Flavor notes for Michigan Craft Guild Conference – 2014 **[Butyric, Caprylic, Caproic, Isovaleric, Indole, Styrene and "Brett" Phenols (Combination of 4-Ethyl Phenol and 4-Ethyl Guaiacol as aroma bottles)] EXTENDED NOTES POST-CONFERENCE! Presented by Gary Spedding, Ph.D. of Brewing and Distilling Analytical Services, LLC, KY. US.**

Compound	Flavor Descriptors	Flavor Threshold	Typical Level in Beer	Notes
Butyric Acid **Spiked at 9ppm.**	**Sharp, cheesy, butter-like, baby vomit, putrid.**	**2-3 ppm.**	**0.5-1.5 ppm.**	Formed by bacteria, either during wort production or in sugar syrups during storage. Occasionally formed during bacterial spoilage of packaged beer. [Megasphaera and Pectinatus]
Caprylic Acid (OCTANOIC) **Spiked at 15 ppm.**	**Goaty, waxy, fatty, rancid, milky, cheesy, tallowy**	**4-6 ppm.**	**2-8 ppm.**	A desirable flavor characteristic of certain pale lager beers (positive to flavor and mouthfeel). It is associated with traditionally-produced lagers which have undergone prolonged conditioning/ maturation and is released into beer via the autolysis of yeast cells. At high concs. it is considered an off-flavor.

So called caprylic flavor – medium chain fatty acids (C6-10) – minor wort constituents that accumulate during fermentation. Forming as much as 85-90% total beer fatty acids. Octanoic (above), decanoic and to a lesser extent hexanoic acid (see below) affect flavor to give the caprylic or soap/fatty characteristics.

[Hexanoic = caproic, Octanoic = caprylic, Decanoic = capric and Dodecanoic = lauric.]

Some brewers consider caprylic character as yeasty.

Each of these fatty acids have low but additive thresholds. Caprylic, decanoic and lauric are often said to be able to occur above flavor threshold. Increased oxygen or addition to fermentation of unsaturated long chain fatty acids (oleic) reduce the formation and excretion of C6-C10 fa's. So the production of these medium chain fa's are yeast strain dependent and OG, wort composition and oxygen content dependent. Production is inversely proportional to fermentation rate.
Rapid release with higher temperatures of maturation or high yeast concentration with long contact times.

Autolytic flavors and maturation. As a diacetyl rest is important for maturation of ales and lagers in particular the warm up period for the rest can be significant in promoting yeast lysis and increasing caprylic flavor. So watch yeast concentration/higher temperatures and avoid long contact times. These three factors should be avoided at the base of deep fermenters – by cooling and programmed removal of yeast before and after warm maturation and at regular intervals until the end of storage.

Incomplete or delayed sedimentation and removal of yeast can lead to an increase in short and medium chain length fatty acids leading to the autolytic/yeasty notes.

Lower pH (4.0) increases fatty aromas – buryric/caprylic type.

Caproic Acid (HEXANOIC)	**Caprylic, goat, vegetable, oil-like, sweaty, cheesy**	**8 ppm.**	**1-6 ppm.**	Found more in lagers and part of a global "caprylic" beer character.
Isovaleric Acid (3-METHYL BUTANOIC ACID) **Spiked at 3 ppm.**	**Cheesy, old-hop-like, sweaty, sweat socks**	**1.5 ppm.**	**0.1-3.4 ppm.**	Aged, oxidized, old hops. The isovaleric flavor note can be imparted to beer through the use of old or degraded hops or use of high hopping rates; it is derived from breakdown of alpha-acids. Isovaleric acid can occasionally be produced by wild yeasts, specifically *Brettanomyces* spp which may be present either as contaminants or introduced into beer for conditioning purposes. Isovaleric, sweaty, cheesy flavor notes are characteristic flavors of some beer styles, *e.g.* India Pale Ale. Typical 'cheesy' characters are often associated with beers of very high bitterness. In pale lager beers, isovaleric character is regarded as an off-flavor.

