellular dehydrogenase

# Sorbic acid

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- Metabolised through  $\beta$ -oxidation in the same manner as other fatty acids and therefore safe for humans
- Effective against some bacteria & found to be effective in inhibiting toxin production by *Clostridium botulinum* and useful in poultry, fish and bacon
- Used as K salt as well

# Propionic acid

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- Acid and its Ca and Na salts are effective against moulds and few bacteria in bakery products
- Occurs naturally in swiss cheese, produced by *Propionibacterium shermanii*
- Effective up to pH of 5

# Propionic acid

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- Toxicity of bacteria and moulds is due to inability of these to metabolise 3-C containing skeletons
- In humans metabolism similar to that of fatty acids

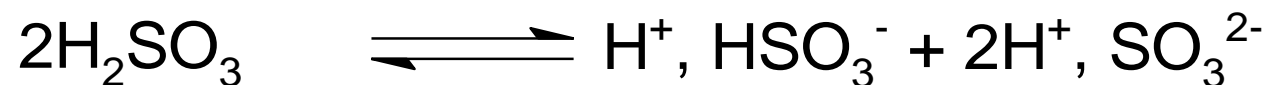
# Glyceryl esters

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- MAG effective against gram +ive bacteria and yeasts
- Used in cured meats, refrigerated fresh fish
- Mechanism facilitate conduction of protons through cell membranes destroying the proton-motive force need for cellular transport

# Sulphites and SO<sub>2</sub>

- Used as gas or Na and K salts



# Sulphites and $\text{SO}_2$

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- Relative proportion of the forms depend on pH
- Most effective under acidic conditions (pH < 3.0)
- Un-dissociated sulphurous acid form is the most effective as antimicrobial as it penetrates the cell wall

# Sulphites and $\text{SO}_2$

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- Effective against bacteria, yeasts and moulds as it
  - Reaction of bisulphite with aldehydes in cell wall
  - Inhibition of sulphur containing enzymes
  - Formation of addition compounds which interfere with respiration



# Sulphites and SO<sub>2</sub>

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- Effective as antioxidant to prevent oxidative flavour defects in beer
- Effective as bread improver to cleave the disulphide bonds
- Effective in bleaching of anthocyanins
- Safety: metabolised to sulphates and excreted in urine, asthmatic reaction and mutagenicity

# Nitrite and nitrate salts

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- Used in curing mix to:
  - Enhance colour of meat
  - Inhibit micro-organisms
  - Develop characteristic flavour
- Effective at 5-5.5 pH
- Nitrosamine formation

# Antioxidants

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- Antioxidants are defined by the FDA as “substances used to preserve foods by retarding deterioration, rancidity or dissociation due to oxidation”.
- The addition is either intentional (direct to the food product) or incidental (e.g. migration from packaging)

# Food antioxidants

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- Primary antioxidants
  - Phenols
    - Gallates, Hydroquinone, Trihydroxy butyrophenone, Nordihydroguaiaretic acid
  - 'Hindered' phenols
    - BHA, BHT, TBHQ, Tocopherols, Gum guaiac, Ionox series
  - Miscellaneous
    - Ethoxyquin, Anoxomer, Trolox-C

# Food antioxidants

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- **Secondary/Synergistic antioxidants**
  - **Oxygen scavengers**
    - Sulphites, Ascorbic acid, Ascorbyl palmitate, Erythorbic acid
  - **Chelating agents**
    - Polyphosphates, EDTA, Tartaric acid, Citric acid, Citrate esters, Phytic acid, Lecithin
  - **Secondary antioxidants**
    - Thiodipropionic acid, Dilauryl, Distearyl esters
  - **Miscellaneous**
    - Nitrites, Amino acids, spice extracts, Flavonoids, Vitamin A, b-carotene, Tea extracts

# Artificial sweeteners

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- Substances or groups thereof evoking a sweet taste or enhance the perception of sweet taste
- Provide low calories than sugar & non nutritive
- Mostly used in beverages
- Have no body & filling capacity

# Artificial sweeteners

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- Types

- Cyclamates: Na & Ca salts, not used due to suspected carcinogen
- Saccharine
- Aspartame
- Acesulfame
- Sucralose



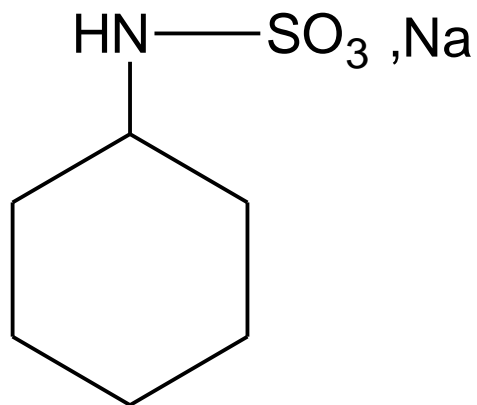
- **Cyclamates**

- Potential carcinogen suspect as hydrolysis of sulphamates yields cyclohexylamine, a known carcinogen
- Not used



