



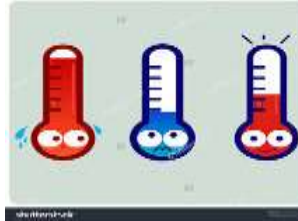
WORLD BREWING CONGRESS

August 13–17, 2016 • Denver, Colorado, U.S.A.

#ElevateBeer



Time, Temperature, and Barrels



And Their Effects on Major Beer
Compounds



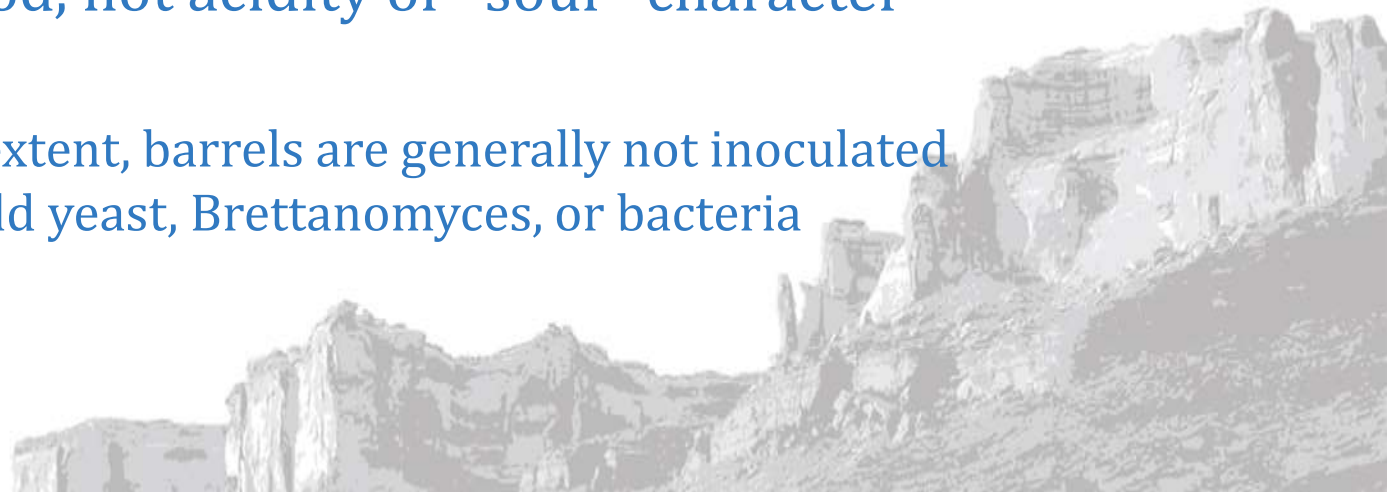
Molly Browning
Trophy Brewing Company





General Wood/Spirit Aging Parameters

- ❖ Post-primary fermentation
- ❖ Usually in an used spirit barrel (but not always)
- ❖ Typically high gravity
- ❖ Goal to obtain “oak” and spirit character and roundness from the wood, not acidity or “sour” character
 - ❖ to this extent, barrels are generally not inoculated with wild yeast, Brettanomyces, or bacteria

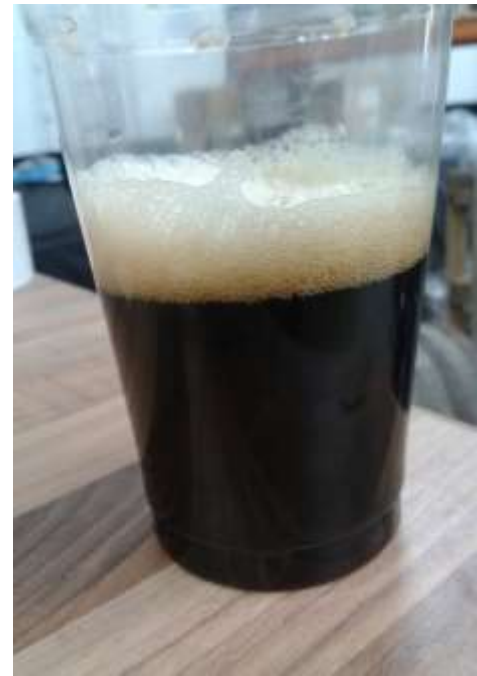




'The Effects of Temperature on Major Beer Compounds During Barrel Maturation'

