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“The Science of Fermentation and alcohol production in yeast”

Lecture Notes (below) courtesy of Mary Brunson

1) Mineral content of water has a subtle effects on flavor
   a) Ca++ and Mg ++ hardness affect yeast metabolism and growth
   b) Bicarbonate affects pH
2) Malted grain provides sugar for fermentation
   a) Harvest barley right when it starts germinating (while all sugars are still there)
   b) The more roasted a grain is, the more it contributes to toasted and caramel flavors
   c) Darker roasted malts provide fewer simple sugars (because it’s been caramelized), so you need to subsidize
3) Hops contributes bitterness
   a) Our ability to detect changes in bitterness is blunt and we can’t taste subtle differences
   b) Hops are a surficants that contribute to head formation because of their ability to stabilize bubbles by increasing surface tension
4) Yeast provides all of the flavor
   a) 3 types of yeast used in brewing:
      i) Ale yeasts – top-fermenting, can ferment at higher temperatures (25°C is warm for brewing), and produce more esters
      ii) Lager yeasts – bottom-fermenting, ferment at lower temperatures, and produce fewer esters giving a more “crisp” taste
      iii) Wild yeasts – produce a lot of unusual compounds that contribute to “horse sweat” flavor that is more acidic and an acquired taste
      iv) Spontaneous fermentation is not the same as wild yeast – it is brewing in an open environment, allowing other things to get into brew
5) Fermentation = glucose \rightarrow \text{ethanol} + \text{carbon dioxide}
   a) Major molecules that contribute to flavor and mouth-feel
      i) Shorter carbon chains on alcohol evaporate more quickly, less oily and slick, lighter
      ii) More alcohol = more boozy flavor
      iii) Amount and type of esters – smells contribute to tastes
      iv) Residual sulfur compounds are bad – a consequence of incomplete fermentation or unintentional oxidation, can let it age for longer to get rid of them
      v) Carbonation
   b) Metabolism – pyruvate can turn into alcohol or acyl-CoA, both combine to form esters
   c) Factors affecting fermentation
i) The faster a yeast grows and the longer the exponential growth phase, the more esters will be produced

ii) Slow down fermentation to give fewer fatty acids produced and fewer esters leading to fewer fruity flavors

iii) Add less yeast to make more fruity flavors (takes longer to reach 100% of carrying capacity of brew)

iv) More aeration leads to less ester production (even though yeast ferment pretty well in the presence of oxygen)

6) Common esters
   a) Ethyl acetate is the more common ester and smells like nail polish remover
   b) Isoamyl acetate has a very low threshold for detection and takes like “fake bananas” flavor and is found in a lot of ales, especially Belgian and wheat style beers (American beers play it down)
   c) Ethyl butyrate has a low to medium threshold and gives hints of passion fruit or pineapple
   d) Ethyl hexonoate has a low to medium threshold and lends a red apple or anise like flavor
   e) If you spice your beer, it will play up these flavors

7) Budweiser – very standardized
   a) Grains & Hops – Pilsner malt, medium amount of hops
   b) Yeast – S. ovarum (lager)
   c) Fermentation – 15°C for 2 weeks, with longer lagering period (at 4°C to let flavors sit), wood chips are added to help yeast flocculate (so it doesn’t settle to bottom)
   d) Other – filtered beer and force carbonated (inject CO₂ into beer)

8) Pabst Blue Ribbon
   a) Grains & Hops – Pilsner malt (small amount), medium amount of hops, majority of sugar comes from corn
   b) Yeast – S. ovarum (lager)
   c) Fermentation – 15°C for 2–3 weeks
   d) Other – filtered beer and force carbonated

9) Guinness (one of lighter beers calorically because of dark roasted malts)
   a) Grains & Hops – dark roasted malt give color, light roasted malts provide sugar for fermentation
   b) Yeast – S. cerevisaea (ale)
   c) Fermentation – 18°C for 2–3 weeks
   d) Other – filtered beer and force carbonated with nitrogen (creaminess comes from the feeling of the smaller bubbles)

10) Hoegaarden
    a) Grains & Hops – Lighter roasted malts and wheat with low to medium hops (to let esters to shine through – less bitter)
    b) Yeast – S. cerevisaea (ale) – grows bright red
    c) Fermentation – 18°C for 2–3 weeks
d) Other – beer is unfiltered and refermented in the bottle for natural carbonation, left in warm room for another few days and tested for pressure (called champagne fermentation)

11) Rodenbach (Flemish sour ales)
   a) Grains & Hops – lighter roasted malts and wheat, low to medium hops
   b) Yeast – “wild” fermentation, spontaneous mixed culture (wood barrels as open fermenters with natural microbes)
   c) Fermentation – 18°C for 2–3 weeks
   d) Other – filtered and refermented in the bottle for natural carbonation