Flavor Production and Off Flavors

Class by: Nathaniel “Droopy” Sears
For Brewing and Distilling Center
Many things affect flavor production in beer. Today we are going to highlight:

- Five basic quality of tastes
- Discuss how fermentation can affect flavor
- Start the Siebel Institute Off Flavor tasting
- Taste some different beer
- How can having infected beer with off flavors affect your brewery?
Based on the information that is transported from the tongue to the brain, there are thought to be at least five basic qualities of taste.

- U.S. National Library of Medicine, August 2016
What are these tastes?

How many can you name?
5 basic qualities of taste

- Sweet
- Sour
- Salty
- Bitter
- Umami
Myster Beer #1

What is the main quality of taste we are tasting in this beer?

Sweet?
Salty?
Sour?
Umami?
Bitter?
Taste: Sweet

**Sweet**

What we perceive as sweetness is usually caused by *sugar* and its derivatives such as *fructose* or *lactose*. But other types of substances can also activate the *sensory cells* that respond to sweetness. These include, for example, some *protein* building blocks like *amino acids*, and also alcohols in fruit juices or alcoholic drinks.
Beer tasting

Do you think this beer tastes “sweet”? 
Why is this beer sweet?

Discuss…
Mystery Beer #2
What do you taste?
Sour
Taste: Sour

Sour

It is mostly acidic solutions like lemon juice or organic acids that taste sour. This sensation is caused by hydrogen ions, chemical symbol: H+, split off by an acid dissolved in a watery solution.
Taste: Salty

Salty

Food containing table salt is mainly what we taste as salty. The chemical basis of this taste is salt crystal, which consists of sodium and chloride. Mineral salts like the salts of potassium or magnesium can also cause a sensation of saltiness.
Mystery Beer #3
Taste? Smell?

What do you taste? Smell?
Beer Tasting

Does this beer taste “Salty”? 
What makes this beer salty?

Discuss...
Myster beer #4
Taste: Bitter

Bitter taste is brought about by many fundamentally different substances. In total there are about 35 different proteins in the sensory cells that respond to bitter substances. From an evolutionary standpoint, this can be explained by the many different bitter species of plants, some of which were poisonous. Recognizing which ones were indeed poisonous was a matter of survival.
Taste: Bitter

Does this beer taste “bitter”? 
What makes this beer bitter?

discuss...
Myster Beer #5
Taste: Umami

Umami/Savory

The “umami” taste, which is somewhat similar to the taste of a meat broth, is usually caused by glutamic acid or aspartic acid. These two amino acids are part of many different proteins found in food, and also in some plants. Ripe tomatoes, meat and cheese all contain a lot of glutamic acid. Asparagus, for example, contains aspartic acid. Chinese cuisine uses glutamate, the glutamic acid salt, as flavor enhancers. This is done to make the savory taste of foods more intense.
Taste: Umami

Does this beer have “savory/umami” qualities?
What makes the umami flavors?

Discuss?

https://www.merriam-webster.com/dictionary/umami
Simple answer

Beers properly aged on yeast sediment can develop umami-like character. See *stouts*. Given that hydrolyzed (heat-treated) yeast is often used as a meat-like flavoring in foods, this cannot be considered surprising. Oenologists are currently studying the possible contribution of lees (yeast sediment) contact to the development of positive umami characteristics in wine.
Does Fermentation affect flavor?

Discuss???
Fermentation

“Both positive and negative, the impact of the fermentation conditions is probably greater than that of any other variable as far as finished product quality is concerned.”

