The Chemistry of Food
Lecture 3

Chemistry in Context
06525/06529/06509

Dr AN Boa

FLAVOURS

- We normally associate taste as the property of liquids, solids and gases in solution detected by the sensory cells on the tongue and oral cavity ….
- ... and associate aroma with the volatiles substances detected by the olfactory system of the nose.
- Very few *flavours* allow a clear distinction between these two.

Sweetness	**Astringency**
Saltiness	**Pungency**
Sourness	**Meatiness**
Bitterness	**Fruitiness**
(synthetic flavours)	**(off-flavours / taints)**

Browning Reactions

- *Caramelization*

sugar —(high temps)→ brown pigments + flavours

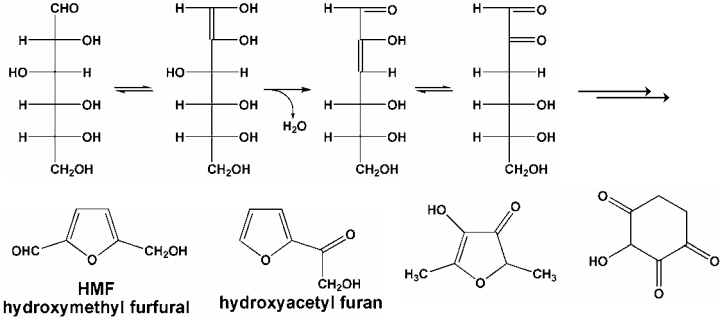
- *The Maillard Reaction*

reducing sugar + amino acid → brown pigments + flavours

- Other enzyme-mediated browning reactions can take place, which do not involve sugars - *see lecture 2*

Caramelization

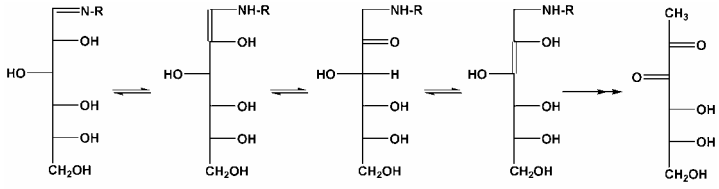
- acid / base catalysed (organic acids / water)
- any sugar – here glucose



CARAMEL FLAVOURS

The Maillard Reaction

AMADORI REARRANGEMENT



IMINE
(R-NH_2 from amino acid)

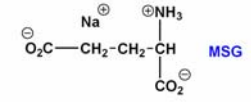
AMADORI COMPOUND

- deamination and further isomerization leads to several reactive dicarbonyl compounds (HMF and others)
- cyclic products polymerize to form *brown, insoluble poorly defined high MW materials.*

Meatiness

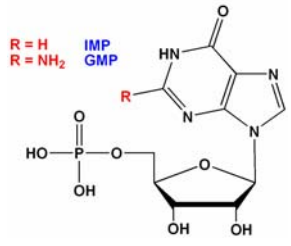
- Water soluble, non-volatile taste components
  - Known as '*umami*' by the Japanese

- Monosodium glutamate, MSG, *umami*$_1$
  - Levels of 10-35 mg/100 g meat



MSG

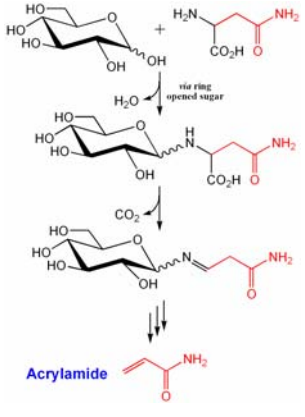
- Inosine monophosphate, IMP, *umami*$_2$
  - Levels of 1-200 mg/100 g
  - Also, but less important, GMP (0-10 mg/100 g)



R = H IMP
R = NH_2 GMP

The Maillard Reaction (continued)

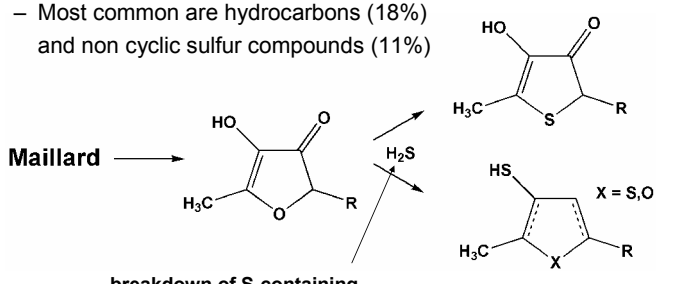
- Acrylamide, a probable carcinogen and agent known to cause neurological damage, has been detected in many roast and fried foods.
- Believed to arise from the Maillard reaction involving asparagine.
- Levels detected very variable, but best technique for extraction and analysis still a matter of debate.