Indole **Spiked at 45 ppb.** **This one was disappointing on the day. More like mothballs rather than feacal (fecal).**	**Farmyard, Like pigs on a farm, faecal, coliform, jasmine**	**15 ppb.**	**<5 ppb.**	The indole flavor note is formed by contaminant 'coliform' bacteria during primary fermentation. Occasionally associated with the use of adjunct sugar syrups that have undergone bacteria spoilage. Typically about half of the population are very sensitive to indole while the remainder are not. Small amounts of indole are present in normal beer due to thermal breakdown of tryptophan.
Styrene [Ethenylbenzene] **Spiked at 20 ppb.**	**Polystyrene, plastic, burning plastic, styrene**	**20 ppb.**	**<5ppb. [Not detectable in normal beer.]**	Styrene is an off-flavor produced by contaminant wild yeasts during fermentation. It can also arise as a taint through use of defective carbon dioxide gas supplies. Possibly at threshold in some ales- yeast strains with phenyl acrylate decarboxylase activity (PAD). German and Belgian wheat beer strains high PAD activity; can be around threshold to well above 10-60 ppb. Styrene can be both an off-flavor and a taint in beer. It is associated with a moderate degree of consumer rejection in beer. It can be described by consumers as 'chemical', 'plasticy' or 'contaminated'.

Styrene has a similar mechanism of production as do traditional wheat beer phenolics. All related to the thermal and enzymatic breakdown of complex acids. Styrene comes from the thermal decarboxylation of cinnamic acid (wort boiling) and by enzymatic decarboxylation (fermentation) and is formed very fast (compared to the other "wheat beer type" phenols).

Reaction occur in parallel with decarboxylation of ferulic and p-coumaric acid to produce the 4-vinyl guaiacol and 4-vinyl phenol by the same decarboxylase. All cinnamic acid in wort is converted in a few hours. All this related to a term called POF+ (which all top fermenting yeast are. POF = phenolic off flavor and is in part yeast strain dependent) If POF flavor occurs in lager, therefore, it is due to contamination (wild or non-pitched yeast).

So styrene production depends on fermentation management during wheat beer production. To control it use higher fermentation temperatures (25 °C vs 16 °C) and open fermentation management which leads to rapid decrease in styrene while maintaining typical wheat beer flavors.

Bottle refermentation? POF+ strains will have higher styrene content in final beer.

Select low cinnamic acid malt and optimize the mashing process (Phenolic rests are being discussed currently in the literature).

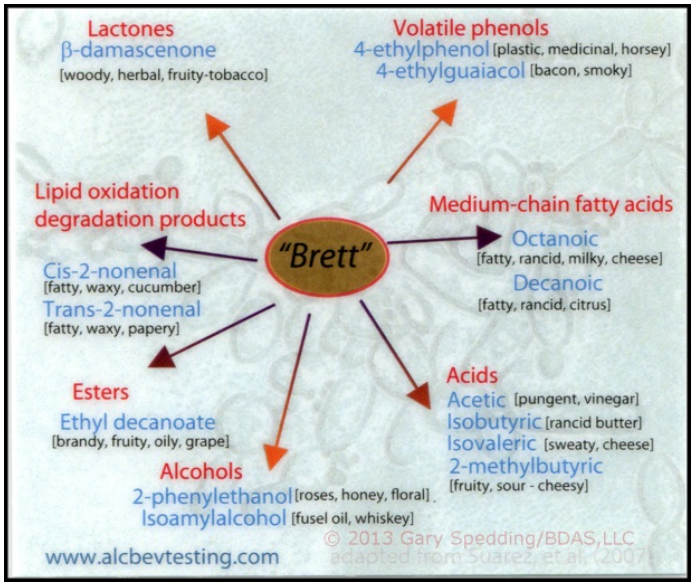
Phenols NOT GOOD in non-wheat beers. Styrene not good in any beer?

