Optimizing High Gravity Fermentations

AHA Conference 2008

Cincinnati

Going Big

- Why?
  - Many Beer Styles to be conquered
  - More Flavor
  - Need to Overcome technical difficulties
- How?
  - Wort and Ingredients
  - Fermentation

Brewhouse

Fermentation

Big Fermentations

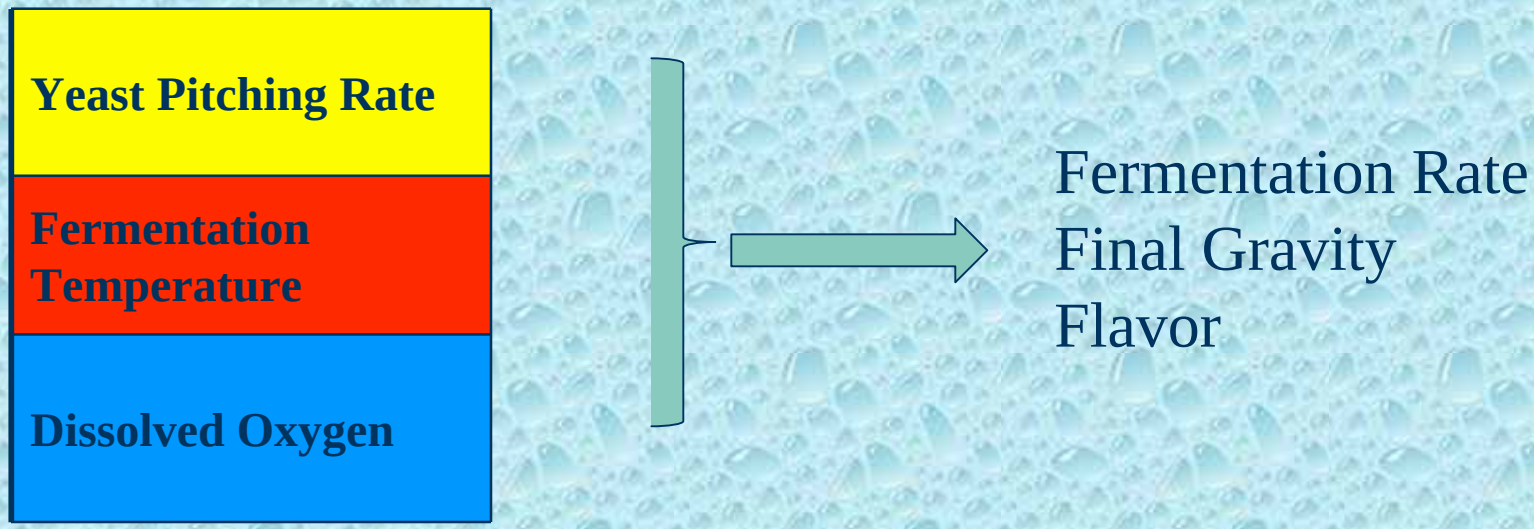
StReSsFuL:

Yeast has a lower glycogen content when subjected to stress
Yeast with lower glycogen leads to problematic yeast growth
possible underattenuation

In higher gravity fermentations:
yeast has a lower glycogen content throughout fermentation
Chlup et al 2007 (MBAA tech)

low glycogen content at end of fermentation will make reuse difficult

3 Controls in Fermentation



Trial Fermentations

MEASURE:
Fermentation Rate
Final Gravity
Flavor

Yeast Pitching Rate

?Pitch?

Yeast culture

1 million cells/ml/plato
10 plato = 10 million cells/ml
20 plato = 20 million cells/ml

1 lb per bbl
= 0.5 million cells/ml

Concentration of slurry?
Concentration of yeast culture/propagation?

Yeast Pitching Rate

Time (hours)	5 mil cells	10mil cells	20ml cells	30mil cells	40mil cells
0	18.7	18.7	18.7	18.7	18.7
24	17.8	17.6	16.8	16.5	16
48	13.6	13.2	12.5	12.1	12
72	10.9	10.9	9.3	9.7	9.8
96	9.3	9.1	8.7	8	8.2
120	7.4	7.3	6.8	6.6	6.6
144	5.9	5.9	5.9	5.8	5.8
168	4.8	4.7	4.8	5.1	4.9

Yeast Pitching Rate

	5 mil cells	10mil cells	20ml cells	30mil cells	40mil cells
GROWTH RATE					
3 Days	5.5	3.4	1.9	1.5	1.5

Fermentation Temperature

- Higher Temperatures-
  - Faster Fermentations
  - Increased secondary metabolites
  - Increased flavor active compounds in your beer