– The Practical Brewer
Fermentation

Some of the things we’re going to talk about with fermentation all affect the flavor of the beer. That’s why we are going to talk about it. Some items you may not understand how it relates, but I will illustrate how these items all affect flavor in the end.
Active Fermentation

https://www.youtube.com/watch?v=qQMgo8ApSjg

https://www.youtube.com/watch?v=xm33934qM4E
Effects of Underpitching & Overpitching Yeast

Underpitching affects flavor more and can lead to:

a) Excessive levels of diacetyl
b) Increased fusel alcohol formation
c) Increased ester formation
d) Increase in volatile sulfur compounds
e) High terminal gravities
f) Stuck fermentations
g) Increased risk of infection

Overpitching has a negative effect on yeast health but is more tolerant before fermentation defects are evident. Can lead to:

a) Very low ester formation
b) Very fast fermentations
c) Thin body or mouthfeel
d) Autolysis, which is yeasty flavors due to dying of yeast cells
e) Fewer generations of new vigorous yeast and too many old and tired yeast
Fermentation fun: Diacetyl

Diacetyl causes:

1. Time fermenting
2. Temperature fermenting
3. Temperature spike in packaged beer once it leaves brewery
Fermentation fun: Diacetyl (continued)

What’s it taste like?

Do you want that in your beer?

True, very trace amounts are acceptable and expected in some English style beers.
Fermentation fun: Diacetyl

Does everyone perceive diacetyl the same?
Diacetyl

Diacetyl (2, 3 - butanedione) Butter or butterscotch

Common sources: Microbial contamination or improper maturation
Fermentation: Stuck Fermentation

If your beer quits fermenting (stuck fermentation) and you give up and package it, it will not taste correct. It will be too sweet, diacetyl may be present, along with several other possibilities.
Fermentation: Stuck Fermentation

How to fix stuck fermentations. This process is way easier when homebrewing. But when you are in a production brewery you have to apply out of the box thinking how to save several barrels of beer sometimes.

Scenario 1: Maybe the fermenter got too cold and the yeast settled out before fermentation is complete? What do you do? If this was homebrew you can manhandle 5 gallons of beer and switch what is happening as opposed to maybe, say, 50 barrels of beer.
Fermentation: Stuck Fermentation

Scenario 2: Maybe the yeast wasn’t viable and the yeast is done. What do you do?

How do you know what to do in these two scenarios???
Fusel alcohols are those that are described as having an aroma or flavor similar to nail polish remover or even paint thinner in extreme instances. Fusel alcohols in beer can include butanol, isobutanol, propanol, and isoamyl alcohol (among others), rather than the more friendly ethanol. Beyond tasting and smelling solvent-like, fusel alcohols can be harsh on the tongue and throat, they can go beyond throat warming straight to being hot.

Solvent-like alcoholic character is typically caused by fermenting your beer at too high a temperature. Most ale yeasts like to ferment around 68°F. If your wort isn't chilled to that level before you pitch your yeast or is allowed to rise in temperature during the early phases of primary fermentation, you'll get more fusel alcohols in your beer. You definitely don't want to let an ale ferment at anywhere near 80°F unless you're making a high temp fermenting style such as a saison.
Flavor Production: Esters

Esters. What are they?
Esters

The fruity aromas perceivable in beer are typically generated by yeast esters, unless there’s actual fruit in the recipe. During fermentation, a reaction between organic acids present in the wort and the developing alcohol cause esters to form. Common aromatic ester characteristics include banana, pear drop, apple, honey, roses and even solvent-like in some instances.

While the reaction between the acids and alcohol actually form esters, three variables influence the amount of esters that can potentially develop. By understanding and managing these variables, homebrewers can have a certain level of control over the character and level of esters produced.

- www.homebrewassociation.org
Flavor Production: Esters

Causes:

Wort Composition

High concentrations of sugar, zinc and free amino acids tend to promote higher ester levels. Higher levels of dissolved oxygen and lipid content can inhibit ester formation.