# Sweetener

- Cyclamates



Sodium cyclamate

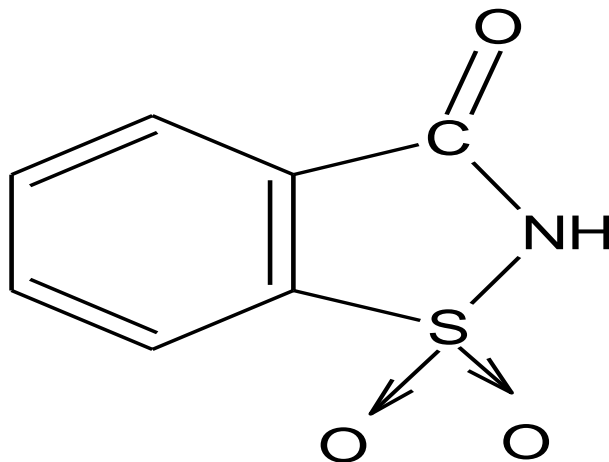
# Sweeteners

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- Saccharine
  - Na & Ca salts
  - 300 x sweet for conc up to 10% sucrose solution equivalent
  - Readily absorbed and excreted in urine
  - High conc produces bitterness
  - Brands: Sweet n'Low

# Artificial sweeteners

- Saccharin



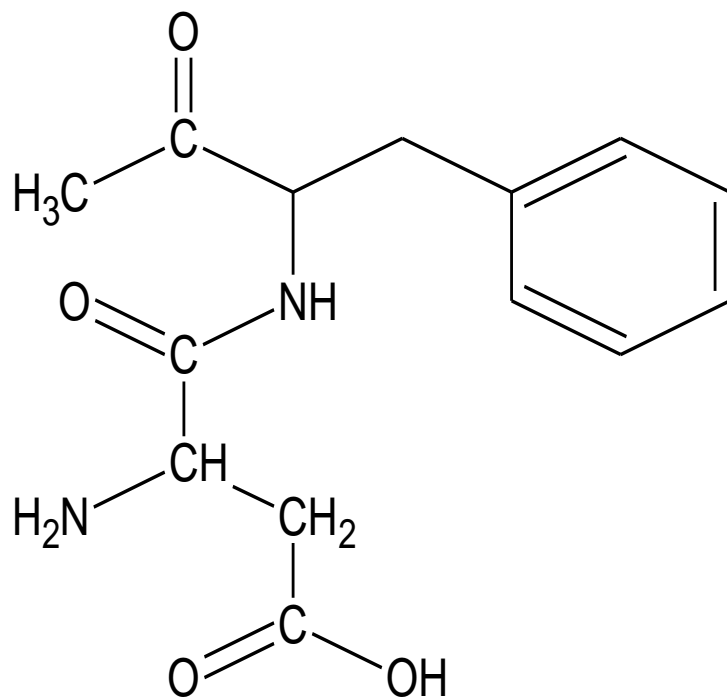
Saccharine

# Sweeteners

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- **Aspartame**
  - L-aspartyl-L-phenylalanine methyl ester
  - Dipeptide & provides calories
  - 200x sweet at 4% sucrose conc
  - Limited shelf life due to hydrolysis by enzymes, mo
  - Used in soft drinks
  - Brands: Nutrisweet, Equal

# Aspartame



L-aspartyl-L-phenylalanine  
(Aspartame)

methyl

ester

OzScientific

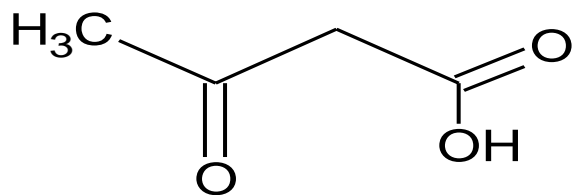
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# Acesulfame K

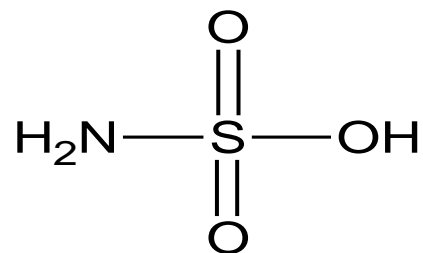
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- 200X as sweet as sucrose at 3% solution
- Intermediate sweetness between cyclamate and saccharine
- Brands: Sunette

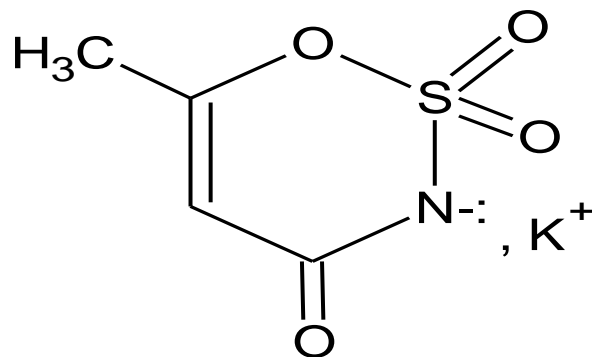
# Acesulfame K



Aceto-acetic acid



Sulfamic acid



Acesulfame K

# Sucralose

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- Sucralose is the newest non-caloric sweetener to be approved for limited use by the FDA.
- It is about 600 times sweeter than sugar and is the only sweetener made from sugar. It has a sugar-like texture and appearance.
- Sucralose is also not metabolized and is eliminated after consumption. In addition to the FDA, other health organizations around the world have confirmed the safety of sucralose.
- It can also be used for baking because it does not lose its sweetness at normal baking temperatures.
- Brands: Splenda



# Further reading

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- Food Additive Toxicology (eds J.A. Maga and A.T. Tu), Marcel Dekker, New York

Lecturer contact:

[Ranjan.Sharma@OzScientific.com](mailto:Ranjan.Sharma@OzScientific.com)