4-Ethyl Phenol **BOTH THIS AND EP (below) SPIKED AT 450 ppb. EACH AND IN COMBINATION – NOT SEPARATELY!**	**Band-aid, contaminated with Brettanomyces, plastic, medicinal, horsey.** **The key note of Brett contam. in wine. [The EP to EG ratio makes for subtle differences in notes and acceptance.]**	**Not well known in beer. 440 ppb. Water 605 ppb. wine**	**Aggregate detection threshold 4-EP and 4-EG (wine) 400 ppb.**	Well covered in wines and possibly becoming understood through the Brettanomyces project of Chad Yakobson (Crooked Stave) and Troy Casey (at Coors) "English character" and Belgian Beers! **Ethyl phenol is the characteristic odur of *Brettanomyces* contamination. It is produced in red wines by *Brettanomyes* yeasts during barrel ageing, and - occasionally - after bottling. The compound imparts an unpleasant band aid-like character, described as medicinal or horsey. The flavor masks more subtle varietal notes in affected wines**
4-Ethyl Guaiacol	**Phenolic, clove, smoky, ash-like, bacon, smoked bacon/cheese.**	**Not well known in beer.**		See under 4-ethyl phenol. Brett spoilage (in wine) has been defined as 426 ppb or more of 4-EP and 4-EG, or 620 ppb or more of 4EP.

This pair spiked together was also a bit disappointing. These two are supposed to be the key to "Brett flavor". But we got more the Wheat Beer/band-aid notes here. This lead to a neat discussion of other Brett flavors – see the chart below (and request a larger copy and further details if desired). Experiments are needed to add in more flavors to try and get to that truer note of Brett for training purposes. Not so much known yet in beer!

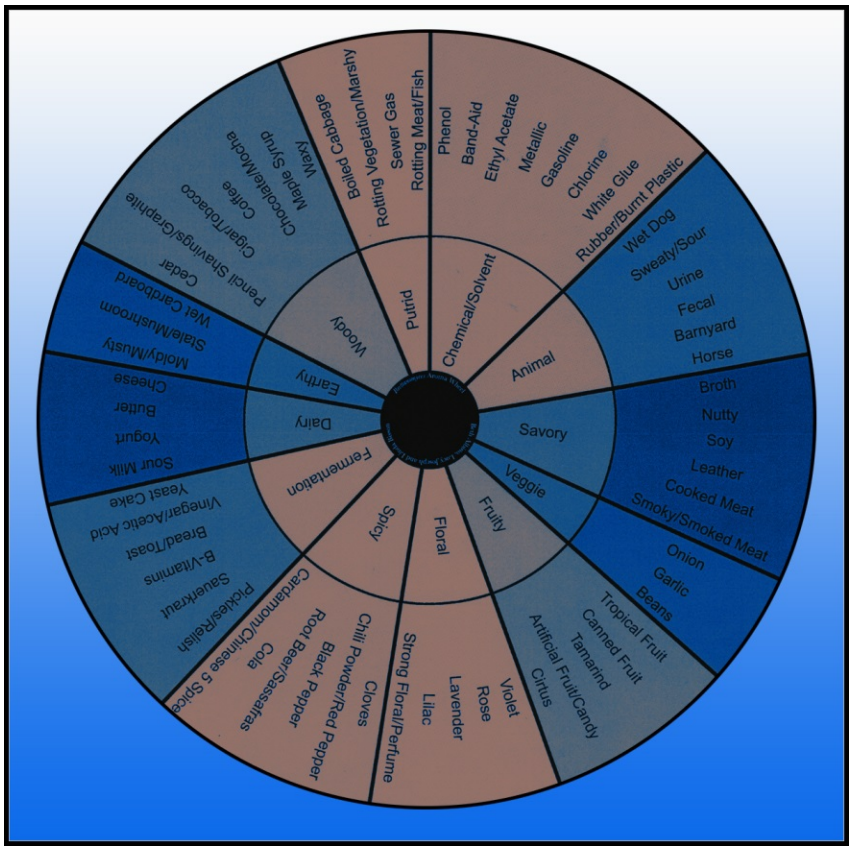
Some notes derived from FlavorActiv (suppliers of sensory test kits).

THE BRETT DISCUSSION CONTINUED…



While the two phenols listed (top right) are considered the major volatiles associated with Brett character, the other components all play a role in beers brewed or infected with Brettanomyces strains.

The new Brettanomyces aroma wheel by Dr. Linda Bisson and Lucy Joseph at US Davis



Gary Spedding for Brewing and Distilling Analytical Services, LLC, 2014. For more on flavor notes and training BDAS, LLC is the most qualified analytical company in the US offering such services and information for brewers and now developing programs for distillers too! Go to: info@alcbevtesting.com/gspedding@alcbevtesting.com/www.alcbevtesting.com.