Off Flavours in Beer

“I can’t drink that beer anymore...”

GTA Brews – June 2016
Eric Cousineau
ericbrews.com
This and other past presentations available at:
http://www.gtabrews.ca/learning/
What is Covered in This Presentation?

• What is an off flavour?

• Common off flavours
  • Acetaldehyde, Alcoholic, Astringent, Diacetyl, DMS (dimethyl sulfide), Estery, Grassy, Light-Struck, Oxidized, Phenolic, Solvent, Sulfur, Yeasty
  • Bitter, Autolysis

• Uncommon off flavours
  • Metallic, Musty, Sour/Acidic, Vegetal
  • Butyric Acid, Earthy, Geraniol, Indole, Isovaleric Acid
  • THP (tetrahydropyridine)
### Descriptor Definitions (Mark all that apply):

- **Acetaldehyde** – Green apple-like aroma and flavor.
- **Alcoholic** – The aroma, flavor, and warming effect of ethanol and higher alcohols. Sometimes described as *hot*.
- **Astringent** – Puckering, lingering harshness and/or dryness in the finish/aftersense; harsh graininess, huskiness.
- **Diacetyl** – Artificial butter, butterscotch, or toffee aroma and flavor. Sometimes perceived as a slickness on the tongue.
- **DMS (dimethyl sulfide)** – At low levels a sweet, cooked or canned corn-like aroma and flavor.
- **Estery** – Aroma and/or flavor of any ester (fruits, fruit flavorings, or roses).
- **Grassy** – Aroma/flavor of fresh-cut grass or green leaves.
- **Light-Struck** – Similar to the aroma of a skunk.
- **Metallic** – Tinny, coiny, copper, iron, or blood-like flavor.
- **Musty** – Stale, musty, or moldy aromas/flavors.
- **Oxidized** – Any one or combination of stale, winy/vinous, cardboard, papery, or sherry-like aromas and flavors.
- **Phenolic** – Spicy (clove, pepper), smoky, plastic, plastic adhesive strip, and/or medicinal (chlorophenolic).
- **Solvent** – Aromas and flavors of higher alcohols (fusel alcohols). Similar to acetone or lacquer thinner aromas.
- **Sour/Acidic** – Tartness in aroma and flavor. Can be sharp and clean (lactic acid), or vinegar-like (acetic acid).
- **Sulfur** – The aroma of rotten eggs or burning matches.
- **Vegetal** – Cooked, canned, or rotten vegetable aroma and flavor (cabbage, onion, celery, asparagus, etc.)
- **Yeasty** – A bready, sulfury or yeast-like aroma or flavor.
Acetaldehyde

• Chemical Name: Acetaldehyde
• Flavour: Green Apple, Latex Paint, Fresh Cut Squash/Pumpkin
• Source: Formed as an intermediate fermentation byproduct to be converted to ethanol
• Causes:
  • Present in beer removed from yeast too early (Budweiser)
  • Incomplete fermentation from under-oxygenation
  • Bacterial contamination (acetobacter, zymomonas)
• Threshold: 10-20 mg/L
Alcoholic

- No flavour standard, combo flavour
- Chemical Name: Ethanol and higher alcohols (propan-2-ol, etc...)
- Flavour: Warming, hot sensation
- Source: Yeast metabolize fatty acids in trub as source of oxygen
- Causes:
  - High gravity wort
  - Low pitching rate
  - Inadequate oxygen or FAN (Free Available Nitrogen)
Astringent

• No flavour standard, palate sensation
• Flavour: Mouth puckering sensation similar to grape seeds/skins
• Source: High concentration of tannins
• Causes:
  • Over extraction from grain husks
    • Overcrushing, oversparging, sparge pH over 6.0 pH or 170°F
  • Polyphenols from acetobacter of wild yeast
  • Oxidation, creating polyphenols and aldehydes
  • Spices such as coriander, orange peel, or cinnamon