Yeast Strain Selection

Some yeast strains are more inclined to produce esters. For example yeasts used to ferment Bavarian wheat beers are known for producing high levels of isoamyl acetate, which give that signature banana-like flavor found in many German wheat beers. Generally speaking, ale yeasts produce more strains than lagers, but this is likely mainly do to the warmer fermentation temperatures.
Flavor Production: Esters

Fermentation Environment and Conditions

Believe it or not, the shape of the fermenter can impact the production of esters. Tall, narrow fermenters tend to produce lower levels of esters than shallower, more open vessels. This is because high hydrostatic pressure and levels of CO2 in the tall, narrow vessels inhibit ester formation.
Let’s take a break!
The compounds responsible for sulfury off-flavors are ultimately derived from ingredients. The levels at which they appear in the final product are largely determined by the brewing process. Some of these flavors are desirable in continental lager styles, where they complement the malty aroma. On the other hand, some are considered defects by brewers of British ales, who select the malt, yeast, and fermentation method most likely to minimize the formation of volatile sulfur compounds (3). Though strain-dependent, lager yeasts generally produce a much larger variety of sulfur compounds during fermentation than ale yeasts; sulfury flavors are therefore one way of distinguishing between lagers and ales.
## Fermentation: Sulfur Compounds

<table>
<thead>
<tr>
<th>Table I: Class 7 Compounds</th>
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<tr>
<td>1st Tier</td>
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<tr>
<td>Sulfitic</td>
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| | Shrimplike | Water in which shrimp was cooked |
|---------------------------|-----------------------------|
| Vegetative | | |
| 0730 | Cooked vegetable | Dialkyl sulfides |
| 0731 | Parsnip/celery | Wort infection |
| 0732 | DMS | Dimethyl sulfide |
| 0733 | Cooked cabbage | Overcooked green vegetables |
| 0734 | Cooked corn | Cooked maize, canned sweet corn |
| 0735 | Cooked tomato | Tomato juice, tomato ketchup |
| 0736 | Cooked onion | Cooked onion |
| Yeasty | | |
| 0740 | Yeasty | Fresh yeast |
| 0741 | Meaty | Brothy, cooked meat, meat extract, yeast broth |
Flavors

Let’s take a second and talk about some flavors in beer. We’ve been talking about them for awhile. What flavors (good or bad) stand out to you the most?
Let’s take a side bar to the beer flavor wheel

https://9148ac0e-a-62cb3a1a-s-sites.googlegroups.com/site/beerflavorwheel/home/wheel-alt.png?attachauth=ANoY7crgZuFBAQLsfS86ridfKsLXKxel5vADMHybym2aqOA-Ta_5nZFt2XcISEhf-u1ByehTW0X-42qvE4qVF9psPkMvN2MaSLX9Rxs37SP1VKH_7l8kddtM1jJO1RWj722Rs8eym516ZL8oZ9dR_r_m80qBmDmQzEwQd_o-RkD14eK5O5tfYWROAHm7fc5TARCotQwYhqgmqwi2W4JJ6L7_bDkCBLy165FLIN9E-1Vmjz5k275soms%3D&attredirects=0

http://www.beerflavorwheel.com
Fermentation: High Terminal Gravities

How would a high final gravity affect the flavor of beer?
Fermentation: High Terminal Gravity

Brewers should always examine all possible causes of high final-gravity readings, such as:

- improper aeration of the wort
- low fermentation temperature
- lack of viable yeast
- or too many dextrins
Fermentation and underpitching: Increased risk of infection

Why?
Increased risk of infection:

- Bacteria has a better chance to grow.
- Underpitching non-viable yeast will produce off flavors, diacetyl, and possible other infections
- The possibilities are endless
How off flavors can affect your brewery

In 2015, Goose Island released their much anticipated, annual release of Bourbon County Brand Stout. It was soon discovered that a contamination issue rocked the brewery on its heels. The brewery did a nationwide recall on their popular Bourbon County Brand stout and some of the variants.
What happened?


40,000 x 15 = $600,000. That total is before the recall of the regular and proprietor’s stout.

What was the infection?