- ❖ Heriot-Watt Brewing and Distilling MSc Project:
 - ❖ Control Beer Parameters:
 - ❖ 8% ABV, pH 4.19, IBU 52.1, Color: 237.5 (EBC)
 - ❖ Two Bourbon Barrels
 - ❖ Ambient room (avg temp 14.7°C)
 - ❖ Cold room (avg temp 9.4°C)
 - ❖ Beer aged for 6 months
 - ❖ Tested for:
 - ❖ gravity, pH, colour, esters, higher alcohols, VDKs, acetic acid, aldehydes, total polyphenols, strains of lactobacillus and pediococcus (PCR), taste panel







Properties of American Oak

Properties

- ❖ Lower polyphenol levels
- ❖ Less porous than European oak
- ❖ Higher amounts of whiskey lactone (β -methyl- γ -octalactone)
- ❖ Higher amounts of ellagic acid and vanillin

Contribution

- ❖ Can change the mouthfeel (whiskey literature)
- ❖ Less oxygen diffusion
- ❖ Sweet, coconut flavor
- ❖ Sweet-like flavor



Temperature Parameters

Month	Cold Room Barrel (°C)	Ambient Room Barrel (°C)	Temperature Difference (°C)
February (Month 1)	6.7	8.0	1.3
March (Month 2)	7.1	8.8	1.7
April (Month 3)	9.3	13.8	4.5
May (Month 4)	9.6	15	5.4
June (Month 5)	11.3	18.7	7.4
July (Month 6)	12.2	23.8	11.6



Esters



Tested For

- ❖ Iso-amyl acetate, iso-butyl acetate, ethyl hexanoate, ethyl butyrate, ethyl octanoate

- ❖ Ethyl lactate
 - ❖ (3.8-4.8ppm Ambient) (3.1-4.0ppm Cold)
- ❖ Ethyl acetate
 - ❖ (60-87ppm Ambient) (57-72ppm Cold)

Results

- ❖ All decreased
- ❖ Ambient room showed greater rate of decline
- ❖ Below flavor threshold

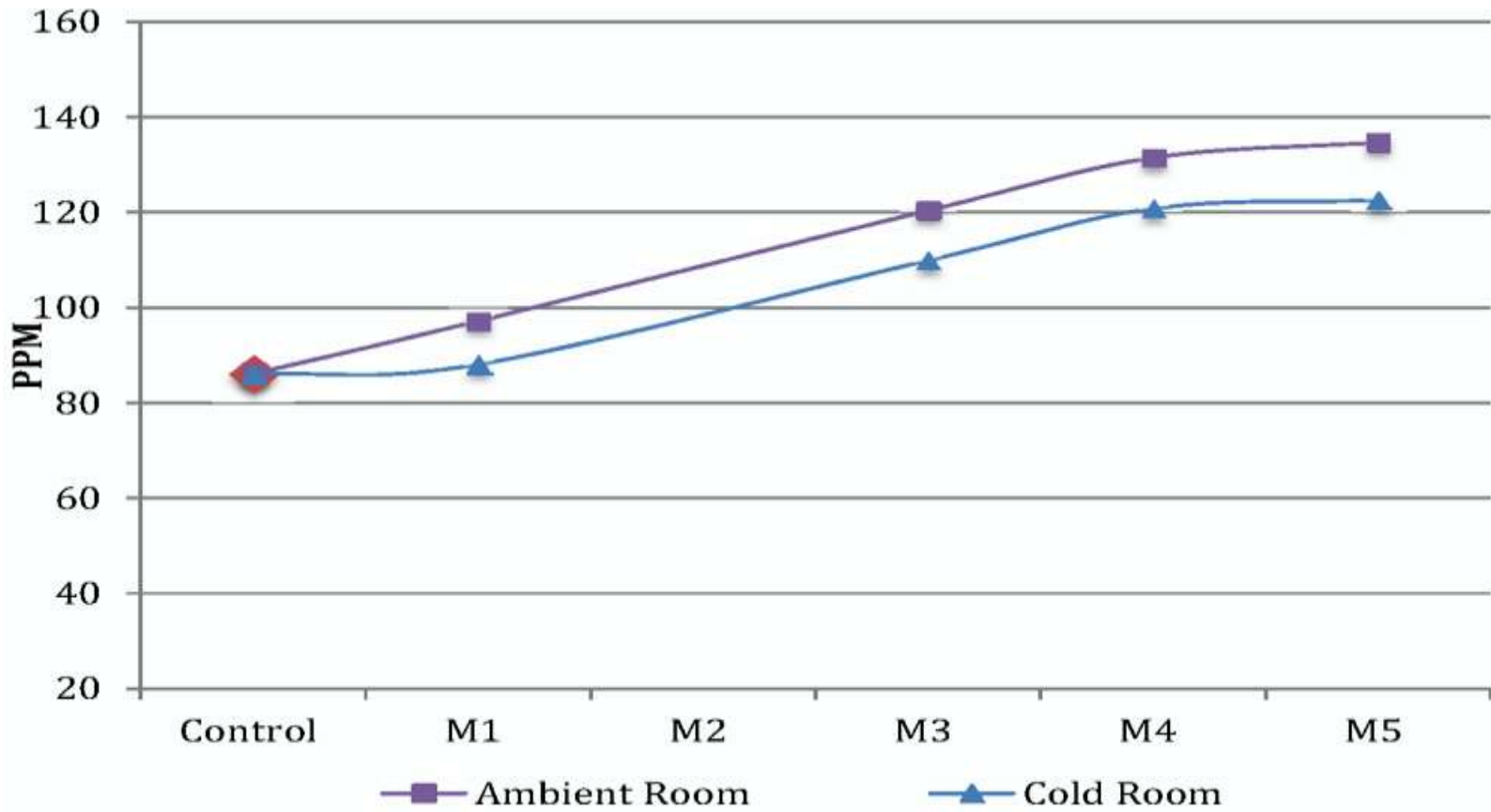
- ❖ Increased
- ❖ Ambient Barrel showed greater rate of increase
- ❖ Ethyl acetate above flavor threshold (30ppm)



