An introduction to beer flavour

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Overview

- How do we sense flavour?
- Beer flavour overview
- The importance of beer flavour
- Why sensory?
- Managing a sensory panel

Learning objectives

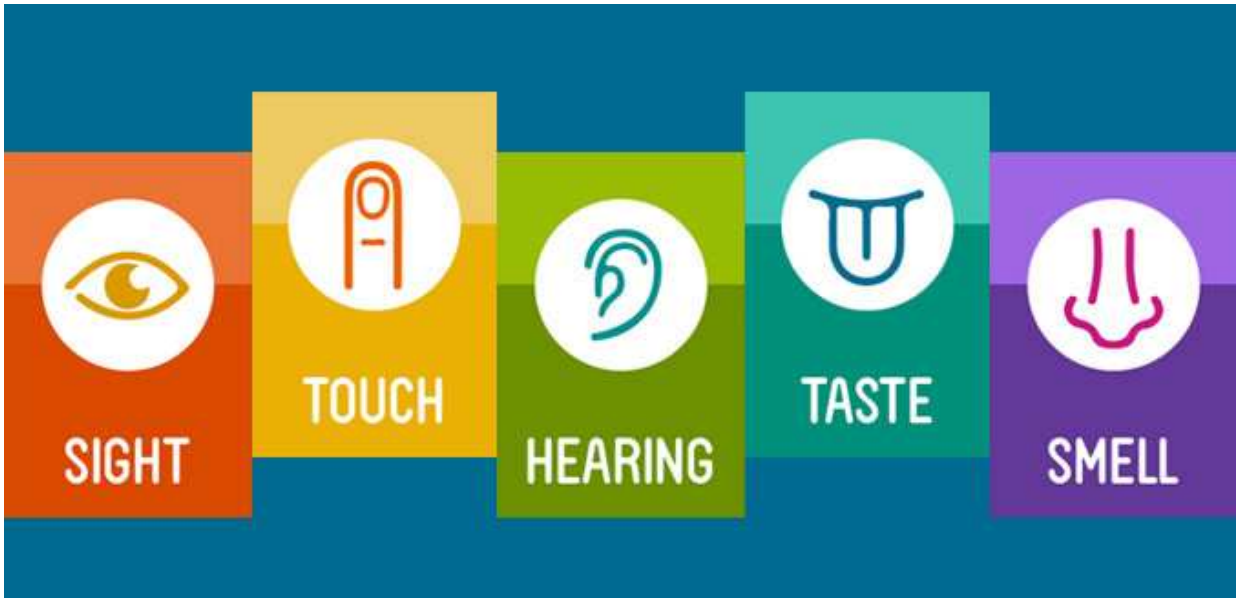
At the end of this session you should be able to

- **List the main contributions made by raw materials, yeast and processing to the flavour of beer**
- **Name the main flavour compounds associated with the flavour of fresh beer**
- **Name the main flavour defects associated with beer**
- **Name the process parameters you can control to optimize the flavour of beer**

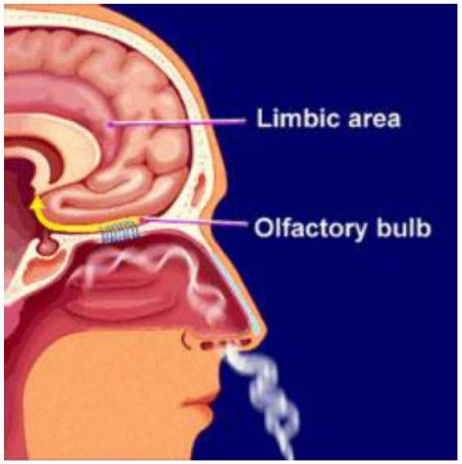
So how do we sense flavour?

Sensory perception

- Sight
- Hearing
- Touch
- Smell
- Taste



Sense of smell

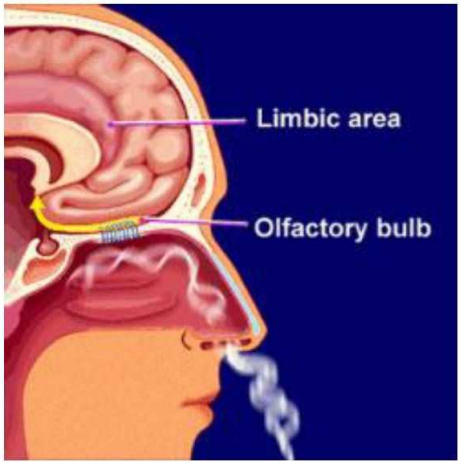


- Humans can detect over 10,000 compounds
- Odour molecules sensed by olfactory receptors – Orthonasal and Retronasal
- We sense smells at a molecular level
- We can discriminate closely related molecules
- We can classify based on impression ie fruit/sulphury etc.

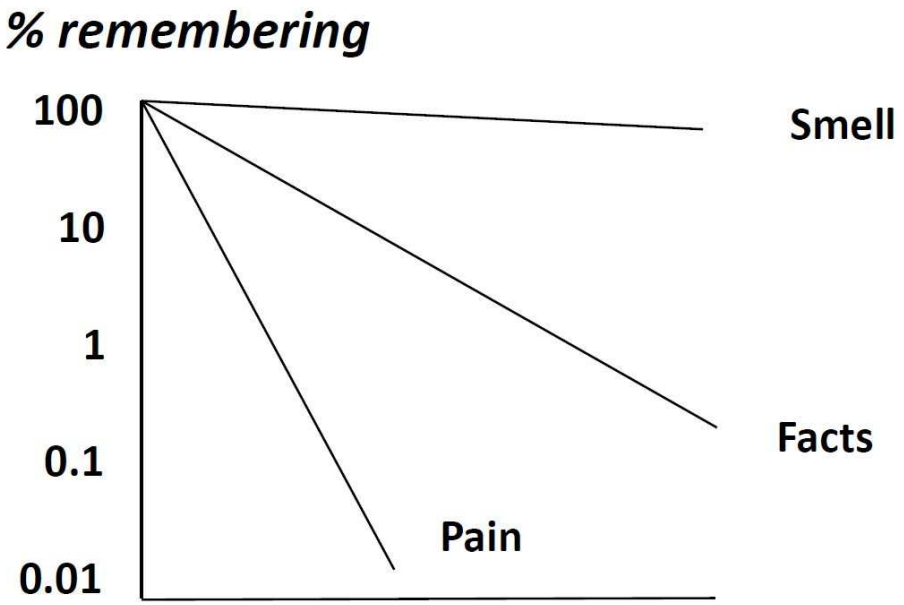
Sense of smell

- Blindness and sensitivity varies by person
- Variation to sensitivity can be up to 10,000 fold
- Detection rates vary greatly! Femtograms to Grams
- The particular compound and variety of compounds varies by person