*Lactobacillus acetotolerans* (New Latin ‘vinegar-tolerating milk-bacillus’) is a species of *gram positive bacteria* in the genus *Lactobacillus*. Discovered in rice wine vinegar, it has a very high tolerance for *acetic acid*.\(^1\) It can tolerate an acetic acid concentration of over 9% and a pH as low as 3.3. It is known to produce sour flavors in beer it invades, by producing *lactic acid*.\(^2\)
Batches of the 2015 Bourbon County Brand Stout bottles affected were bottled on the following dates:

Flavor Production: Pilsner
Flavor Production: Pilsner

Water pg. 148 and 166

Brewing a pilsner

- Lager yeast
- Primarily Pilsner malt
- Very specific hops like Saaz
- Very little to no sulfate
- Fermentation is really important
- Ferment at lager temps
- Diacetyl rest
Off Flavor Tasting #1.
What do you taste?
#1 Acetaldehyde

Green apple or cut grass
What do you taste?
#2 Acetic Acid

Vinegar-like

Common sources: Contamination (Mash, bacteria, or wild yeast)

A bacterial byproduct, sour-tasting acetic acid is common in sour beer styles such as Flanders red ales, which are open-fermented to welcome such funk-inducing compounds. In most styles, though, acetic acid is an off flavor; it’s detectable by a green apple, vinegar or paint aroma and/or flavor. Its most common cause is a contamination in the brewing process or your pub’s tap system.
Similar

Acetaldehyde and Acetic Acid are similar. Both can produce green apple off flavors.
What do you taste?
#3 - Almond (Benzaldehyde)

Almond (Benzaldehyde) - Marzipan and Almonds

The best way to evaluate almond flavour in beer is as follows. ... The flavour threshold of benzaldehyde in beer is 1 mg / l. Benzaldehyde is produced during wort production and modified by yeast during fermentation. It is also released during beer ageing of beer in package or barrels.
#4 Bitter

Bitter - Isolone. Hoppy and bitter

Common sources: Hopping, hop additions
This is a fun one

What do you taste and smell???
# 5 Butyric Acid

Butyric Acid - Putrid and baby vomit

Common Sources:

Bacterial Contamination produced by anaerobic bacteria...not aerobic.

Can be from adjuncts added to the kettle. Also can be from pre or post boil bacteria.
#6 Capyrilic Acid

Soapy, fatty, candle wax
#7 Contamination

Contamination: Sour and buttery

Common sources: Contamination (Lactobacillus)
#8 D.M.S.

Cooked corn
#9 Diacetyl

Butter or butterscotch
Earthly: (2-Ethyl fenchol). Geosmin, soil-like

Common Sources: Packaging or water-derived contamination
#11 Ethyl Acetate

???: Geosmin, soil-like, nail polish remover.

Common sources: Wort Composition and yeast growth

(hint: This is an ester)
Wrap up day 1

We’ve tasted several flavors so far today. Which one from today has stuck out the most so far?

Did you like any of them?

Which ones did you hate?
Flavor Production and Off Flavors - Night 2

Class by: Nathaniel "Droopy" Sears
For Brewing and Distilling Center
There are several breweries now who experiment with non-traditional brewing ingredients to set themselves apart from the rest. We’re going to highlight some of the recent trends in American brewing.
What is wine-grape must???

**Must** (from the Latin vinum mustum, "young wine") is freshly pressed fruit **juice** (usually **grape juice**) that contains the skins, seeds, and stems of the fruit. The solid portion of the **must** is called pomace and typically makes up 7–23% of the total weight of the **must**. Making **must** is the first step in winemaking.
Commercial Examples

**Batch size:** 5 gallons (19 liters)

**Brewhouse efficiency:** 72%

**OG:** 1.074

**FG:** 1.017

**IBUs:** 35

**ABV:** 7.5% (plus the contribution of the wine-must addition)

**MALT/GRAIN BILL**

11.75 lb (5.3 kg) German Pilsner malt

14.6 oz (414 g) flaked wheat

10 oz (283 g) Caramalt

10 oz (283 g) Cara-Pils/Dextrine

0.5 gal (1.89 l) sterile wine must

-  [www.beerandbrewing.com](http://www.beerandbrewing.com)
When to add the wine must?

Mash at 150°F (66°C). Ferment at 70°F (21°C). Add the sterile wine must at the tail end of fermentation before reaching terminal gravity, about 24 hours before dry hopping. Dry hop for 3 to 5 days under pressure in the keg, then cold crash and force carbonate to 2.55 volumes.
Commercial Examples

Dogfish Head 61
- Made with Syrah grape must
- Dogfish’s flagship IPA, 60 minute IPA with syrah grape must.
Wine-grape must and IPA's

Why do you think both examples I found using wine-grape must chose an IPA to pair the must with?
What do you think about this trend?