Acetic Acid



- ❖ Very sensitive to temperature = spikes at 8°C
- ❖ Below flavor threshold (175ppm)





Higher Alcohols



Tested For

- ❖ Propanol, iso-butanol

- ❖ 2-methylbutanol, 3-methylbutanol

Results

- ❖ Decreased

- ❖ Increased

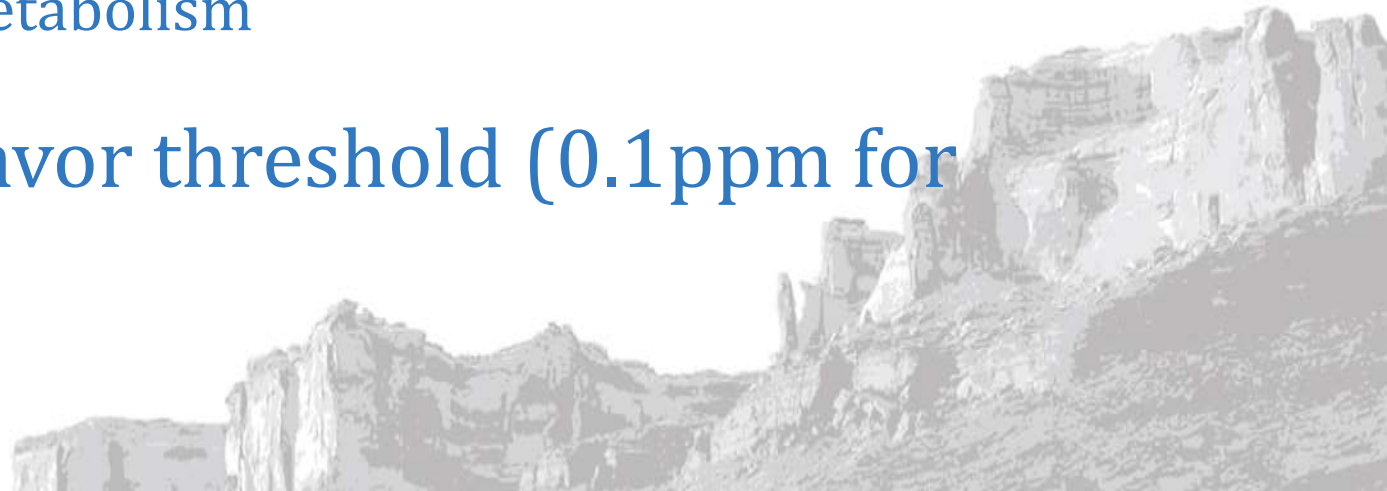
- ❖ No significant changes until above 10°C
- ❖ All below flavor threshold
- ❖ Decrease in propanol and iso-butanol possibly due to limited melanoidin-facilitated oxidation (low porosity of the wood, high alcohol content of the beer)



