An overview of beer flavour and sensory training

Cara Technology, UK

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11 August 2016

Overview

- Beer flavour overview
- Flavours from malt
- Flavours from hops
- Flavours from yeast
- Flavour defects
  - Off flavours and taints
  - Aged beer flavours

Beer flavour overview

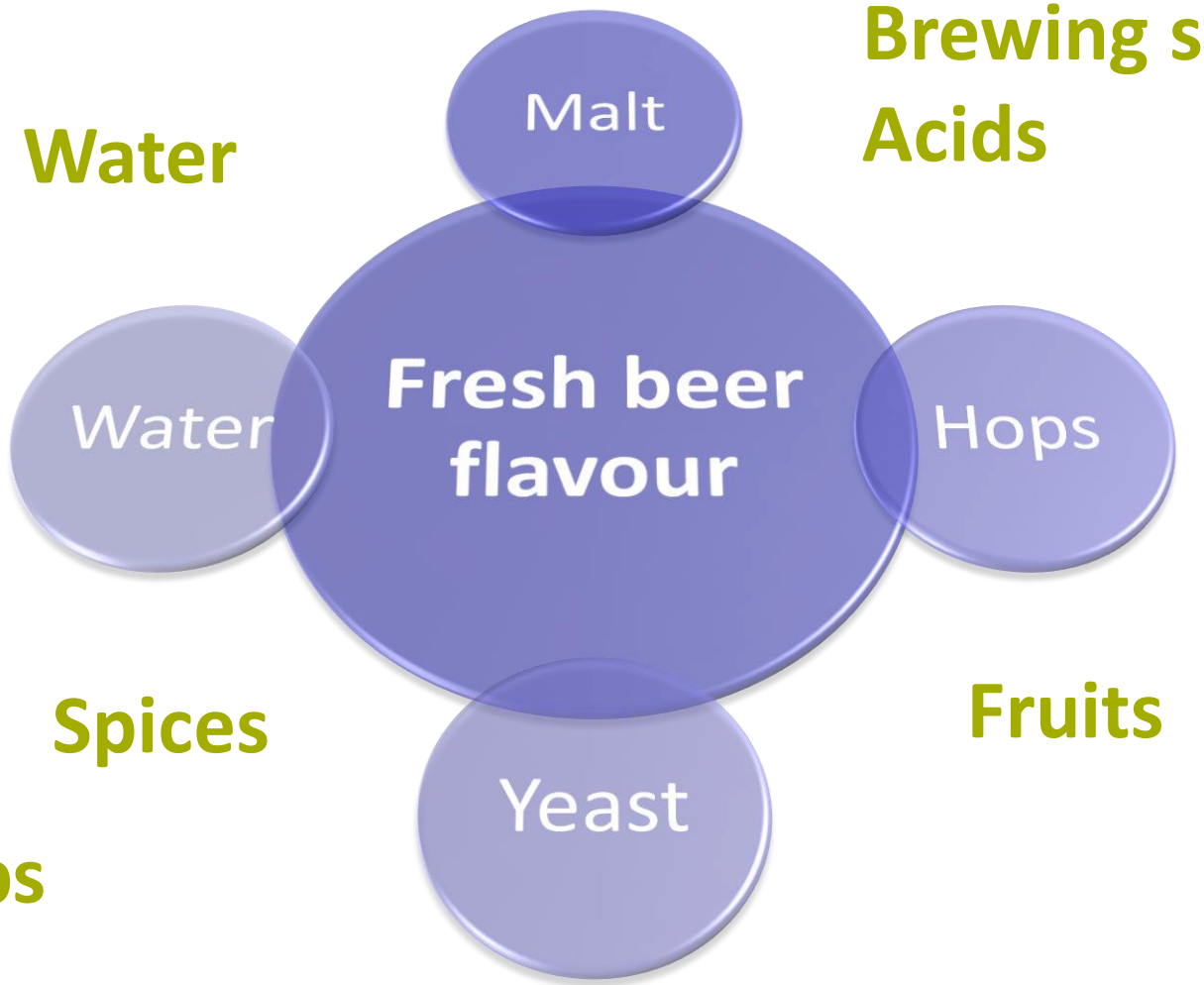
Beer styles

- 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

Craft beer flavour

- Most craft ales have between 30 and 40 positive flavour characters
- Originate from raw materials and process conditions
- Typically 15 – 20 main flavour characters
  - ✓ Burnt sugar | Caramel | Chocolate
  - ✓ Bitter | Citrus hop | Floral Hop
  - ✓ Isoamyl acetate | Ethyl acetate | 4-Vinyl guaiacol
- Potentially 50 – 60 off-flavours and taints from microbial contamination, tainted processing aids or packaging materials

Origins of fresh beer flavour



Adjuncts
Brewing salts
Acids

Water

Spices

Herbs

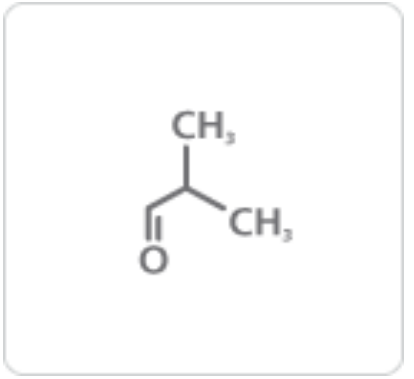
Fruits

Flavours derived from malt

Flavours from malt

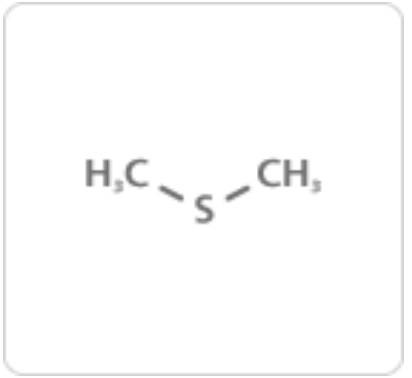
Chemical	Flavour	Origins
2-Acetyl pyridine	Malty-biscuity	Formed during kilning
Isobutyraldehyde	Grainy	Formed during wort boiling
Isovaleraldehyde	Grainy	Formed during wort boiling
Methional	Worty	Formed during wort boiling
Methyl sulphide	DMS	Precursor in malt
Various sugars	Sweet taste	Derived from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

Grainy



- Positive flavour in some types of beer - off-flavour in other beer types
- Derived from precursors in malt
- Concentration depends on malt specifications, brewhouse procedures and fermentation practices
- Isobutyraldehyde and other aldehydes such as isovaleraldehyde also contribute to the grainy characteristics of beer
- Flavour thresholds 0.01 – 0.025 mg/l

DMS



- Positive flavour in some types of beer - off-flavour in other beer types
- Derived from precursors in malt
- Dimethyl sulphide from *S*-methyl methonine
- 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

Sweet

- Positive flavour in beer
- Taste characteristic
- Contributed to beer by sugars such as glucose, maltose and maltotriose
- Derived from precursors in malt
- Concentration depends on brewhouse procedures and fermentation practices
- Flavour threshold of sugars is in the range of 1 – 5 g/l
- Interaction with other taste characteristics in beer