Smell

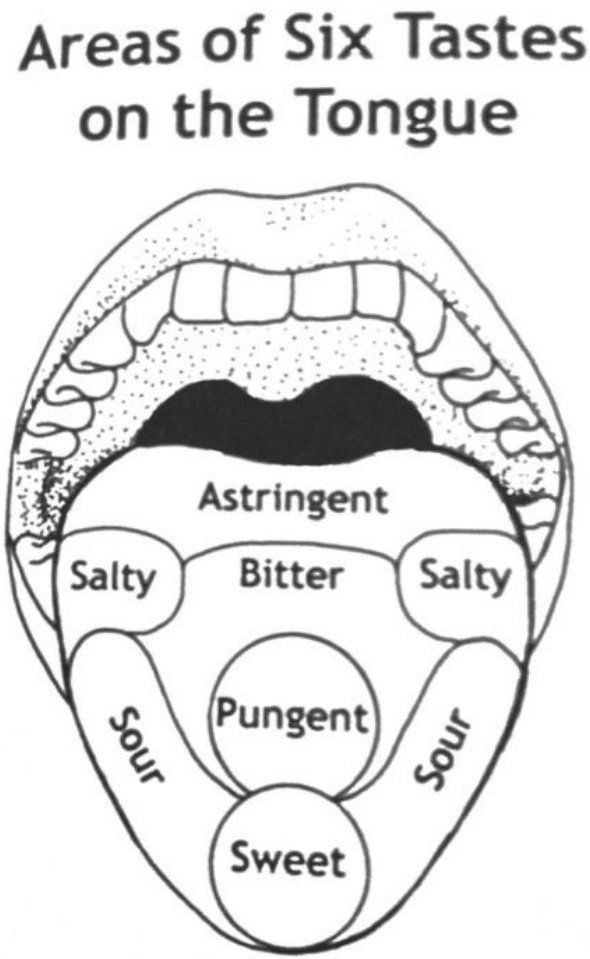


- We remember smells in a completely different way than we remember other sensory memories

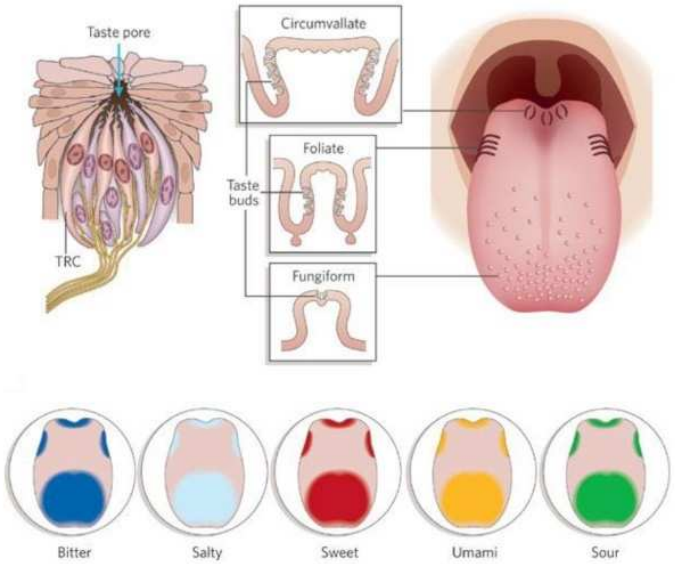


Taste

- Sweet
- Salt
- Bitter
- Sour
- Umami
- Emerging: Fat



Taste



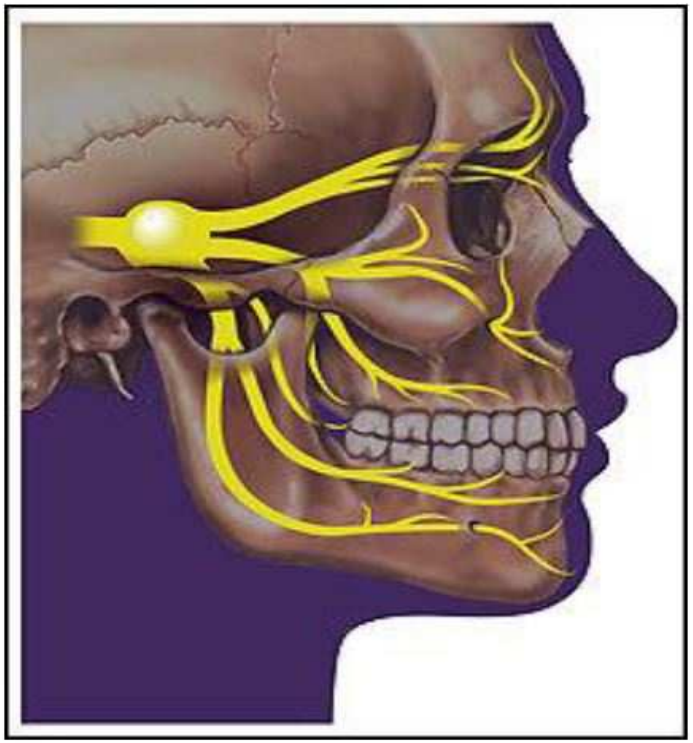
- We sense taste through our taste buds that are located on:
- - Roof of the mouth
- - Tongue
- - Cavity behind the mouth and nose
- - And elsewhere….

Factors affecting taste

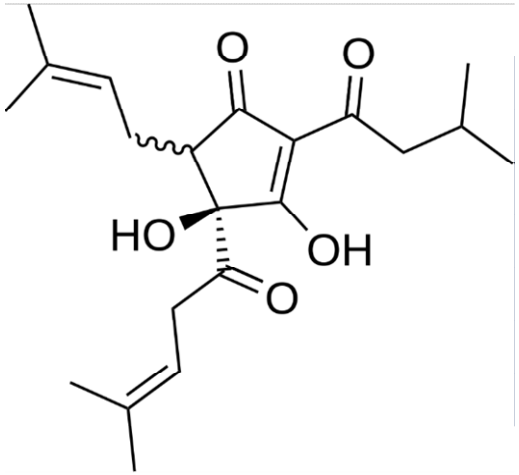
- Health
- Medication
- Personal Hygiene (mouthwash)
- Smoking
- Age
- Sex
- Genetic variations

Sensing of texture/pain

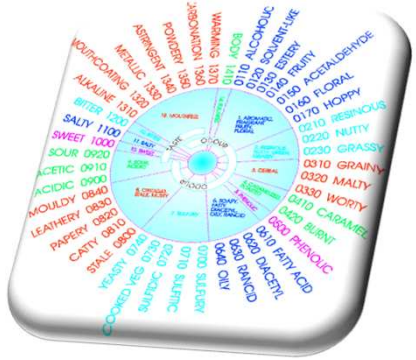
- Known as the trigeminal sense
- Neither taste nor aroma
- Attributes detected:
  - metallic
  - astringency
  - carbonation
  - mouthfeel
  - chalkiness



Beer flavour



Beer flavour



Ethyl hexanoate

Ethyl acetate

Smoky

Caprylic

Isoamyl acetate

Diacetyl

'Yeast bite'

Earthy

Butyric

Isovaleric

'Trubby'

Worty

Acetaldehyde

Grapefruit

Leathery

Sweet

Bromophenol

Burnt rubber

Astringent

Methional

Woody

H_2S

'Cooked'

Floral

Mouldy

Acetic

Ethyl butyrate

Metallic

Bitter

Caramel

Grainy

Phenolic (4-VG)