VDK`s y`all

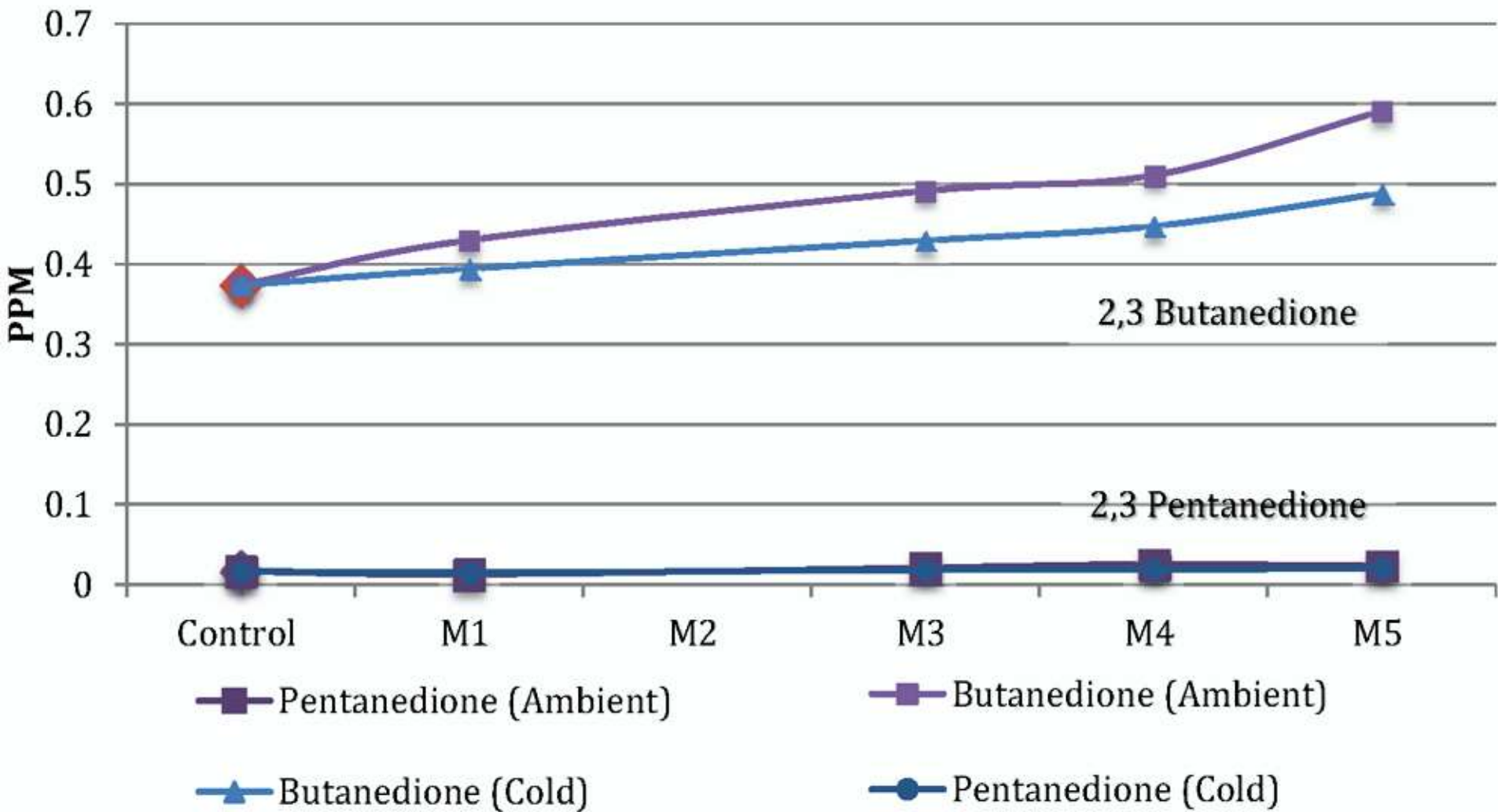


- ❖ 2,3 butanedione = great sensitivity to temperature, rises from 10°C
- ❖ Possibly the result of Maillard reactions
(Vanderhaegen, et. al, Aging Characteristics of Different Beer Types, 2006).
 - ❖ Maillard compounds can potentially inhibit yeast cell metabolism
- ❖ Above flavor threshold (0.1ppm for diacetyl)





VDKs





Aldehydes



Tested For

- ❖ 2-methyl propanal, 2-methyl butanal, 4-methyl butanal, pentanal, hexanal, furfural, acetaldehyde
- ❖ All increased, with the Ambient Room showing the greatest increase

Contribution

- ❖ Indicates the degree of aging during maturation
- ❖ All of these are above flavor threshold except for furfural
- ❖ Potential marker for oxidation