What other trends do you think could happen in the future?
**We see coffee a lot now in craft beer. Why?**

1. **It adds a different dimension to the beer.**
2. **A lot of people like coffee.**
3. **It may draw in someone to drink your beer that normally wouldn’t try it.**
4. **With the addition of this one ingredient it automatically adds another beer to your portfolio to choose from. You can literally have the base beer on tap at the same time you have the coffee version of the same beer on tap and it is another option for people that is completely different.**
5. **You can pair with a local coffee place and it’s cross advertising for both the beer and coffee shop. Everyone wins.**
Coffee commercial examples

- Terrapin Wake n’ Bake Stout
- Prairie Bomb
- Mantra Japa
- Wiseacre Gotta Get Up To Get Down
- Blackhorse Coffee Milk Stout
- Bearded Iris V. Latte
- Crafty Bastard Epiphany Coffee Porter
- Country Boy Nate’s Coffee Stout
Cross Brand Advertising
Coffee Beer

Wiseacre - Gotta Get Up
to Get Down
Back to off flavor tasting!!!
What does this taste/smell like?

???
What does this smell/taste like?

???
#12 Ethyl Hexanoate

Aniseed, apple, or licorice
#13 Geraniol

Floral, geranium flowers

Sources: Hop addition and variety
#14 Grainy (Isobutyraldehyde)

Husk-like, nut-like

Sources: Excessive run-off
#15 Hefeweizen

Spicy and Banana

Sources: Beer styles. Common in Bavarian Hefeweizen yeast
#16 Indole

Farm, barnyard

Sources:

Bacterial infection during fermentation
#17 Isoamyl Acetate

Banana, peardrop

Sources: Fermentation product, wort composition, or yeast health
#18 Isovaleric Acid

Cheesy, old hops, sweaty socks

Sources:

Use of old, degraded hops
#19 Lactic Acid

Lactic Acid: Sour and sour milk

Common Sources: Beer spoilage bacteria
#20 light struck

Skunky, toffee, or coffee like
#21 Mercaptan

Sewer-like, drains

Sources:

Poor yeast health, autolysis
What does this taste/smell like?
#22 - Metallic

Metallic: Metal, tin-like, blood.

Common sources: Water sources, non-passivated vessels. Primarily from water.

***
What does this beer smell/taste like?
What does this taste like?

Hmmmm?
What does this taste like?

Hmmmm?
Hefeweizen

Hefeweizen: Spicy and banana

Common sources: Yeast

What other flavors do you experience?
Yazoo Hefeweizen
What is gram positive bacteria?

**Gram-positive**: Gram-positive bacteria retain the color of the crystal violet stain in the Gram stain. This is characteristic of bacteria that have a cell wall composed of a thick layer of a particular substance (called peptidologlycan).
What does this taste like?

Hmmmm?
What does this taste like?

Hmmmm?
Caprylic Acid

Caprylic Acid: Soapy, fatty, candle wax

Common Sources: Microbial contamination or yeast breakdown at maturation

(No example to give, but wanted to go over the off flavor.)
Natural flavorings in beer are concentrated extracts sold in bottles that you can easily add to your beer by pouring in the correct ratio to achieve the taste you are looking for. There are companies dedicated to making this flavorings from fruit to honey to chocolate to everything in between.

A lot of breweries are against “natural flavorings” in beer, otherwise called “extracts.” Some purists see it as cheating the customer, cheapening your brand, etc. A lot of people would say it tastes medicinal. But, the breweries that do this obviously don’t care and are targeting a specific consumer.
Natural Flavorings

Some popular breweries that use “Natural Flavorings”:

1. Terrapin
2. Southern Tier
3. Evil Twin
4. Abita
Mystery beer tasting!

What “natural flavoring” do you taste in this beer?
Natural Flavorings example:
Beer Tasting

What does this beer smell/taste like?
Natural Flavorings example:
What does this taste/smell like?