Rotten vegetable

Citrus

Solvent alcoholic

Mercaptan

Musty

Chlorophenol

Honey

Indole

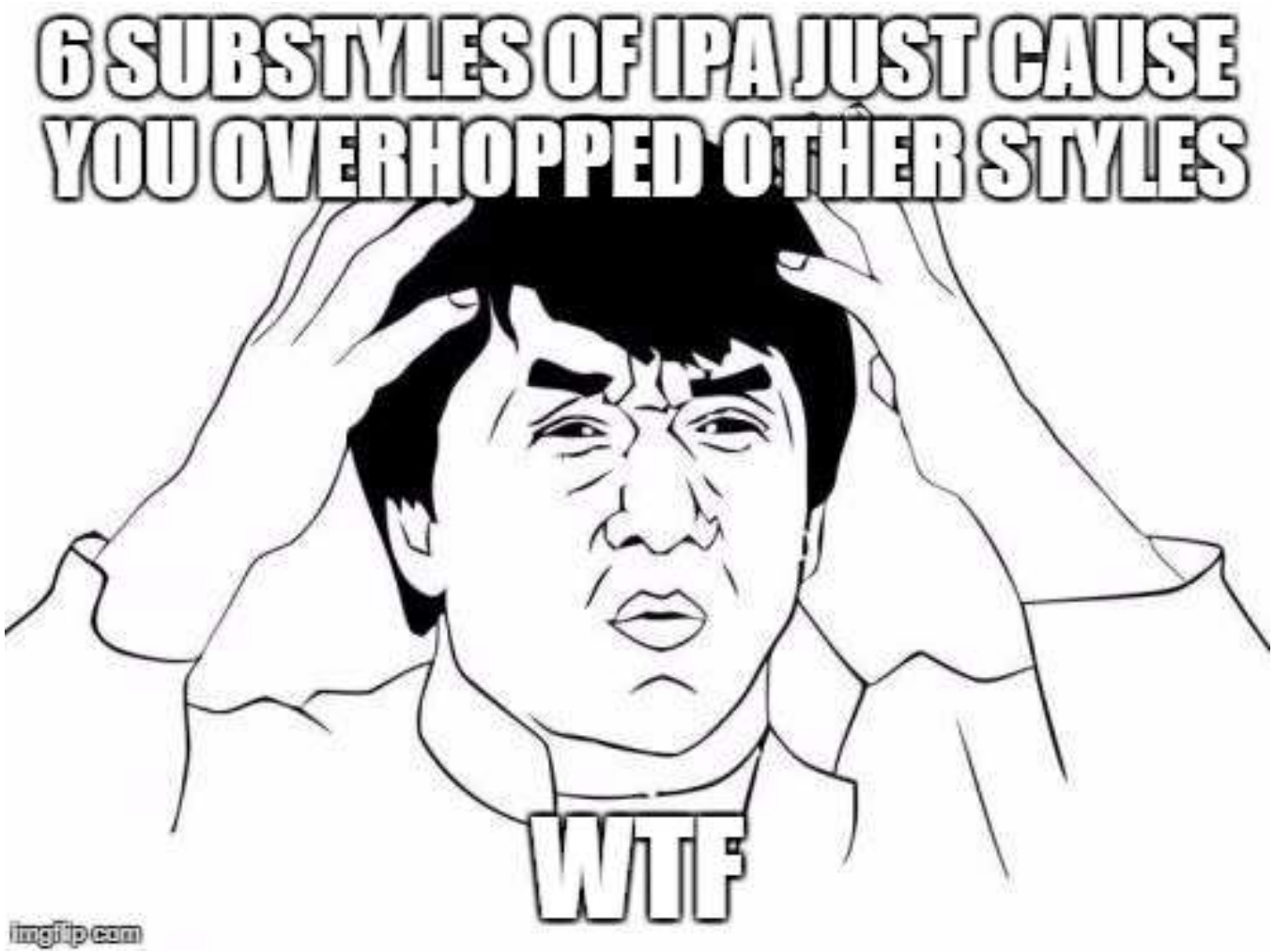
DMS

beer flavour

Beer styles

- A great diversity of beer styles is available in many markets today
- The ability of consumers to access this diversity of styles increases daily
- Examples of beer styles include:
  - ✓ Pale Lager | Pilsner | Bock | Dopplebock
  - ✓ Pale Ale | India Pale Ale | Red Ale | Barley Wine
  - ✓ Hefeweizen | Witbier | Saison | Gueuze
  - ✓ Rauchbier | Porter | Stout | Framboise

Beer Styles


6 SUBSTYLES OF IPA JUST CAUSE
YOU OVERHOPPED OTHER STYLES
WTF
imgflip.com

Lager beer flavour

- Most lager beers have between 15 and 25 positive flavour characters
- Typically 7 – 10 main flavour characters
- Examples include:
  - ✓ Malty-biscuity | Grainy | DMS
  - ✓ Bitter | Spicy hop | Floral hop
  - ✓ Isoamyl acetate | Ethyl acetate

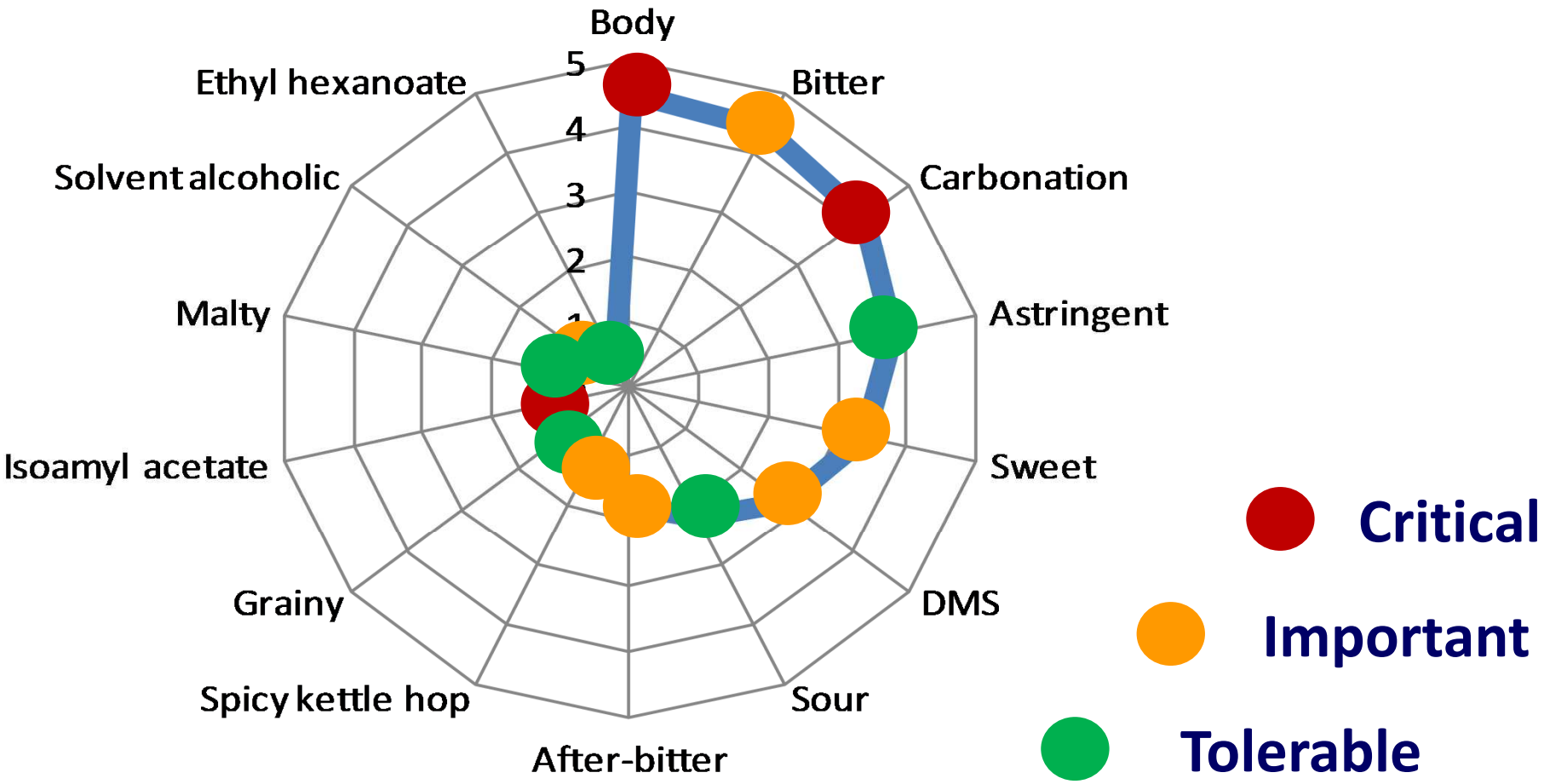
Craft/Ale beer flavour

- Most craft ales have between 30 and 40 positive flavour characters
- Typically 15 – 20 main flavour characters
  - ✓ Burnt sugar | Caramel | Chocolate
  - ✓ Bitter | Citrus hop | Damascenone
  - ✓ Isoamyl acetate | Ethyl acetate | 4-Vinyl guaiacol

What constitutes a beer flavour specification?