Acrylamide

Meatiness

- Many volatile aromas present in meats
  - Over 650 identified in beef
  - Most common are hydrocarbons (18%) and non cyclic sulfur compounds (11%)



Maillard

H_2S

breakdown of S-containing amino acids

X = S,O

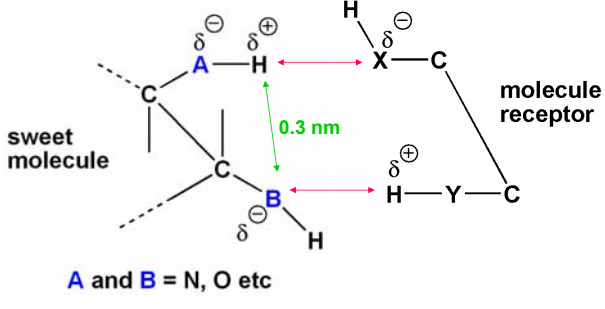
ROASTED MEAT FLAVOURS

Sweetness

- Sweetness is found in many types of molecules (not just sugars), and relative sweetness is normally compared to sucrose
- Natural sugars
  - sucrose (1.0); glucose (0.76); fructose (1.52)
- Also artificial sweeteners
  - sodium cyclamate (30); acesulpham K (140); aspartame (200); saccharin (350); 1-*n*-propoxy-2-amino-4-nitrobenzene (4000)

Schallenberg's "saporous unit" theory

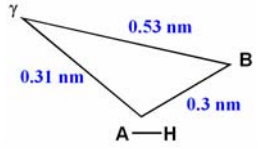
- Sweet molecules contain H-bonding groups such as hydroxyls, amines etc.

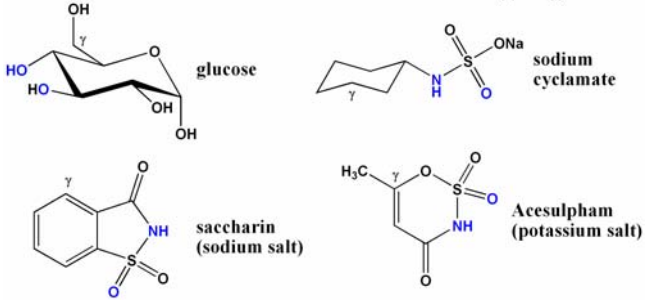


- Geometry of so-called "saporous" units crucial for interaction with a "sweetness" receptor

Extended theory

- An extended theory of sweetness includes a hydrophobic γ-site





Sourness

- Sourness *assumed* to be linked with acidic solutions
- However the presence of unionized organic acids (i.e R-CO_2H) is more important for the taste of sourness
  - citric, malic, tartaric (grape), isocitric, oxalic, acetic, lactic
- In foods:
  - Sourness of vinegar due to acetic acid, but also adds importantly to aroma, such as with fish and chips
  - Lactic acid in pickled foods such as sauerkraut comes from bacterial fermentation of the sugars in the vegetables
  - Sodium lactate is used in salt and vinegar flavoured crisps

Bitterness

- Several classes of compounds exhibit bitterness
- Taste buds at back of tongue responsive to
  - group 1 and 2 halide salts
  - certain phenolics
- KBr is both salty and bitter
  - Halide salts with the sum of their ionic diameters greater than KBr are bitter, if the sum is less then they are salty

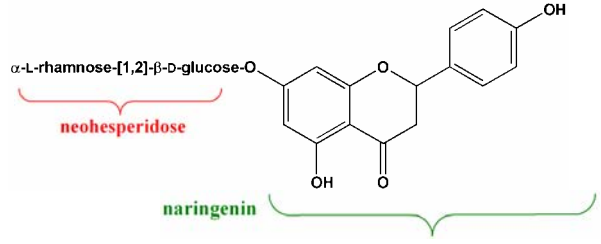
NaCl (0.556) < KBr (0.658 nm) < KI (0.706) < $MgCl_2$ (0.850)

Bitterness

- Many plants contain molecules which we perceive as very bitter
  - Nicotine, atropine, emetine, quinine
- Role in plants unknown…..
  - but many have undesired pharmacological properties
  - physostygmine (eserine)
- Animals' ability to perceive these have undoubtedly evolved to avoid eating these plants
  - Quinine antiplasmodial agent used to prevent and cure malaria by consumption of tonic waters

Phenolics: *Seville oranges*

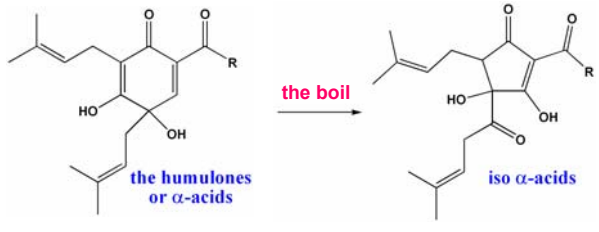
- Phenolics in the form of flavanoids are source of bitterness in citrus fruits.
  - Naringin is a bitter sugar-flavanone conjugate found in Seville oranges. Its bitterness is detected at 1:50,000 dilution.