2016/01/09 Eric Cousineau
Diacetyl

- Chemical Name: 2,3-butanedione
- Flavour: Butterscotch, Artificial Butter, Toffee-like, Slick Sensation
  - Some tasters are completely blind to diacetyl
- Source: Fermentation by-product that is usually absorbed by yeast
- Causes:
  - Present in beer removed from yeast too early
  - Excess oxygen during fermentation, low FAN, yeast mutation
  - Bacterial contamination (pediococcus damnosus)
- Diacetyl rest!
- Threshold: 0.1-0.2 mg/L

2016/01/09 Eric Cousineau
DMS (dimethyl sulfide)

• Chemical Name: dimethyl sulfide
• Flavour: Cooked vegies (corn, cabbage), tomato sauce, shrimp water
• Source: Created by the heat-induced conversion of malt derived SMM (s-methyl-methionine) to DMS in the boil
• Causes:
  • Inadequate venting of boil vapours
  • Slow fermentation
  • Contamination (wild yeast or zymomonas)
• Possibly not a concern with modern malts
• Threshold: 25-50 µg/L

2016/01/09  Eric Cousineau
Estery

• Generic term that encompasses many kinds of esters
• Flavours: banana, strawberry, pear, apple, plum, papaya, other fruit...
• Source: Combination of alcohol and organic acid
• Not always an off flavour
• Examples: Ethyl-Hexanoate, Ethyl-Acetate, Ethyl-Butyrate, Isoamyl-Acetate, and lots more!

2016/01/09
Eric Cousineau
Estery - Ethyl-Hexanoate

• Flavour: Aniseed, red apple, licorice
• Source: Esterification of caproic acid and ethanol
• Causes:
  • Yeast strain, ferment temp, pitch rate, gravity, oxygen, excess fatty acids
• Threshold: 0.2 mg/L
Estery – Ethyl Acetate

• Flavour: Pear (low levels), solvent, nail polish remover
• Source: Esterification of acetic acid and ethanol
• Causes:
  • Combination of excess oxygen with wild yeast, brettanomyces, and/or acetobacter
    • Creates acetic acid
• Threshold: 20-40 mg/L
Are you **bored** already?

Who doesn’t want a pineapple party in their beer?! Brettanomyces Claussenii FTW!

Listen to this one!
Estery - Ethyl-Butyrate

• Flavour: Tropical fruit, mango, tinned pineapple, cheesy fruit
• Source: Esterification of butyric acid and ethanol
• Causes:
  • Yeast strain (usually brettanomyces)
  • Contamination of butyric acid bacteria (clostridium butyricum and others)
• Threshold: 0.4 mg/L
Estery - Isoamyl-Acetate

- Flavour: Banana, peardrop
- Key flavour in German Weissbier
- Source: Esterification of acetic acid and isoamyl alcohol
- Causes:
  - Yeast strain
- Threshold: 1.4 mg/L
Grassy

- Chemical Name: cis-3-hexanol
- Flavour: fresh cut grass, crushed green leaves
- Undesirable in high amounts
- Causes:
  - Oxidation of alcohol in finished beer
  - Immature or poorly stored hops/malt
  - Excess use of certain American or English hops
- Threshold: 15 mg/L
Light-Struck

• Chemical Name: 3-methyl-2-butane-1-thiol (MBT)
• Flavour: skunky, sunstruck
• Source: Photochemical reaction of iso-alpha acid and in finished beer
• Causes:
  • Beer exposed to light during storage
• Some breweries don’t consider this a fault (Jester King, Corona, Heineken, etc...)
• Threshold: 4 ng/L (very low)
Oxidized - Papery

- Chemical Name: trans-2-noneal
- Flavour: wet cardboard, paper
- Source: Not fully understood yet
  - Amino acid precursors from the boil release T2N when beer pH changes (HSA)
  - Oxidation of “free radicals”
- Causes:
  - Excess oxygen introduced to finished beer
- Threshold: 50 - 100 ng/L
Oxidized – Honey/Sherry