- List all flavours that must be present in the beer
- Define their target intensity
- Define the significance and consumer impact of non-conformances in intensity
- List all potential defect flavours
- Define the significance and consumer impact of non-conformances in intensity

Example flavour specification

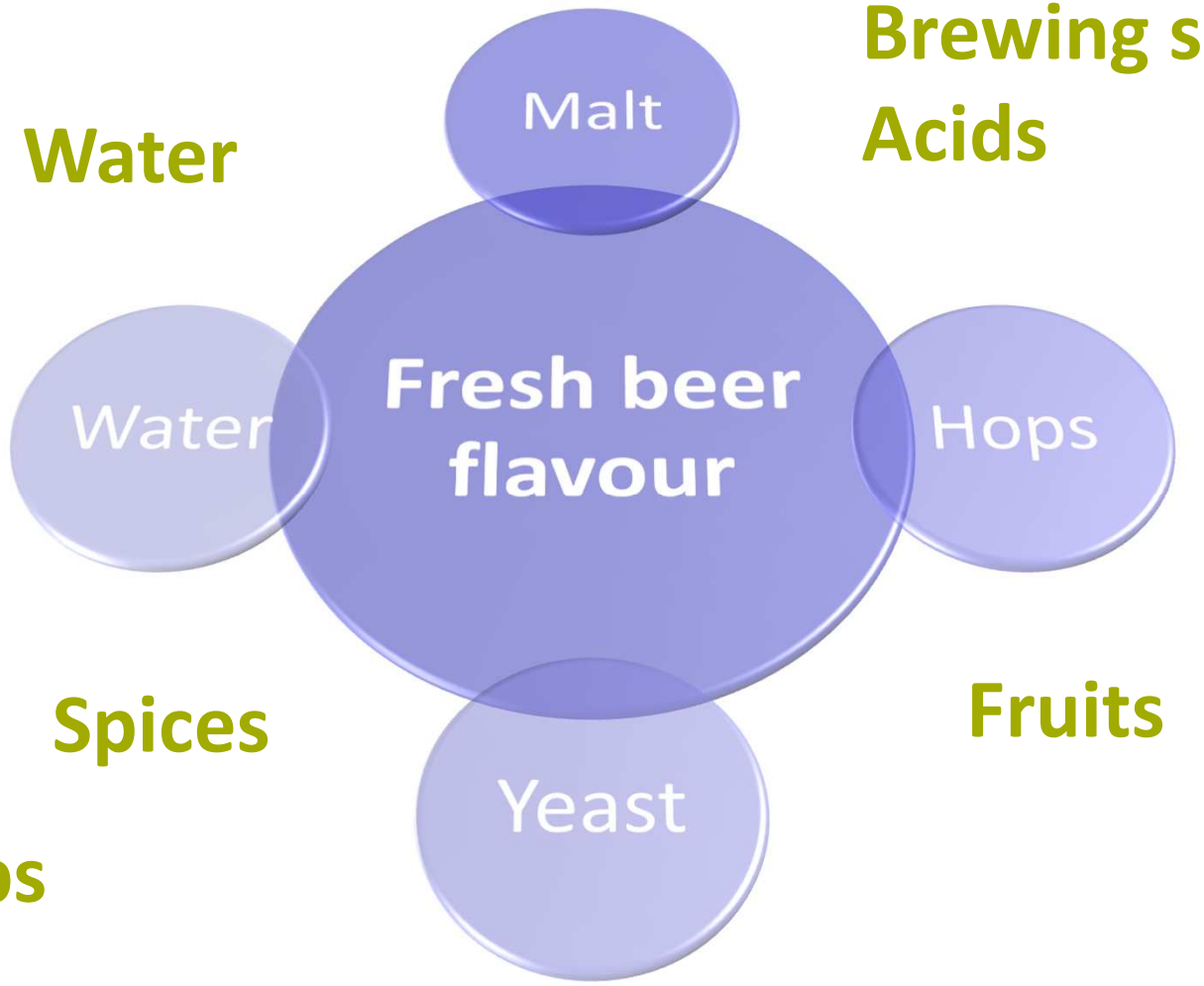


specification

Managing beer flavour

- There's a time and a place for every flavour – with exceptions
- Positive and negative attributes are equally important. Too much of a good thing isn't good.
- What makes my beer different?
- What are my specifications and allowable variances?

Origins of fresh beer flavour



Adjuncts
Brewing salts
Acids

Water

Spices

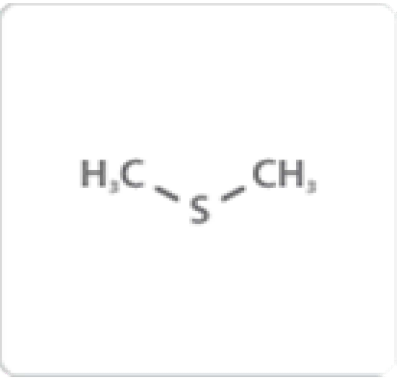
Herbs

Fruits

Flavours from malt

Chemical	flavour	Origins
2-Acetyl pyridine	Malty-biscuity	Formed during kilning
Isobutyraldehyde	Grainy	Formed during wort boiling
Isovaleraldehyde	Grainy	Formed during wort boiling
Methional	Worty	Formed during wort boiling
Dimethyl sulphide	DMS	Precursor in malt
Various sugars	Sweet taste	Derived from barley starch
Furaneol	Burnt sugar	Formed during kilning and fermentation
Furfuryl thiol	Coffee	Formed during kilning
Guaiacol	Smoky	Introduced during drying or kilning
2,3,5-Trimethylpyrazine	Chocolate	Formed during roasting
Vanillin	Vanilla	Formed during kilning

DMS



- Positive flavour in some types of beer - off-flavour in other beer types
- Derived from precursors in malt
- Dimethyl sulphide from *S*-methyl methionine
- Concentration depends on malt specifications, brewhouse procedures and fermentation practices
- Can also be produced by contaminant microorganisms
- flavour threshold 0.03 – 0.05 mg/l

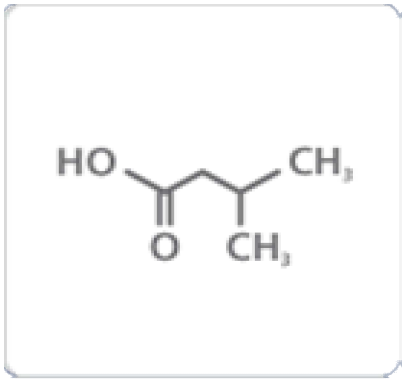
flavours from hops

Chemical	flavour	Origins
Hop bitter acids	Bitter	Developed from precursors in hops
Isovaleric acid	Isovaleric, cheesy	Forms in hops during storage
β-Damascenone	Damascenone	Developed from precursor in hops
Geraniol	Floral, rose-like	Extracted from hops
Linalyl acetate	Fragrant, bergamot	Developed from precursor in hops
4-Mercapto-4-methylpentanone	Blackcurrant, catty	Developed from precursor in hops
α-Humulene	Spicy	Extracted from hops
Myrcene	Raw hop	Extracted from hops
Ethyl-2-methylbutyrate	Apple, strawberry	Developed from precursor in hops
Mercaptohexyl acetate	Passionfruit, lychee	Developed from precursor in hops