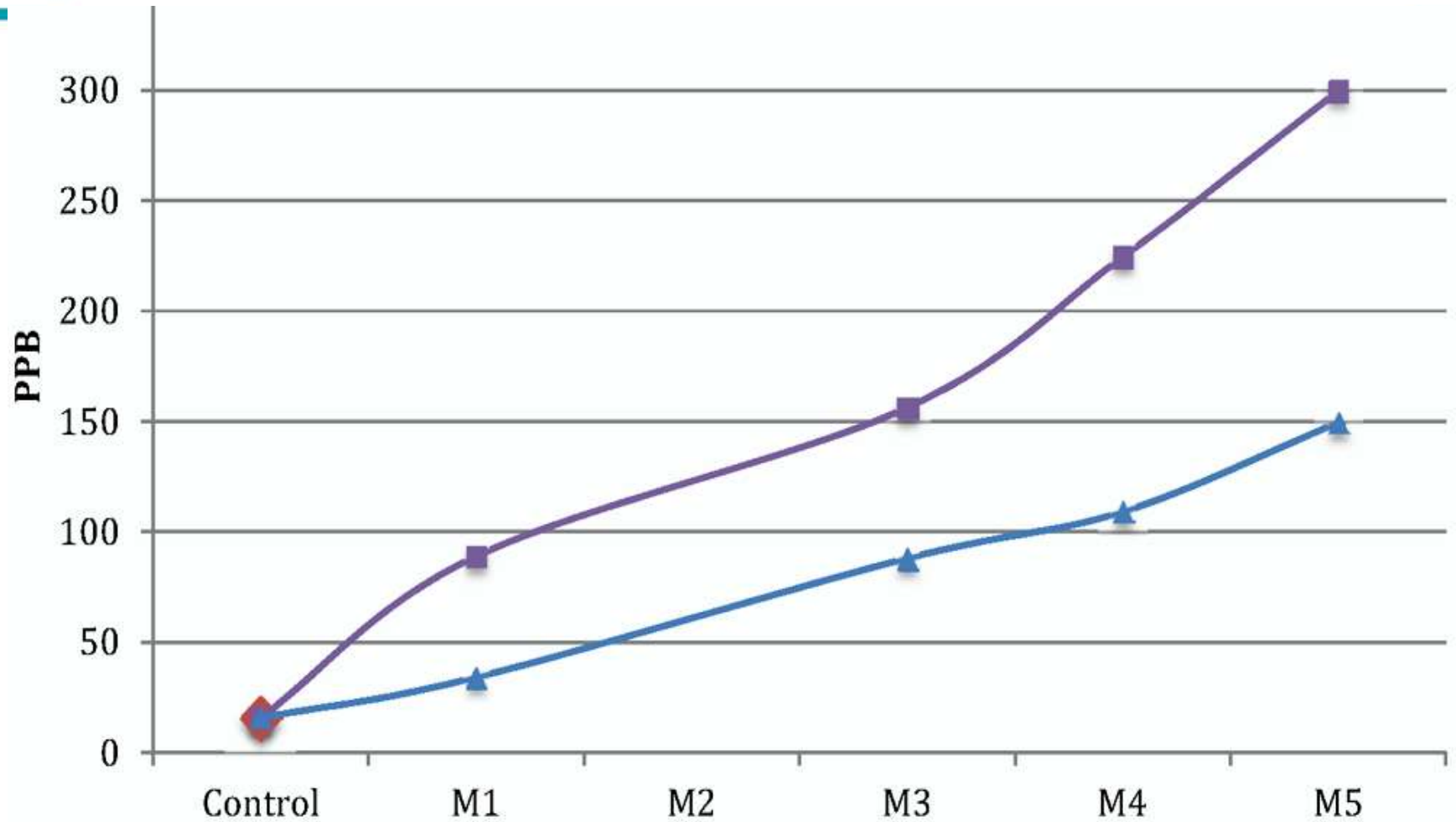


Furfural

- ❖ Furfural rise twice as much in Ambient Barrel Room
 - ❖ Steady rise from 10° C
 - ❖ Whiskey studies – aging marker
 - ❖ American oak lower levels, but in charred barrels the furan compounds equal French oak
 - ❖ Both Ambient and Cold Room below flavor threshold (150ppm)