Flavours derived from hops

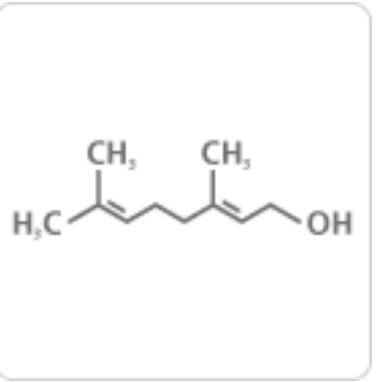
Flavours from hops

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

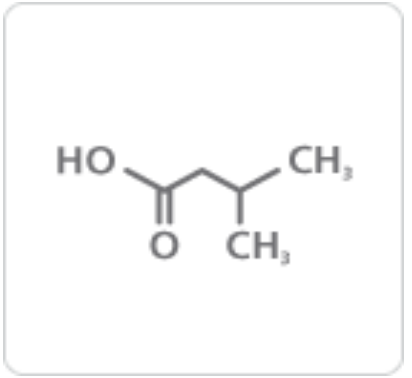
- Positive taste in beer
- Contributed by hops or hop extracts
- Hop alpha acids in the wort kettle
- Six different iso-alpha-acids, together with a wide range of related compounds contribute to this characteristic
- Laboratory measurements expressed as International Bitterness Units (IBU)
- Flavour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

Floral



- Positive flavour in beer
- Contributed by hops or hop extracts
- Geraniol from hops imparts a floral, rose-like flavour to beer
- During fermentation yeast can convert some of the geraniol to geranyl acetate – this depends on yeast strain and fermentation conditions
- Flavour threshold 0.4 mg/l

Isovaleric



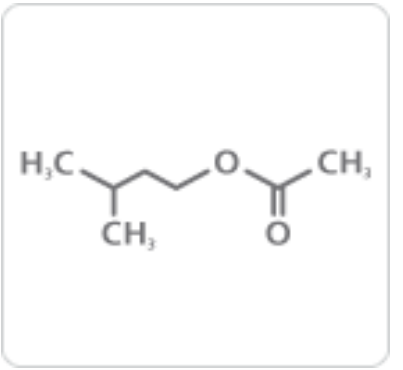
- **Off-flavour** in lager beer – positive character in some types of ale
- Contributed by hops or hop extracts
- Concentration depends on recipe, hop product and variety, **and age of hops or hop product**
- Flavour intensity increases as beer pH value is reduced
- Flavour threshold 3 mg/l

Flavours derived from yeast

Flavours from yeast

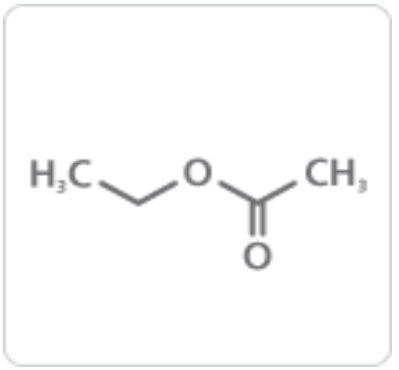
Chemical	Flavour	Origins
Isoamyl acetate	Banana	Produced by brewer's yeast
Ethyl acetate	Solvent, nail varnish	Produced by brewer's yeast
Ethyl hexanoate	Apple	Produced by brewer's yeast
Diacetyl	Butter-like	Developed from precursor produced by brewer's yeast
Acetaldehyde	Green apple	Produced by brewer's 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

Isoamyl 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 wort clarity, dissolved oxygen and fermenter depth
- Flavour threshold 1.1 mg/l

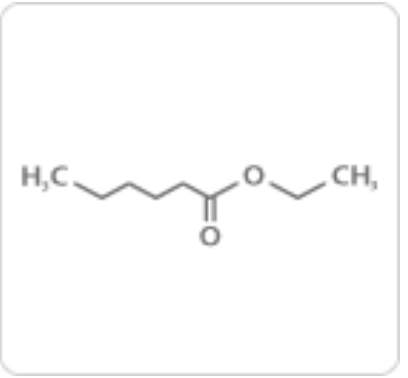
Ethyl acetate



- 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

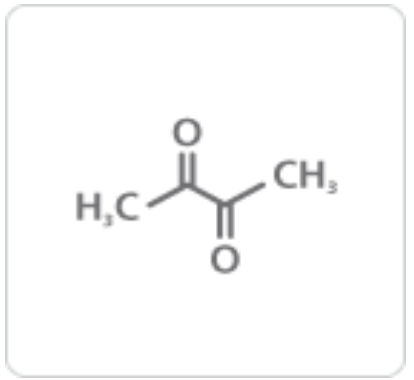
- Positive flavour in beer
- Produced by yeast during fermentation
- Concentration depends on yeast strain and fermentation conditions
- Especially dependent on yeast health and yeast generation number
- Flavour threshold 0.2 mg/l