Bitter

- Positive taste in beer
- Contributed by hops or hop extracts
- Hop alpha acids converted to iso-alpha-acids in prior to delivery to the brewery or in the wort kettle
- Six different iso-alpha-acids, together with a wide range of related compounds contribute to this characteristic
- Laboratory measurements expressed as International Bitterness Units (IBU)
- flavour threshold 3 - 5 mg/l

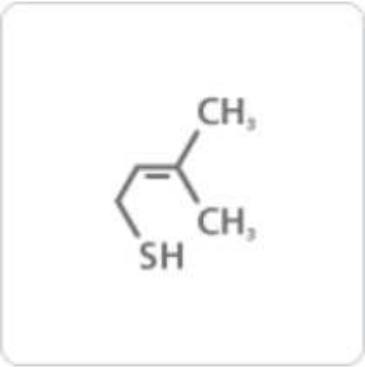
Isovaleric



- Off-flavour in lager beer – positive character in some types of ale
- Contributed by hops or hop extracts
- Concentration depends on recipe, hop product and variety, and age of hops or hop product
- Can also be produced by contaminant wild yeasts
- flavour intensity increases as beer pH value is reduced
- flavour threshold 3 mg/l

Lightstruck

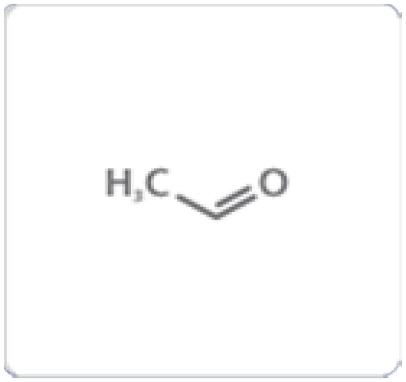
- 3-methyl-2-butene-1-thiol
- Formed by exposure to light
- ‘Sunburn for beer’
- Initiates a reactions involving bitter acids and sulphur compounds
- flavour threshold 4-30 ng/l



flavours from yeast

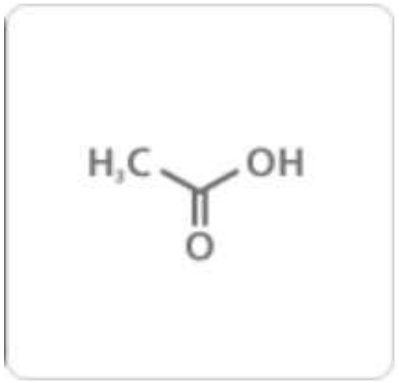
Chemical	flavour	Origins
Isoamyl acetate	Banana	Produced by brewer's yeast
Ethyl acetate	Solvent, nail varnish	Produced by brewer's yeast
Ethyl hexanoate	Apple	Produced by brewer's yeast
Diacetyl	Butter-like	Developed from precursor produced by brewer's yeast
Acetaldehyde	Green apple	Produced by brewer's yeast
Acetic acid	Vinegar	Produced by brewer's yeast
Hydrogen sulphide	Boiled egg	Produced by brewer's yeast
Methanethiol	Mercaptan	Produced by brewer's yeast
4-Vinyl guaiacol	Clove-like	Produced by speciality yeast
4-Ethyl phenol	Horse, blue cheese	Produced by speciality yeast

Acetaldehyde



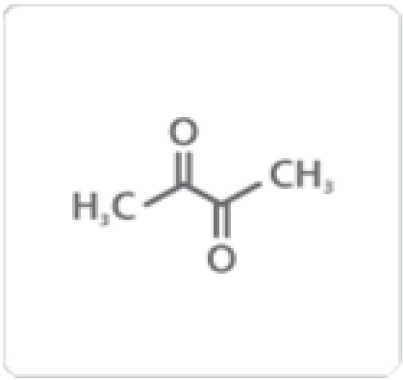
- Positive flavour in some beers - off-flavour in others
- Produced by yeast during fermentation
- Critically affected by wort [Zn] and yeast health
- Can also be produced by contaminant bacteria and as a result of beer oxidation
- flavour threshold 5 mg/l

Acetic



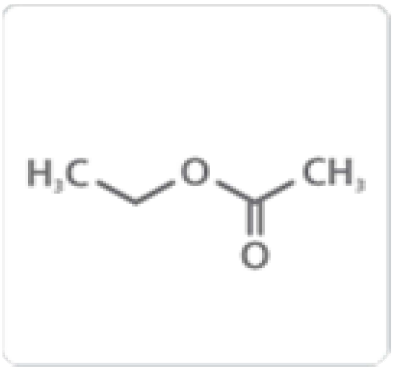
- Positive flavour in some beers – off-flavour in most beer types
- Produced by all yeast
- Concentration depends on yeast strain and growth
- Can also be produced by contaminant bacteria
- flavour threshold 90 mg/l

Diacetyl



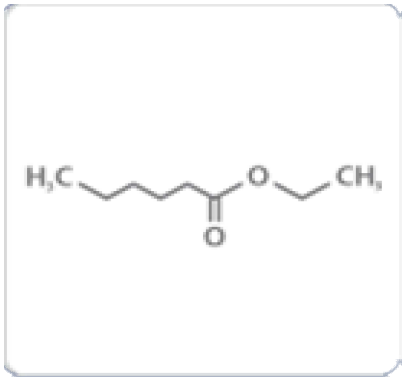
- Positive flavour in some beers - off flavour in other beer types
- Precursor is produced by yeast during fermentation
- Influenced by wort amino acid concentrations and beer pH value
- Can also be produced by contaminant bacteria – *Lactobacillus* and *Pediococcus* spp
- flavour threshold 0.01 mg/l

Ethyl acetate



- Positive flavour in beer – off-flavour at high concentration
- Produced by yeast during fermentation
- Concentration depends on yeast strain, wort quality and fermentation conditions
- Especially dependent on fermentation temperature - can also be produced by contaminant wild yeasts
- flavour threshold 10 mg/l

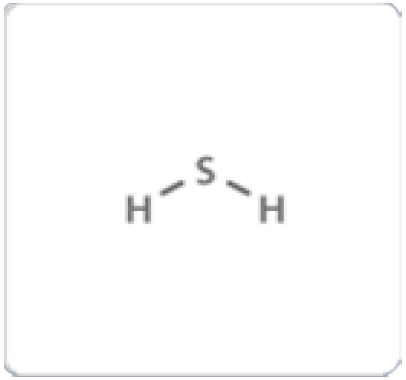
Ethyl hexanoate



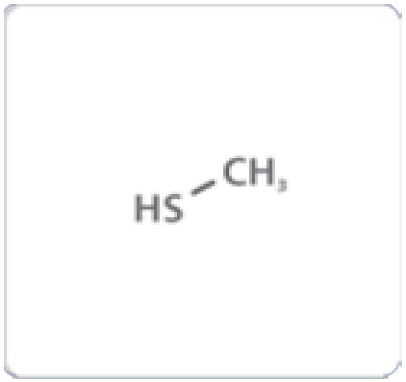
- Positive flavour in beer - off-flavour at high concentration
- Produced by yeast during fermentation
- Concentration depends on yeast strain and fermentation conditions
- Especially dependent on yeast health and yeast generation number
- Used to gauge yeast health