Furfural Levels

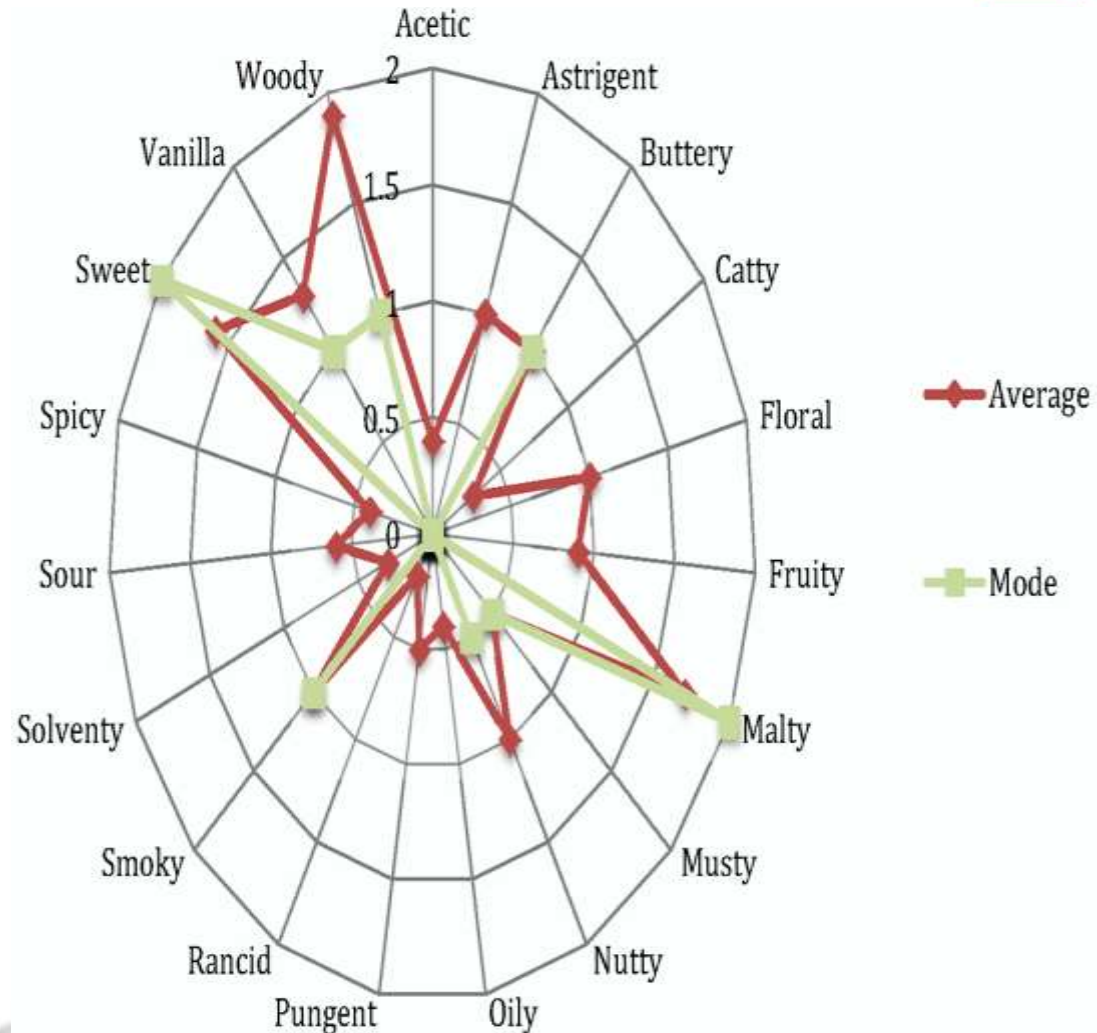




Sensory and Taste Panel

Ambient Room

- ❖ Vanilla, Chocolate, Woody aroma
- ❖ Woody, Oxidized, Alcoholic, Buttery taste
 - ❖ Greater sweet and buttery taste