Dissolved Oxygen

Dissolved Oxygen

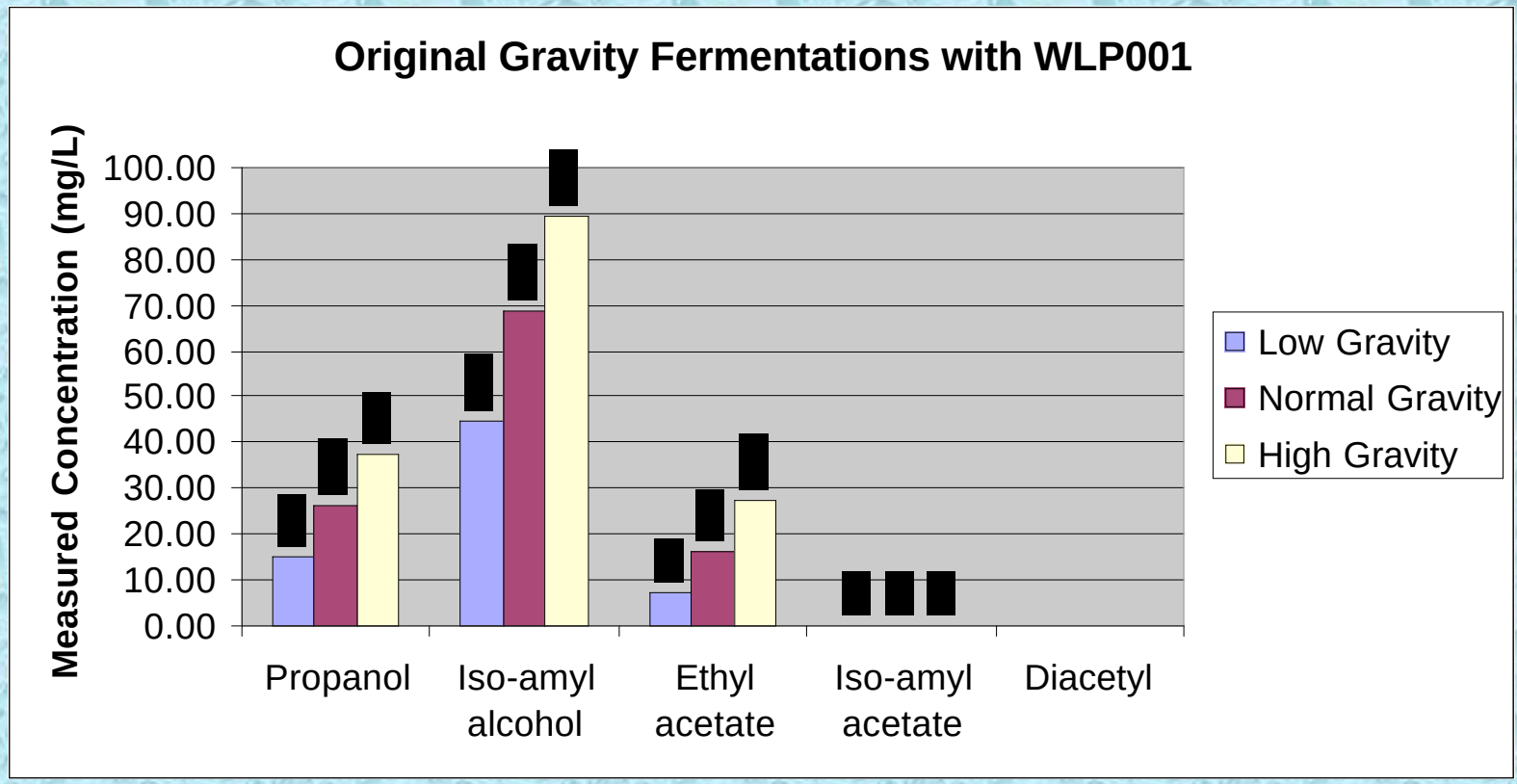
Gravity (plato) vs. Time

	2.71ppm	5.12ppm	9.2ppm	14.08ppm
	shake	30 seconds	1 min	2 min
Time (hours)				
0	18.7	18.7	18.7	18.7
24	17.6	17.3	17.5	16.9
48	13.5	12.8	12.7	11.9
72	11.7	10.7	9.9	9.5
96	10	9	8.8	7.8
120	7.8	7.3	6.5	6.2
144	6.4	6.3	5.5	5.2
168	5.3	5	4.3	4.3