H_2S

- Positive flavour in beer - off-flavour at high concentrations
- Produced by yeast during fermentation and maturation
- Concentration depends on yeast strain, yeast health and fermentation conditions
- Can also be produced by contaminant microorganisms
- Flavour threshold 0.004 mg/l

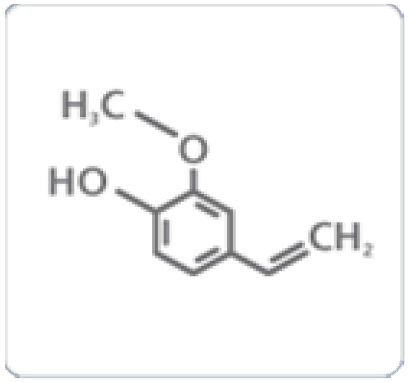


Mercaptan



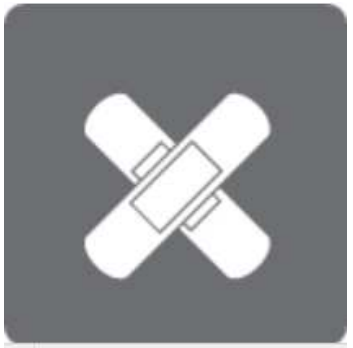
- Off-flavour in lager beer – positive flavour in craft ale
- Produced by yeast during maturation or contributed to beer by dry hopping
- Thiols such as methanethiol
- Concentration depends on yeast strain, yeast health, fermentation conditions and hopping regime
- Can also be produced by contaminant microorganisms
- Flavour threshold 0.0015 mg/l

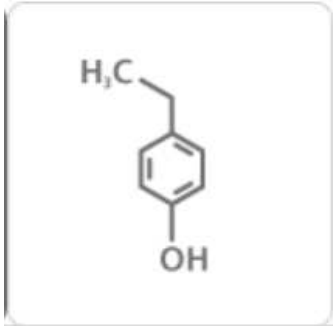
Phenolic - 4-vinyl guaiacol



- Positive character in some beer styles - off-flavour in lager beer
- Produced by *Saccharomyces* and *Brettanomyces* yeasts
- These yeasts posses the PAD gene which codes for production of phenyl acrylate decarboxylase
- Low levels can be produced from malt-derived precursors in the brewhouse
- flavour threshold 0.3 mg/l