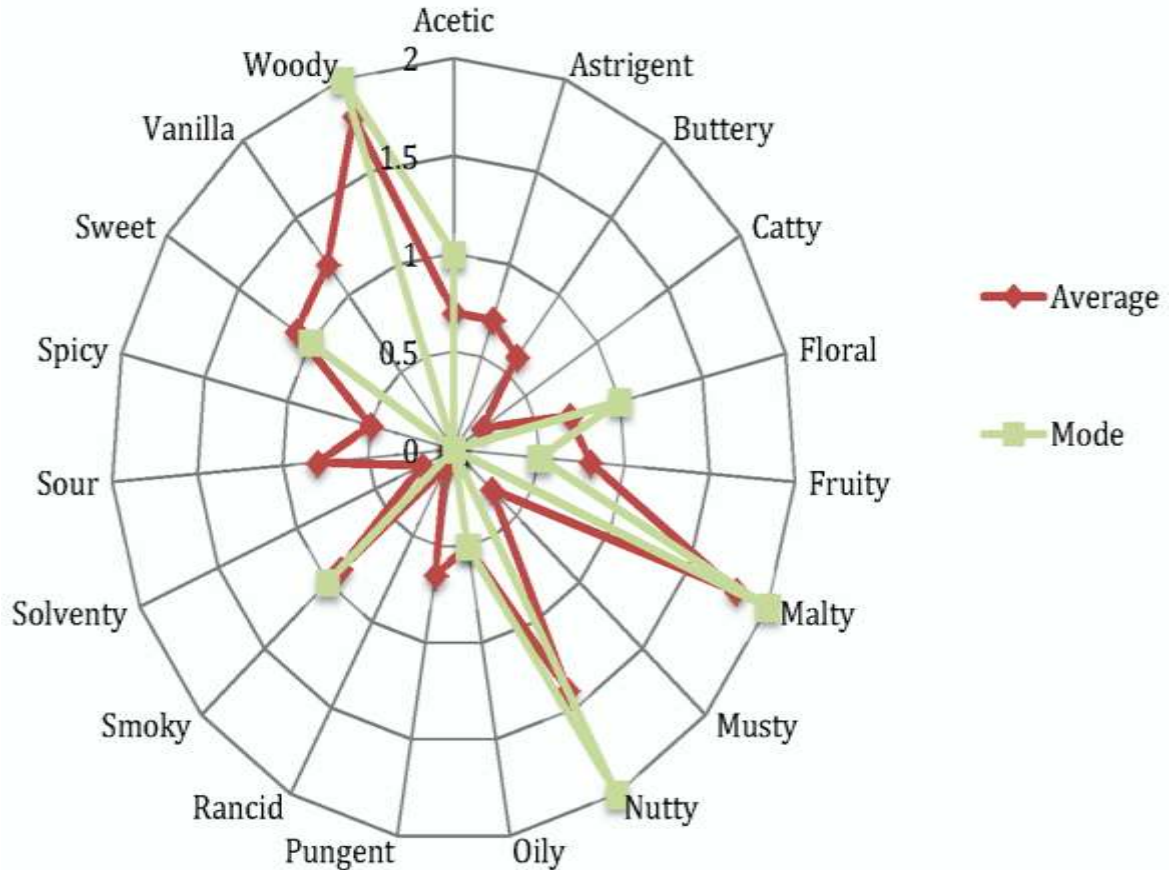




Sensory and Taste Panel

Cold Room

- ❖ Woody, chocolate, alcohol aroma
 - ❖ Greater woody character
- ❖ Nutty, chocolate, malty, taste
- ❖ Lack of vanilla, buttery taste





Temperature Conclusions

- ❖ 10°C crucial temp
 - ❖ most aldehydes, higher alcohols, esters clear change here
- ❖ 8°C
 - ❖ ethyl acetate, acetic acid, 2,3 butanedione, furfural – greater degree of sensitivity to temp

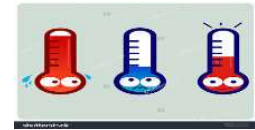


Reaction Rates

- ❖ Oxygen diffusion - increased level in warmer temps ?
- ❖ Cold temp maturation – antioxidant capability
 - ❖ Slower reaction rates
- ❖ Flavor-active monophenols – extracted at a higher temp, low pH, high alcohol content
 - ❖ Evident in Ambient Room Taste Panel preference
- ❖ Faster reaction rates, “oxidized” character in ambient temp room



Practical Take-Aways:



Wood-Aging Warehouse Conditions

- ❖ Looking at 8-10°C (46-50°F) for a stable maturation temperature
- ❖ Evaporation rate: depends on ethanol content, temp, humidity
 - ❖ Around 70% humidity = less evaporation, keeps barrels topped up
 - ❖ Tend to see a greater evaporation at a lower humidity

- ❖ Space Considerations
 - ❖ Well lit room
 - ❖ Decreases mold growth on barrels
- ❖ Barrel Stacking
 - ❖ Racks vs. pallet racking
 - ❖ Height considerations