Ethyl Butyrate

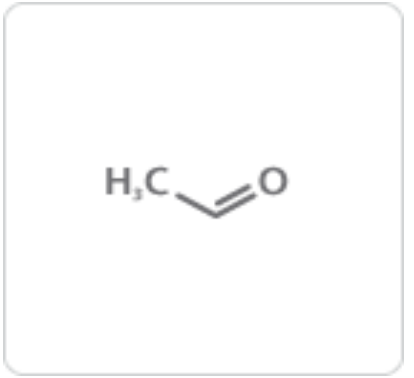
- Contributes a pleasant ‘tropic fruit ester’, pineapple-like note to ales and lagers.
- Associated with the use of particular yeast strains and hop varieties (usually ‘Noble’ hop varieties).
- One of a number of hop derived esters
- Flavour threshold 0.3 mg/l

Diacetyl



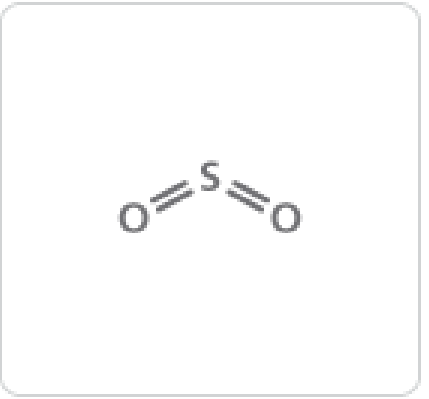
- Positive flavour in some beers - off flavour in other beer types
- Precursor is produced by yeast during fermentation
- Warm rest after fermentation ensures removal
- Influenced by wort amino acid concentrations and beer pH value
- Can also be produced by contaminant bacteria – *Lactobacillus* and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

Acetaldehyde



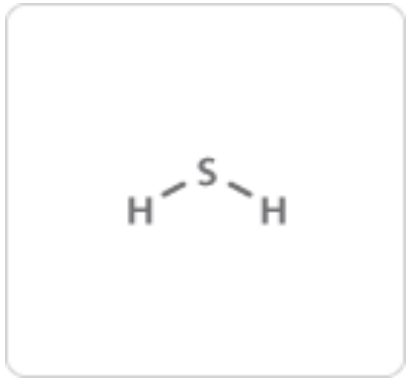
- Positive flavour in some beers - off-flavour in others
- Produced by yeast during fermentation
- Critically affected by wort [Zn] and yeast health
- Can also be produced by contaminant bacteria and as a result of beer oxidation
- Flavour threshold 5 mg/l

Sulphur dioxide



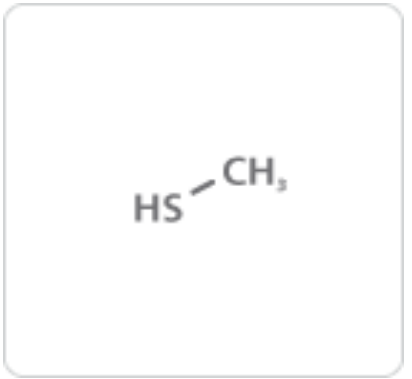
- Positive flavour in lager beer
- Contributes to ‘freshness’
- Provides protection against oxidation of packaged beer
- Produced by yeast during fermentation
- Concentration depends on yeast strain, yeast health and fermentation conditions
- Flavour threshold *ca* 5 mg/l

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

Flavours defects

defects

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
2,3,6-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