  - The non-sugar unit attached to sugar known generally as the aglycone
  - Here the sugar is neohesperidose, and the aglycone is naringenin

Phenolics: *beer*

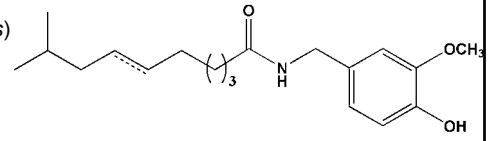
- Before the fermentation stage of the brewing process, the flowers of the hop plant, *Humulus lupulus*, are added to the wort
- Hops are added to add both flavour and bitterness



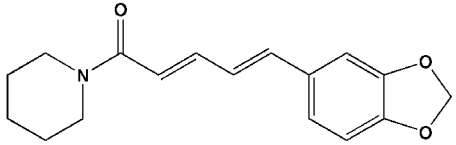
- The humulones are converted to the more soluble and more bitter iso α-acids in the boil

Pungency: *chillies, peppers, ginger*

- Chillies (*Capsicum frutescens*)
  - Capsaicin and dihydrocapsaicin



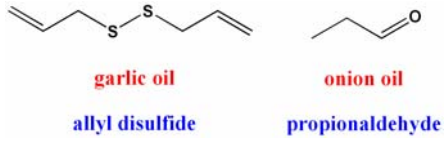
- Black pepper (*Piper nigrum*)
  - Piperine



- Ginger (*Zingiber officinale*)
  - Gingerols and shogaols – ketones similar to capsaicin with hydroxy or alkene groups in a variable length aliphatic side chain

Pungency: *onion and garlic*

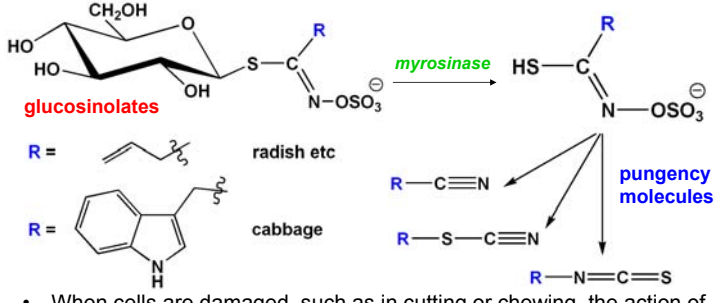
- Garlic and onions – belong to *Allium* species
- Early (19th century) studies using steam distillation isolated non-odorous species
  - Gave rise to trivial name of 'allyl' for the prop-1-enyl unit



- Gentler extraction processes (lower temp, ethanol as solvent) isolated more interesting molecules!

Pungency: *mustards and brassica*

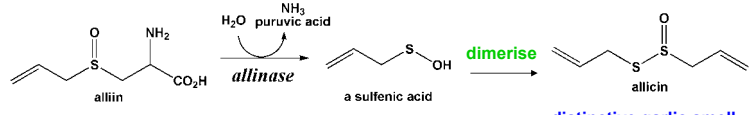
- Pungency in certain raw vegetables [mustards, (horse)radish, cabbages *etc.*] are due to thiosugar derivatives - *glucosinolates*



- When cells are damaged, such as in cutting or chewing, the action of *myrosinase* triggers the breakdown of glucosinolates

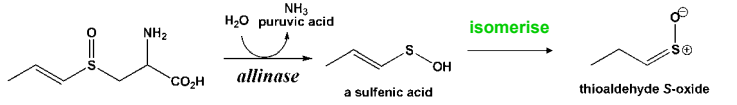
Pungency: *onion and garlic*

- Garlic: on cell rupture *allinase* reacts with alliin, a derivative of the amino acid cysteine



distinctive garlic smell

- Onion: *allinase* reacts with an isomer of alliin



onion lachrymatory factor

Conclusions

- Carbohydrates: saccharides
- Proteins: amino acids and peptides
- Lipids: oils and fats
- Colourings
- Flavour chemicals

…..affect the physical and chemical properties, and of course our enjoyment, of foodstuffs