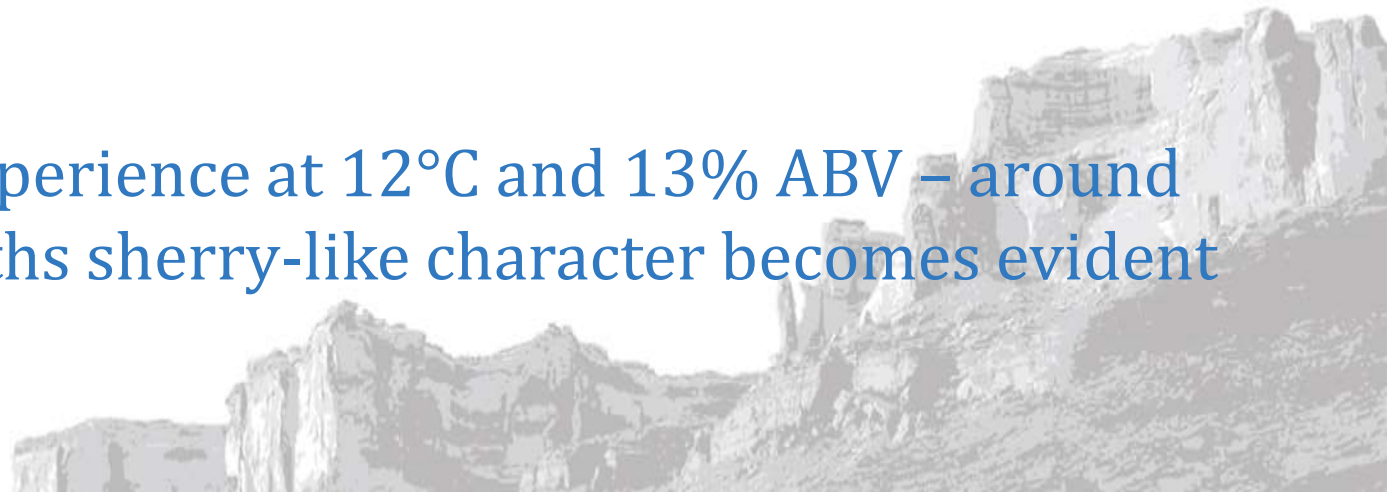





Practical Take-Aways: Time Considerations



- ❖ Degree of protection and flavor contribution (up to a point) from American oak (less oxygen diffusion), active char layer, alcohol
- ❖ Aging time dependant on temperature, alcohol, wood-type
- ❖ Practical experience at 12°C and 13% ABV – around 18-24 months sherry-like character becomes evident



A circular wooden barrel head is mounted on a vertical wooden post. The barrel head is light-colored wood with a dark horizontal band across its center. The French text is written in a white, cursive script. The background is a dark cellar with rows of similar wooden barrels stacked on racks. The lighting is warm and focused on the barrel head.

Le temps ne respecte
pas ce qui se fait
sans Lui

Molly Browning
mollyebrowning@gmail.com



Thank You

- ❖ Dr. Anne Hill and the staff at Heriot-Watt University
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- ❖ Brooklyn Brewery
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- ❖ John Stewart, Perrin Brewing Company





References

Baert, J., De Clippeller, J., Hughes, P., De Cooman, L., and Aerts, G.(2012). On the origin of free and bound staling aldehydes in beer.J. Agric. Food Chem. 60:11449-11472.

Coghe, Stefan., Hollander, H el ene D'Hollander, Verachtert, Hubert., Delavaux, Freddy. (2005). The Impact of Dark Speciality Malts on Extract Composition and Wort Fermentation. J. Institute of Brewing. 111:1 51-60.

Garde-Cerd an, T., Rodr iguez-Mozaz, S., and Anc n-Azpilicueta, C.(2002). Volatile composition of aged wine in used barrels of French oak and of American oak. Food Res. Int. 35:603-610.

Liebmann, A. J., and Rosenblatt, M. (1943). Changes in whisky while maturing. Ind. Eng. Chem. 35:994-1002.

Meilgaard, Morton. Flavor Chemistry of Beer: Part II; Flavor and Thresholds of 239 Aroma Volatiles (1975). MBAA Technical Quarterly. 12:3. 151-168.

Mosedale, J. R. (1995). Effects of oak wood on the maturation of alcoholic beverages with particular reference to whisky. Forestry 68:203-229.

Mosedale, J. R., and Puech, J.-L. (1998). Wood maturation of distilled beverages. Trends Food Sci. Technol. 9:95-101.



References

Poisson, L., and Schieberle, P. (2008). Characterization of the most odor-active compounds in an American bourbon whisky by application of the aroma extract dilution analysis. *J. Agric. Food Chem.* 56:5813-5819.

Saison, D., Schutter, D., Delvaux, F., and Delvaux, F. (2009). Contribution of staling compounds to the aged flavour of lager beer by studying their flavour thresholds. *Food Chem.* 114:1206-1215.

Saison, D., Schutter, D., Delvaux, F., and Delvaux, F. (2011). Improved flavour stability by aging beer in the presence of yeast. *J. Am. Soc. Brew. Chem.* 69:50-56.

Sterckx, F., Saison, D., and Delvaux, F. (2012). Wood aging of beer. Part I: Influence on beer flavour and monophenol concentrations. *J. Am. Soc. Brew. Chem.* 70:55-61.

Sterckx, F., Saison, D., and Delvaux, F. (2012). Wood aging of beer Part II: Influence of wood aging parameters on monophenol concentrations. *J. Am. Soc. Brew. Chem.* 70:62-69.

Vanderhaegen, B., Delvaux, F., Daenen, L., Verachtert, H., and Delvaux, F. (2007). Aging characteristics of different beer types. *Food Chem.* 103:404-412.