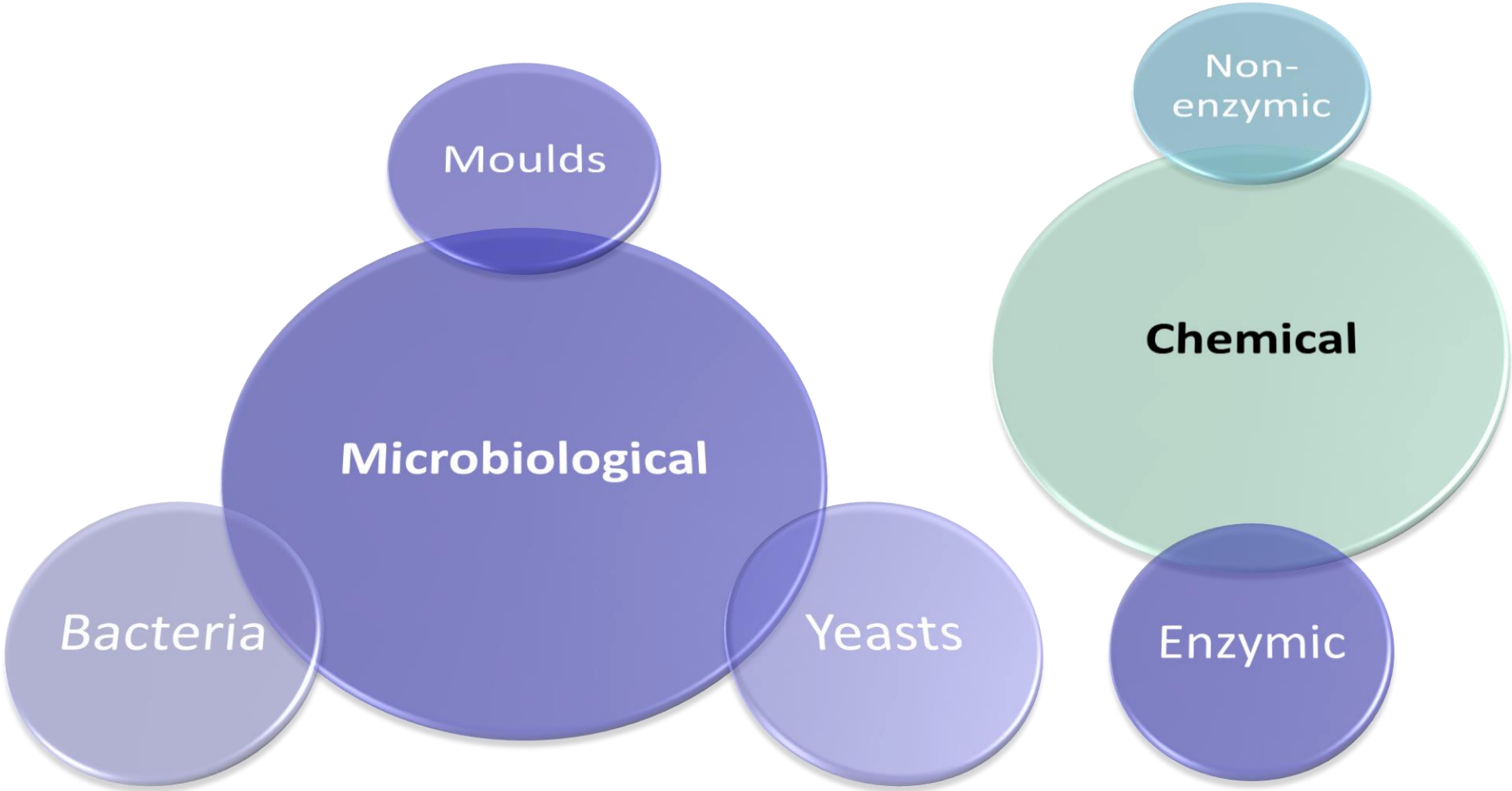
Definitions

Off-flavour	Flavour generated within the product by chemical or biological reactions
Taint	Flavour contributed to the product from an external source *via* a ‘vector’