- Chemical Name: ethyl phenylacetate
- Flavour: honey, sweet mead, sherry
- Source: Forms during beer aging, usually after T2N (papery)
- Causes:
  - Excess oxygen introduced to finished beer
- Threshold: 160 µg/L
Phenolic

• There are lots of kinds of phenols in beer!
  • 4VG (Weiss/Wit phenol)
  • Spicy
  • Chlorophenolic
  • Plastic
  • Band-aid
  • Smoky

• Desirable in some styles (Weissbier, Belgian/French Ales, etc...)
Phenolic – 4VG

• Chemical Name: 4-vinyl guaiacol (4VG)
• Flavour: herbal, spicy, clove
• Key flavour in German Weissbier or Belgian Witbier
• Source: Ferulic acid is converted to 4VG
• Causes:
  • Specialty ale yeasts with POF (phenolic off flavour) gene
  • Wild yeast
  • Natural aroma of buckwheat
• Threshold: 300 µg/L
Phenolic – Spicy

- Chemical Name: eugenol / 2-methoxy-4-(2-propenyl)phenol
- Flavour: clove oil, allspice
- Chemically similar to 4VG
- Appropriate in some Belgian Ales

Source:
- Oxidation of fusel alcohols
- Extracted from wood (barrels)
- POF+ and wild yeasts

Threshold: 40 µg/L
Phenolic – Chlorophenolic

• Chemical Name: 2,6-dichlorophenol
• Flavour: mouthwash, medicinal, antiseptic
• Source: Chlorine bonds with existing phenols
• Causes:
  • Fail to remove chlorine/chloramine from brewing water
  • Cleaning with bleach
• Threshold: 5 µg/L
Phenolic – Plastic

• Chemical Name: styrene
• Flavour: burning plastic, chemical, polystyrene
• Causes:
  • Wild yeast contamination
  • Contaminated CO2 equipment
• Threshold: 20 µg/L
Phenolic – Band-Aid

• Chemical Name: 4-ethyl phenol
• Flavour: band-aid, barnyard, hoseblanket
• Causes:
  • Brettanomyces infection or contamination
• Desired in some styles
• Threshold: 300 µg/L
Phenolic – Smoky

- Chemical Name: guaiacol
- Flavour: smoked bacon, smoked fish
- Causes:
  - Usually by smoked ingredients (malt)
  - Bacteria contamination
- Desired in some styles
- Threshold: 15 µg/L
That’s all the common phenols! Yay!
Solvent

• Not a flavour standard, combo flavour
• Flavour: Acetone, turpentine
• Source: High amount of ethyl acetate, other esters, and fusel alcohols
• Causes:
  • Poor fermentation practices (underpitch, etc...)
  • Wild yeast contamination
Sulfur

• Chemical Name: hydrogen sulphide (H2S)
• Flavour: boiled or rotten eggs, rubber, struck match
• Highly volatile, more common in lagers (cold fermentation)
• Can contribute freshness impression (at low levels)
• Source: Produced by yeast during fermentation
• Cause:
  • Inadequate fermentation vigor or aging time
  • Wild yeast contamination
• Threshold: 4 µg/L
Yeasty

- Not a flavour standard.
- Used as a catch all term
  - Combination of sulfur with the flavour of the yeast itself (bready, bitter)
Autolysis

• Not a flavour standard. Combo flavour.
• Flavour: soy sauce, umami, burnt rubber, marmite
• Source: Death of yeast cells
• Cause:
  • Old beer with excess yeast in it
  • Poor fermentation practices
Metallic

- Chemical Name: ferrous sulphate
- Flavour: inky, blood, copper penny, iron
- Source: Metal ions dissolved in beer
- Cause:
  - High metal ion in brewing water
  - Corrosion of plumbing
  - Poor quality packaging materials (cans, caps)
- Threshold: 1 mg/L
Musty