Corona Light
Let’s take a break.
Flavor Production

Barrel Aging
Barrel Aging

Barrel Aging your beer can drastically affect the flavor of your beer. Barrel aging a high gravity stout has become increasingly popular over the years. It seems most breweries have some sort of barrel aging program whether it is small or large.
Barrel Aging
Flavor Production: Barrel Aging

Discuss
Back to off flavors!
What does this smell/taste like?
DMS - Dimethyl Sulfide

DMS smells and tastes like cooked Corn

Wort boil, wort cooling, or contamination.

(hint: You should know this.)
What does this smell/taste like?
#24 - Spicy

Spicy: Cloves, all spice.

Common Sources: Microbial contamination, wild yeast or aging.
#23 Papery (Trans-2-Nonenal)

Papery: Cardboard, oxidized.

Common sources: Product of oxidation, staling
#25 Vanilla

Vanilla: Custard powder, vanilla essence.

Common Sources: Specific styles like barrel aging. It’s a common wood flavor.
End of Sensory Training

Discuss...
Let’s take a break!

Break!
You see fruit everywhere now. In IPA’s, sours, stouts, porters, etc. Pretty much if it is a beer, you might see a fruit or fruit puree in it.

Why?
Why fruit?

1. People are always wanting the next thing.
2. It attracts different audiences you may not have gotten before
3. It expands your customer base
4. People see your brewery as trendsetters
5. It starts a buzz about your brewery as the people doing different things.
6. More people, broader customer base, etc. means more dollars in your pocket.
7. You can charge a premium for these true fruit beers.
Flavor Production: Fruit

Why use it?

1. It gives you a different dimension.
2. Fruit may attract someone to drink your beer that normally wouldn’t. How?
3. It gives you a tap handle at your brewery and possibly in a craft bar you normally wouldn’t get.
4. Again, you may have the base beer and the fruited version on side by side in your own brewery in which both earn you money.
5. You could have a brand new series of beers revolving around fruit. The possibilities are endless
Flavor Production: Hops

Remember, hops are part of your flavor production. We’ve already had the hops class. But keep in mind, it’s part of this class too. You can drastically affect your flavor profile by what kind of hops you use for the style of beer you are using.
Flavor Production: Hops

www.ychhops.com is a great website to study the different types of hops and what flavor they will give your beer.
Flavor Production: Grain

Remember different types of grain will affect how your beer tastes and looks. The grain is very important.

To brew a good pilsner, you want to use a light, pilsner malt. You don’t want to use a bready, pale ale or 2 row malt. It will not be a clean, light pilsner that you are going after.

From base malt to speciality malts, it is all important on what you choose.
Different grains

Discuss
We’ve gone over a lot of things that contribute to flavor production both positively and negatively these last two days. A lot of knowledge is in this powerpoint.

Feel free to e-mail me at sears.nathaniel@gmail.com with any questions about the flavor production classes. Thank you.
1. Both positive and negative, the impact of the _____________ is probably greater than that of any other variable as far as ________________ is concerned.

-The Practical Brewer

(Fill in the blank)
1. Both positive and negative, the impact of the fermentation conditions is probably greater than that of any other variable as far as finished product quality is concerned.

-The Practical Brewer
Review

2. What chemical compound gives the perception of green apple?

3. What chemical compound gives the perception of butter or butterscotch in beer?
ANSWERS

2. Acetaldehyde

3. Diacetyl
4. Can you, as a brewer, possibly fix a stuck fermentation?
5. The off flavor known as papery (trans-2-nonenal) gives the flavor perception of what?
Cardboard or oxidized
Question

6. Which off flavor gives the perception of sewer-like or drains?
Answer

A. Mercaptan
Quick review

Which sulfide gives the perception of cooked corn??
Answer

Dimethyl Sulfide aka D.M.S.
Which acid gives the perception of soapy, fatty, or candle wax?
Answer

Caprylic Acid