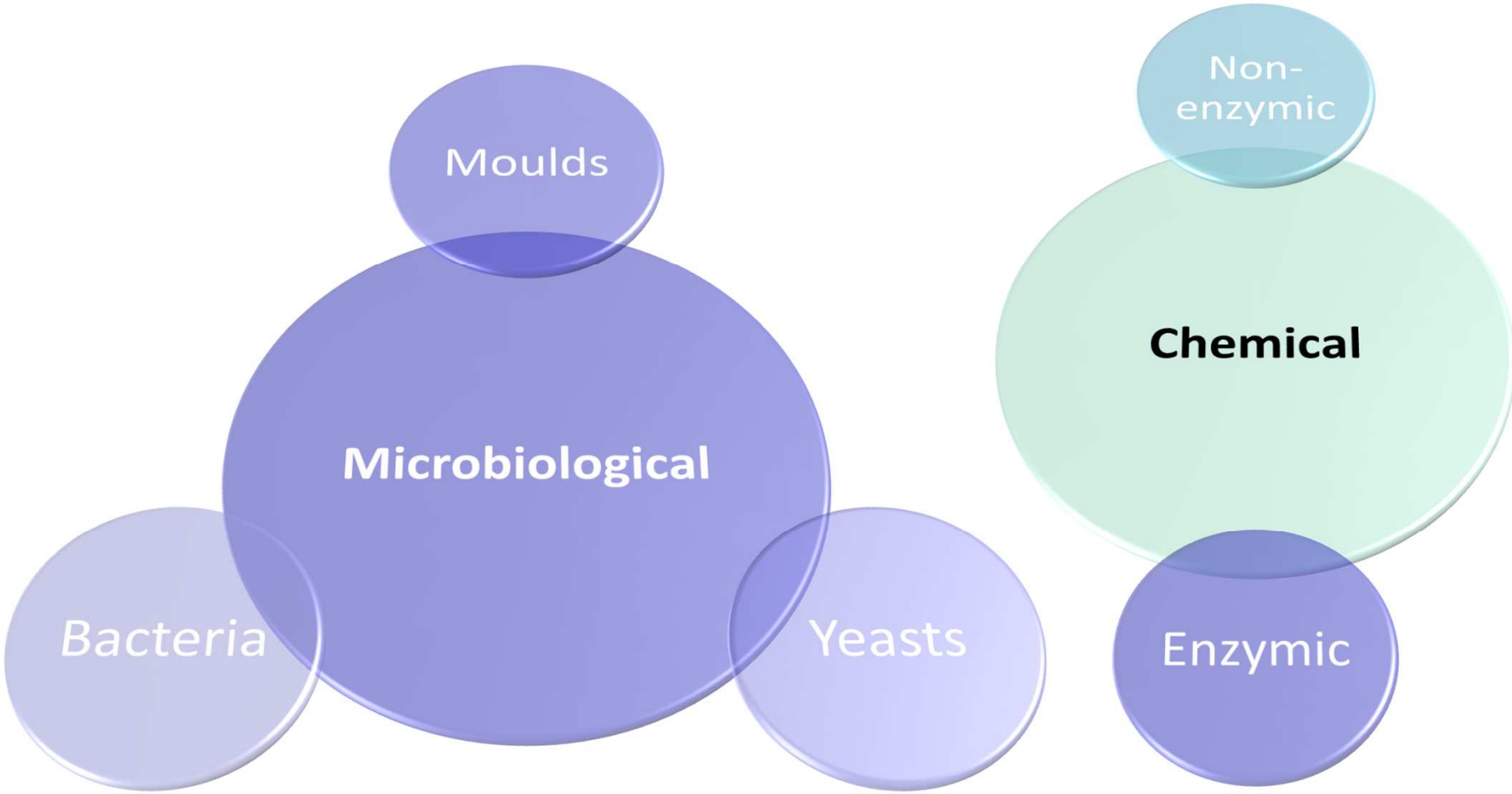
Phenolic – 4-ethyl phenol



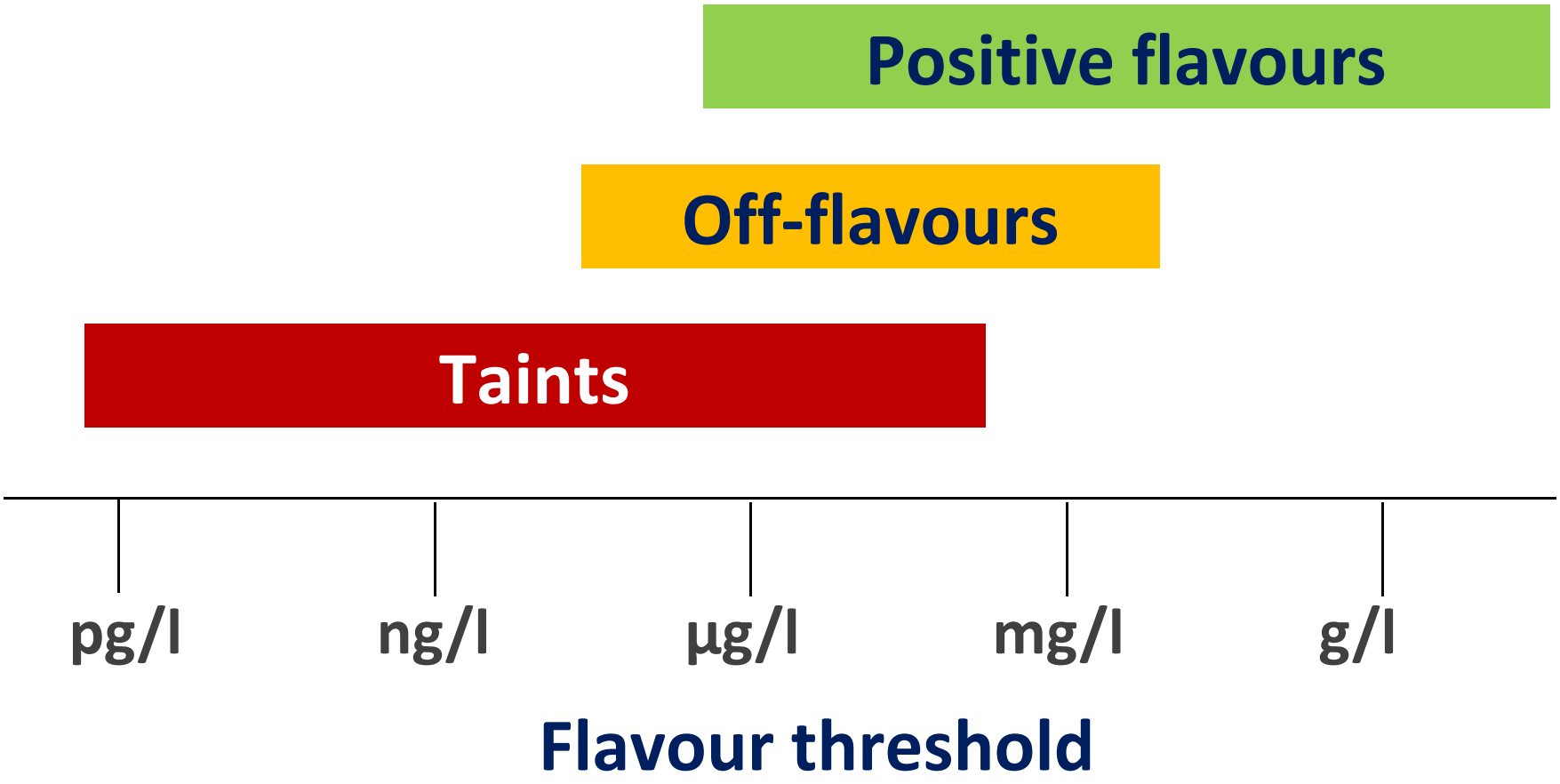


- Positive character in some beer styles - off-flavour in most styles
- Produced by *Brettanomyces* yeasts
- Occasionally produced by LAB
- Indicative of contamination in most beer styles
- flavour threshold 300 µg/l

Origins of off-flavours



Flavour impact

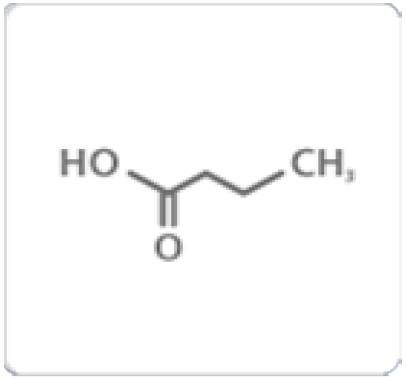


Some compounds can cause product recalls when present at <10 ng/l in the final product

flavour defects

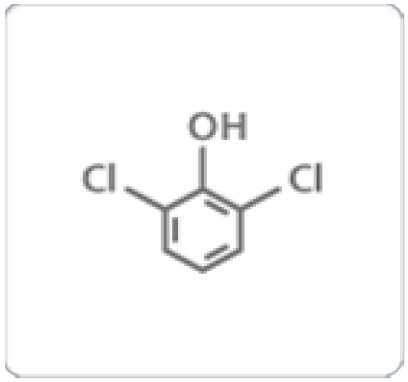
Chemical	flavour	Origins
Sodium hydroxide	Caustic	Accidental contamination
Butyric acid	Baby vomit, mango	Produced by brewhouse bacteria
2-Bromophenol	Inky, museum	Taint
2,6-Dichlorophenol	Medicinal	Taint
2,4,6-Trichloroanisole	Musty	Produced by moulds
Ferrous ion	Metallic	Corrosion of plant
Guaiacol	Smoky	Exposure of raw materials to smoke
1-Napthol	Mothballs	Pesticide residues
4-Ethyl phenol	Band aid	Produced by speciality yeast

Butyric



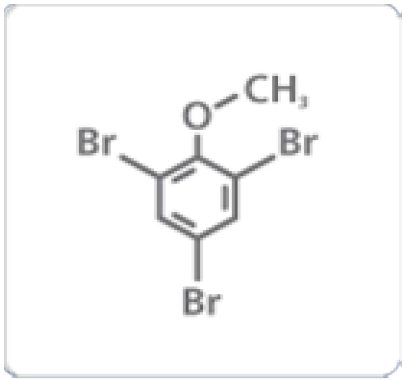
- Off-flavour in beer
- Produced by bacteria in mashing or in sugar syrup
- Flavour not obvious in wort but appears after fermentation
- Can also be produced by contaminant bacteria – *Bacillus* and *Clostridium* spp
- Flavour intensity increases as beer pH value is reduced
- Flavour threshold 3 mg/l

Chlorophenol



- Taint in beer
- Contributed to beer through contaminated water and water treatment media, and reaction with cleaning agents
- Originates through reactions between chlorine and phenolic compounds
- Flavour threshold 300 ng/l

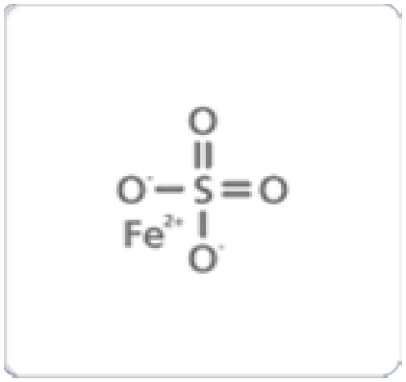
Musty



- Taint in beer
- Contributed to beer through contaminated raw materials, filter aids, processing aids or packaging materials
- 2,4,6-Trichloroanisole
- Originates through conversion of environmental chlorophenols to chloroanisoles by moulds
- ‘Cork taint’ in wine
- flavour threshold 10 – 500 ng/l

Metallic

- Taint in beer
- Contributed to beer through contamination with metal ions, either from raw materials or corrosion of brewery equipment
- Iron, copper and manganese can all give metallic flavours
- Detected by ‘trigeminal’ sense and by odour
- flavour thresholds in the region of 0.05 – 0.3 mg/l



Different flavours form at different times

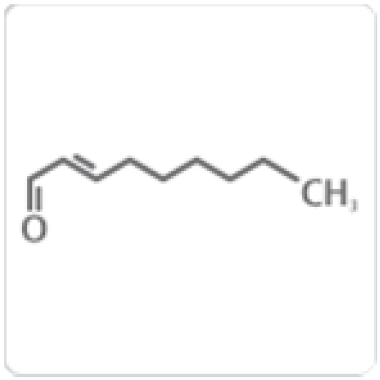
Age of beer	Compounds formed	flavour impact
< 4 weeks	*trans,trans*-2,4-Heptadienal, methional	Rancid oil, mashed potato
4 – 12 weeks	*trans*-2-Nonenal, 3-methylbutanal, acetaldehyde	Papery, grainy, acetaldehyde
6 – 18 weeks	β-Damascenone, dimethyl trisulphide	Black tea, onion
8 – 20 weeks	Various Maillard reaction products	Caramel, sweet
10 – 50 weeks	Various quinones, oxidized polyphenols, 2-furfuryl ethyl ether	Leathery, astringent, 'old beer'
>20 weeks	Various acetals	Sherry, winey, 'oxidized'