Consumer impact

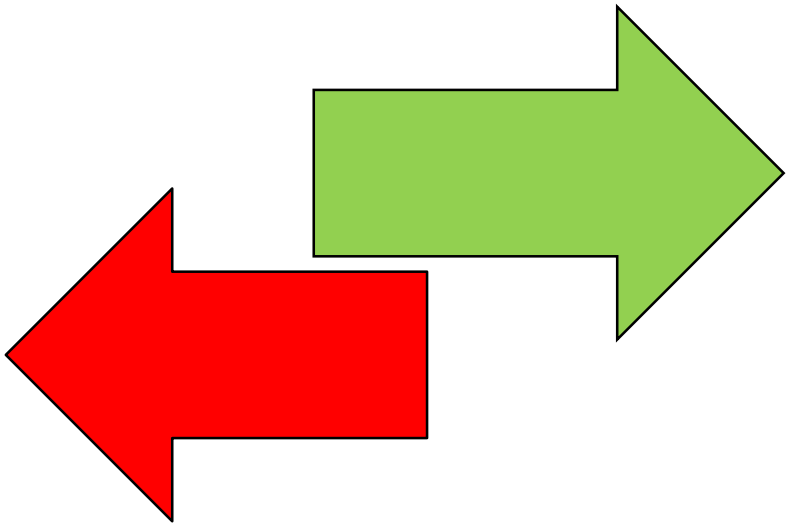
1. “It’s different”
2. “It’s not quite right”
3. “I’m not sure I like this”
4. “There’s something wrong here”
5. “I’m worried”
6. “Help!”

Origins of off-flavours



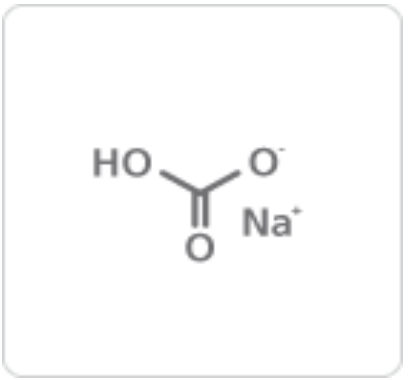
Taint ‘vectors’

- Ingredients
- Water
  - Product water
  - Process water
- Gases
  - Environmental air
  - Process gases
- Packaging materials
- Environment



taints

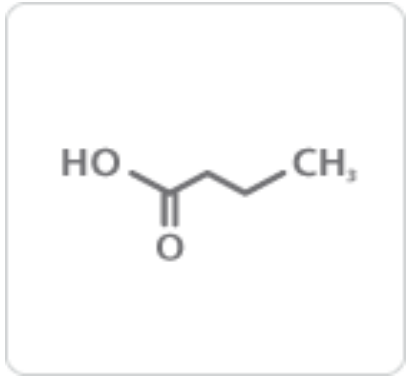
Alkaline



- Taint in beer
- Contributed to beer through contamination with caustic cleaning agents (such as NaOH)
- Beer sodium content and colour are also increased
- Only ‘trace’ concentrations of cleaning agents are needed to spoil beer flavour

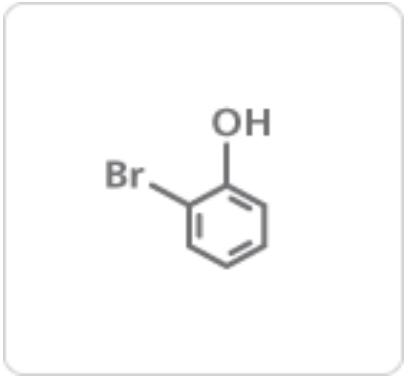
Butyric

- 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

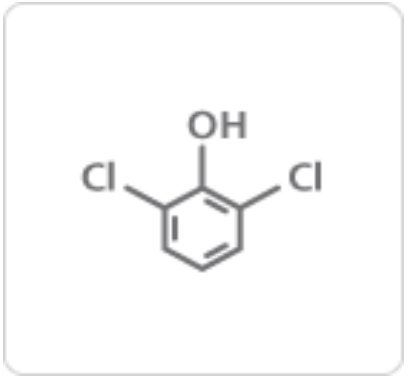


Bromophenol

- Taint in beer
- Contributed to beer through contaminated packaging materials
- Bromophenols are common environmental contaminants as they are used as fire retardents
- Especially associated with recycled wood and cardboard
- Flavour threshold 100 ng/l