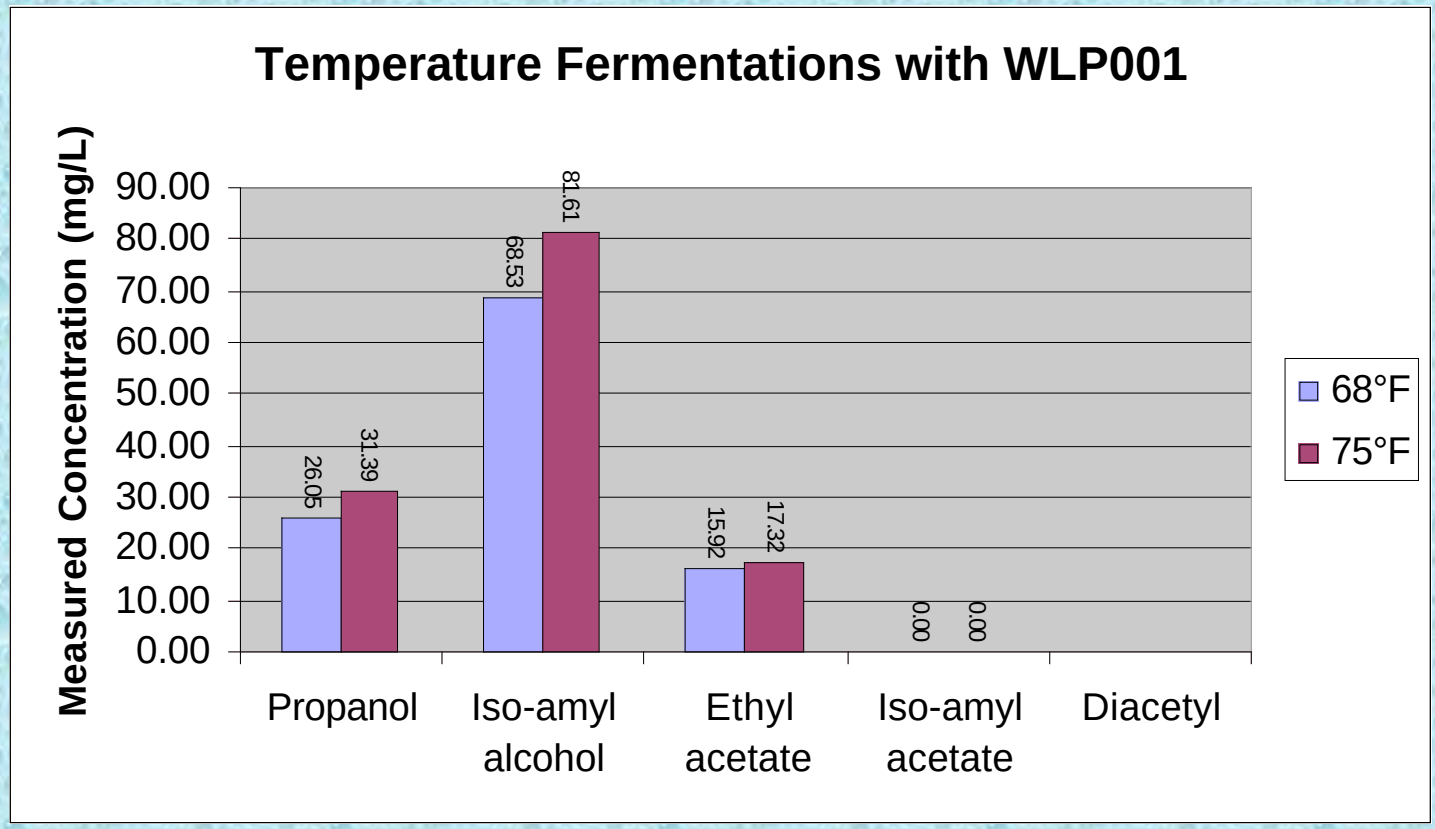
Flavor

Flavor Compound	Detection Limit (mg/L)	Typical Level in Beer (mg/L)	Flavor Threshold (mg/L)
n-Propanol	1-1000	3-16	600-800
Iso-amyl Alcohol	10-100	50	70
Ethyl Acetate	10-100	10-50	30-50
Iso-amyl Acetate	1-10	0.5-3	1-2
Diacetyl	0.05-0.8	0.01-0.6	0.08

Flavor


Original Gravity Fermentations with WLP001
Measured Concentration (mg/L)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Propanol
Iso-amyl alcohol
Ethyl acetate
Iso-amyl acetate
Diacetyl
Low Gravity
Normal Gravity
High Gravity