- Chemical Name: 2,4,6-tribromoanisole
- Flavour: musty, damp cellar, cork taint
- Source: Mould metabolizing chlorophenols
- Cause:
  - Use of semi-porous packaging
  - Damp storage area
- Threshold: 25 ng/L
Sour/Acidic – Acetic Acid

• Flavour: vinegar, acidic, tongue watering
• Source: Created by acetobacter/brettanomyces in presence of oxygen
• Desirable some certain Flemmish sours
• Cause:
  • Excess oxygen in sour beer container
  • Contamination of brettanomyces, acetobacter, and/or wild yeast/bacteria
• Threshold: 130 mg/L
Sour/Acidic – Lactic Acid

- Flavour: sour milk, yogurt, sharp acidity
- Common in many sour beers
- Source: Produced by lactobacillus/pediococcus from sugar
- Cause:
  - Bacteria contamination of lactobacillus/pediococcus
  - Excess use of acid additions or acid malt
- Threshold: 400 mg/L
Vegetal – Cooked Vegetable

• Chemical Name: methylthioacetate
• Flavour: boiled cauliflower
• Source: Produced by lager yeast during fermentation
• Threshold: 85 µg/L
Vegetal – Rotten Vegetable

• Chemical Name: dimethyl disulphide (DMDS)
• Flavour: boiled cabbage
• Source: Produced by yeast with H2S
• Cause:
  • Can build up if fermenter venting is poor
• Threshold: 75 µg/L
Butyric Acid

• Flavour: rancid, baby vomit, putrid
• Source: Produced by anaerobic bacteria
• More intense with lower pH
• Commonly confused with isovaleric acid
• Cause:
  • Contamination of butyric acid bacteria (clostridium butyricum and others)
• Threshold: 3 mg/L
Earthy

- Chemical Name: 2-ethyl fenchol
- Flavour: damp soil, geosmin
- Source: Water contamination with algae/geosmin
- Cause:
  - Source water contaminated with algae
  - Damp cellar where microbes migrate through packaging.
- Threshold: 5 µg/L
Geraniol

- Chemical Name: geranyl alcohol
- Flavour: rose like, rose water, floral, geranium flowers
- Can react with acids to create esters
- Source: Oil imparted via certain hops
- Threshold: 18 (1/3) µg/L – 350 (2/3) µg/L

2016/01/09
Eric Cousineau
Indole

• Flavour: farmyard, faecal, septic, jasmin, coliform
• Occurs commonly with DMS/DMTS
• Cause: Contamination of coliform bacteria
• Threshold: 15 µg/L
Isovaleric Acid

- Flavour: stale/rancid cheese, parmesan, sweaty socks
- Commonly confused with butyric acid
- Fades over time
- Brettanomyces can convert to ethyl isovalerate (fruity, berry)
- Cause:
  - Old/degraded hops
  - Wild yeast and bacteria contamination
- Threshold: 18 (1/3) µg/L – 350 (2/3) µg/L
THP (tetrahydropyridine)

- No flavour standard available yet
- Chemical Name: 2-acetyl-3,4,5,6-tetrahydropyridine
- Flavour:
  - High amounts: mousy, urine
  - Low amounts: cheerios, captain crunch
- Source: Produced by brettanomyces and bacteria
  - Exactly how and why is still being studied
- Follow the Milk the Funk wiki page to stay up to date
Conclusion

• Covered: All the blue off flavours
• There are a lot of possible off flavours in beer
• I encourage you to go back and browse the entire presentation at your own pace
• Thanks for listening!
Sources

- http://www.milkthefunk.com/wiki/
- https://www.siebelinstitute.com/products/sensorykits/
- https://beersensoryscience.wordpress.com
- http://sourbeerblog.com/understanding-esterification/
Questions?