Sulphur dioxide is lost a constant rate during storage impacting perception of other beer flavours

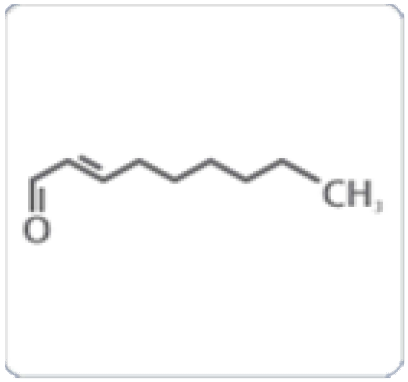
Compounds found in stale beer

- Unsaturated carbonyl compounds play a big part in development of stale flavours in lager beer
- These have:
  - ✓ Very low flavour thresholds
  - ✓ Unpleasant aromas and flavours

For example:
***trans*-2-Nonenal**



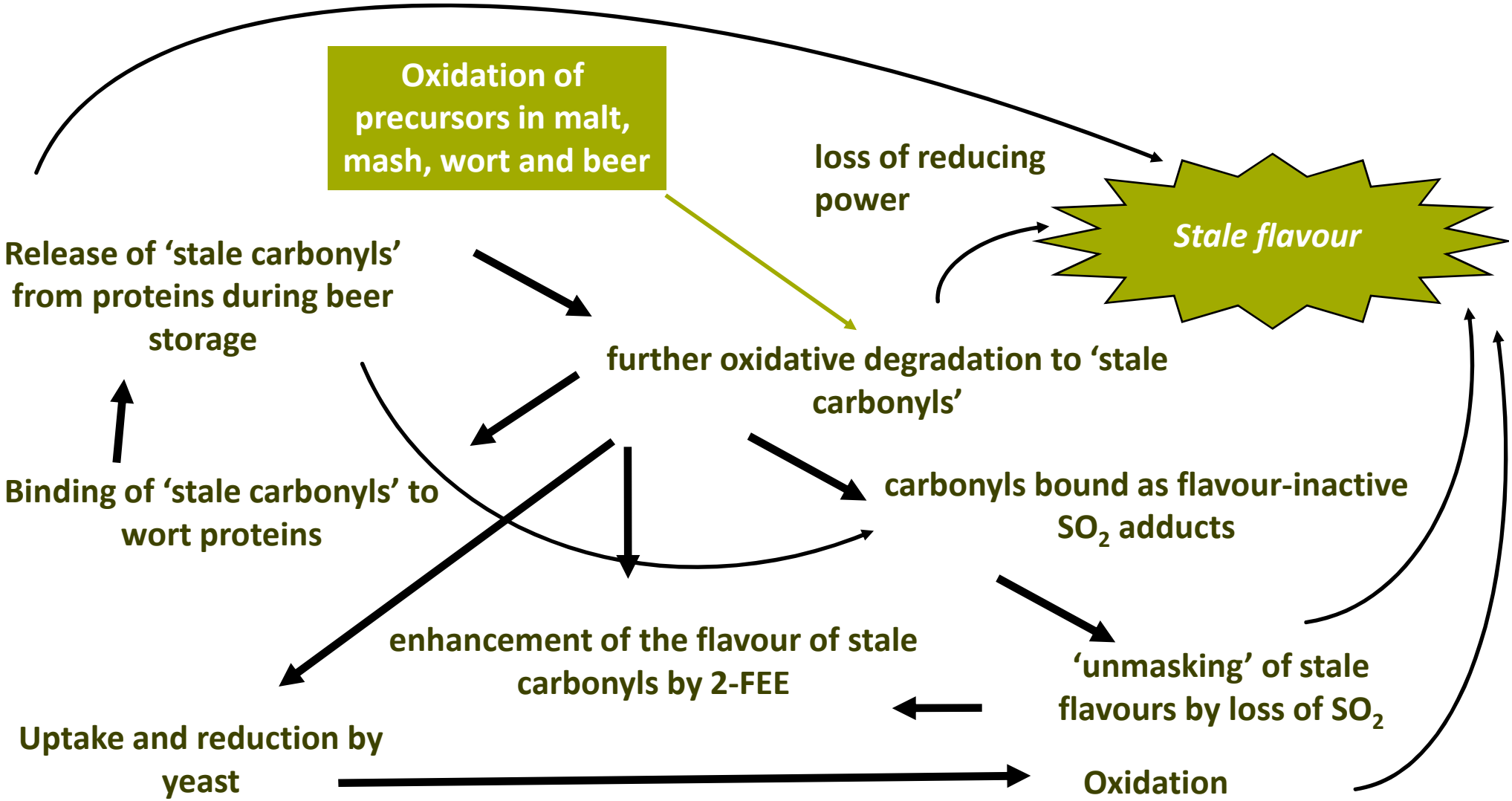
Papery



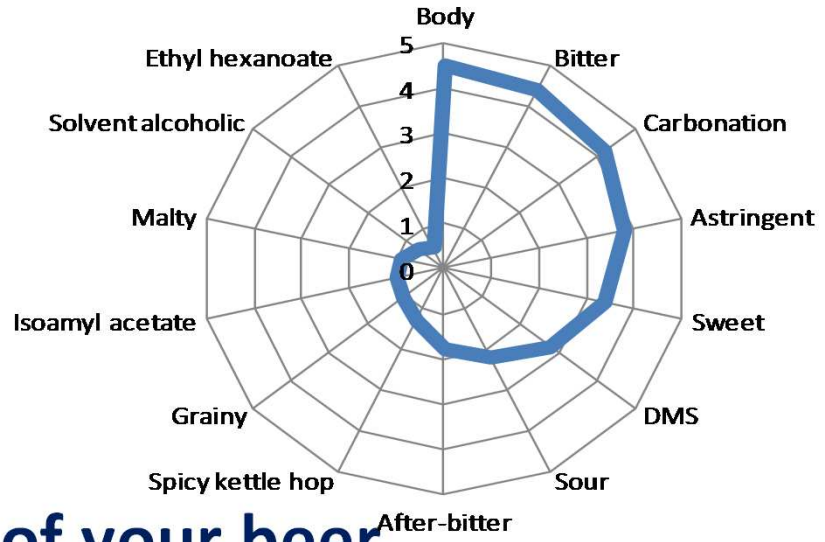
- *trans*-2-Nonenal
- Produced by breakdown of malt-derived lipids - binds to malt proteins during wort boiling
- Released from protein during storage of packaged beer
- Beer pH controls rate of release – yeast controls the beer pH value
- flavour supressed by sulphur dioxide
- flavour threshold *ca* 50 ng/l

Current views on flavour stability

- One slice of a complicated situation!



So why do sensory training?



- Cost effective
- Objective results
- Build a sensory profile of your beer beers
- Better judges

Management of taste panels

- Recruitment and selection of assessors
- Training and coaching of assessors
- Management and administration of taste sessions
- Analysis and reporting of test results
- Managing taster welfare

acknowledgements

Thanks to Amaey J. Mundkur and Dr. Bill Simpson

Questions?

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