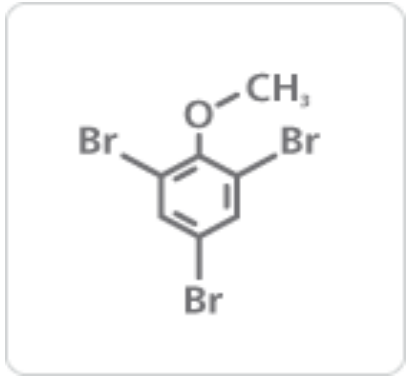


Chlorophenol



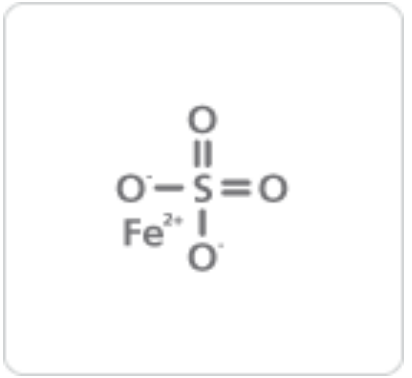
- Taint in beer
- Contributed to beer through contaminated water and water treatment media, and reaction with cleaning agents
- Originates through reactions between chlorine and phenolic compounds
- Flavour threshold 300 ng/l

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

Why is beer flavour unstable?

Where do flavour life problems come from?

- Design of the product
- Poor quality raw materials
- Production in the brewery
- Handling in distribution
- Handling in the market

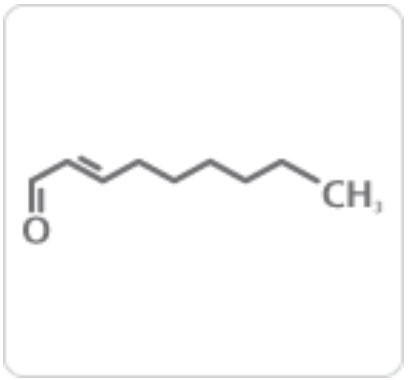
origin of problems

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

Papery

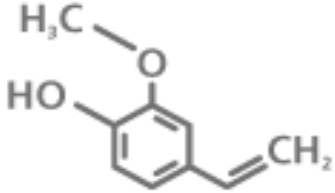


- *trans*-2-Nonenal
- Produced by breakdown of malt-derived lipids - binds to malt proteins during wort boiling
- Released from protein during storage of packaged beer
- Beer pH controls rate of release – yeast controls the beer pH value
- Flavour supressed by sulphur dioxide
- Flavour threshold *ca*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

NSBCo. Mountain Weiss draught

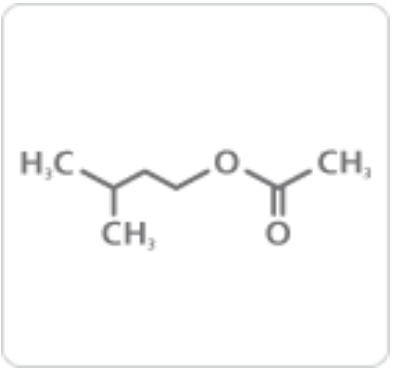
- WB06 Weiss yeast
- Low to no hop character – 10 IBU
- >50% malted wheat breadiness
- Yeast derived flavours
  - ✓ Yeast phenol – 4 Vinyl guaiacol – spicy, clove
  - ✓ Fruity esters – iso amyl acetate

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

Isoamyl acetate



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- Concentration depends on yeast strain, wort quality and fermentation conditions
- Especially dependent on wort clarity, dissolved oxygen and fermenter depth
- Flavour threshold 1.1 mg/l