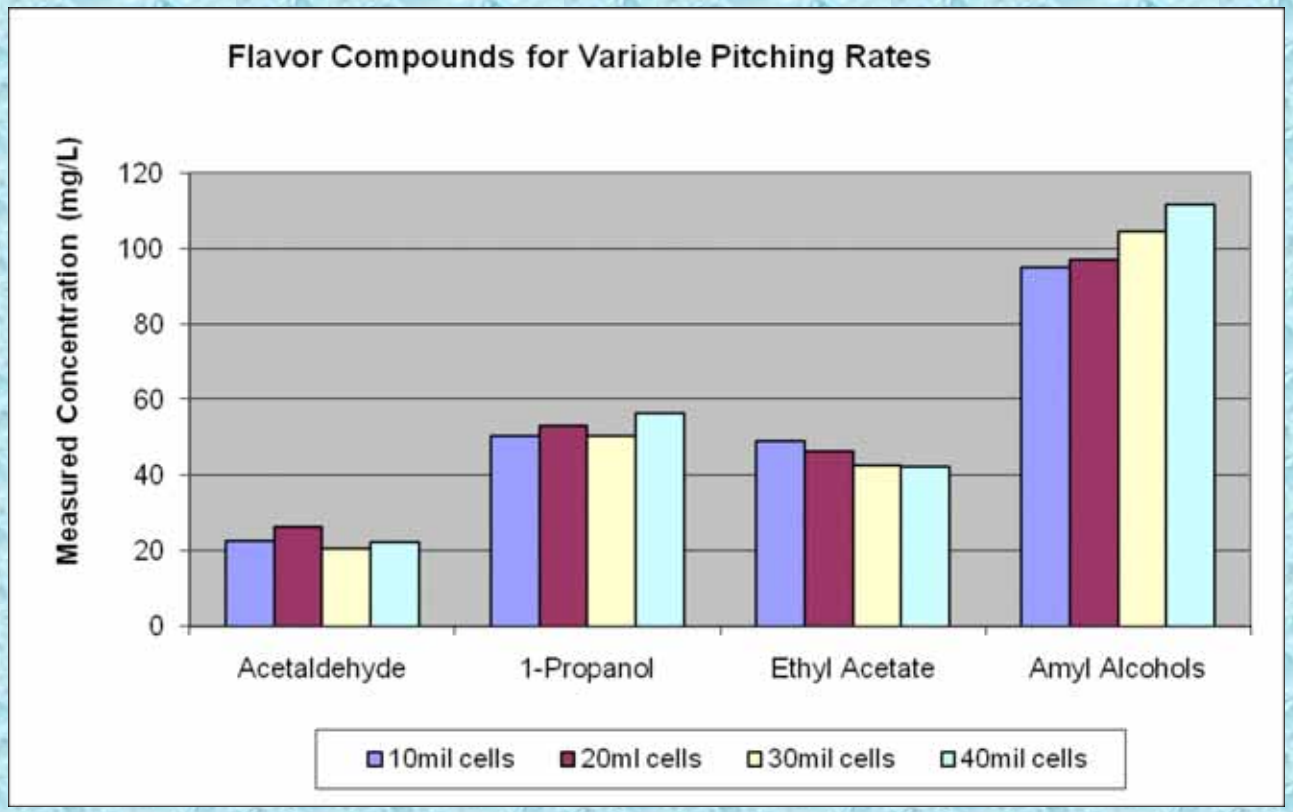
Flavor: Temperature Effects



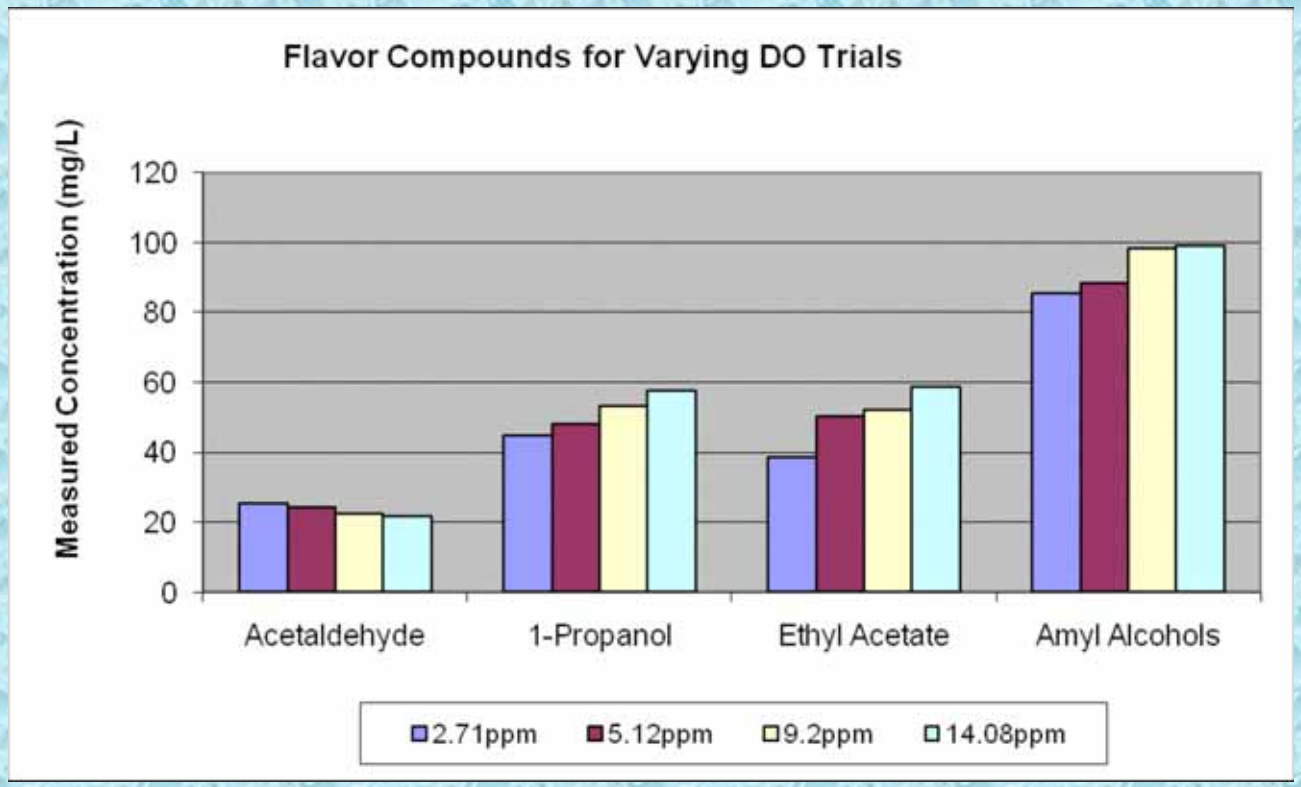
Temperature Control Matters?

	75 F	66 F	Threshold
Ethanol	5.04% abv	4.74% abv	1.4% abv
1-Propanol	22.76 ppm	23.78 ppm	600 ppm
Ethyl Acetate	33.45 ppm	22.51 ppm	30 ppm
Iso-amyl alcohol	114.92 ppm	108.43 ppm	70 ppm
Total Diacetyl	8.23 ppb	7.46 ppb	150 ppb
Total 2,3-pentanedione	3.17 ppb	5.09 ppb	900 ppb
Acetaldehyde	152.19 ppm	7.98 ppm	10 ppm

Flavor: Pitching Rate Effects



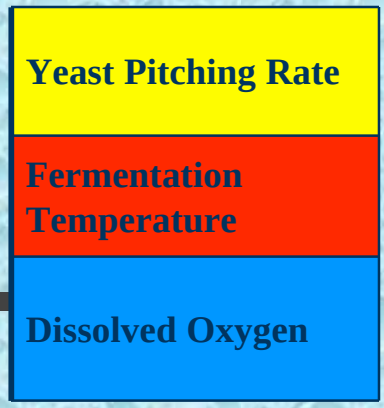
Flavor: Dissolved Oxygen Effects



Other: Trial Fermentations

Time	WLP001	WLP028	WLP051	WLP530	WLP575	WLP400	WLP099
0	12.5	12.5	12.5	12.5	12.5	12.5	12.5
22	9.5	8.4	8.2	9.3	9.7	9.5	9.1
44	4.5	3.9	4.1	3.8	3.6	4.6	3.9
68	3.3	3.5	3.5	3	2.8	3.1	2.4
92	2.6	3.3	3.2	2.7	2.6	2.6	1.7
140	2.5	3.2	2.9	2.6	2.6	2.5	1.2

Recommendations



- ✓High Glycogen: Pitch the *healthiest* yeast possible
- ✓Control the Temperature: Already have increased flavor
- ✓Control the Dissolved Oxygen Levels: Let's get them drier
- ✓Enjoy Your Beer!!

Thanks!

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The lab staff in San Diego