Very high gravity brewing: effects of the processes on fermentation in 30 ° Plato wort

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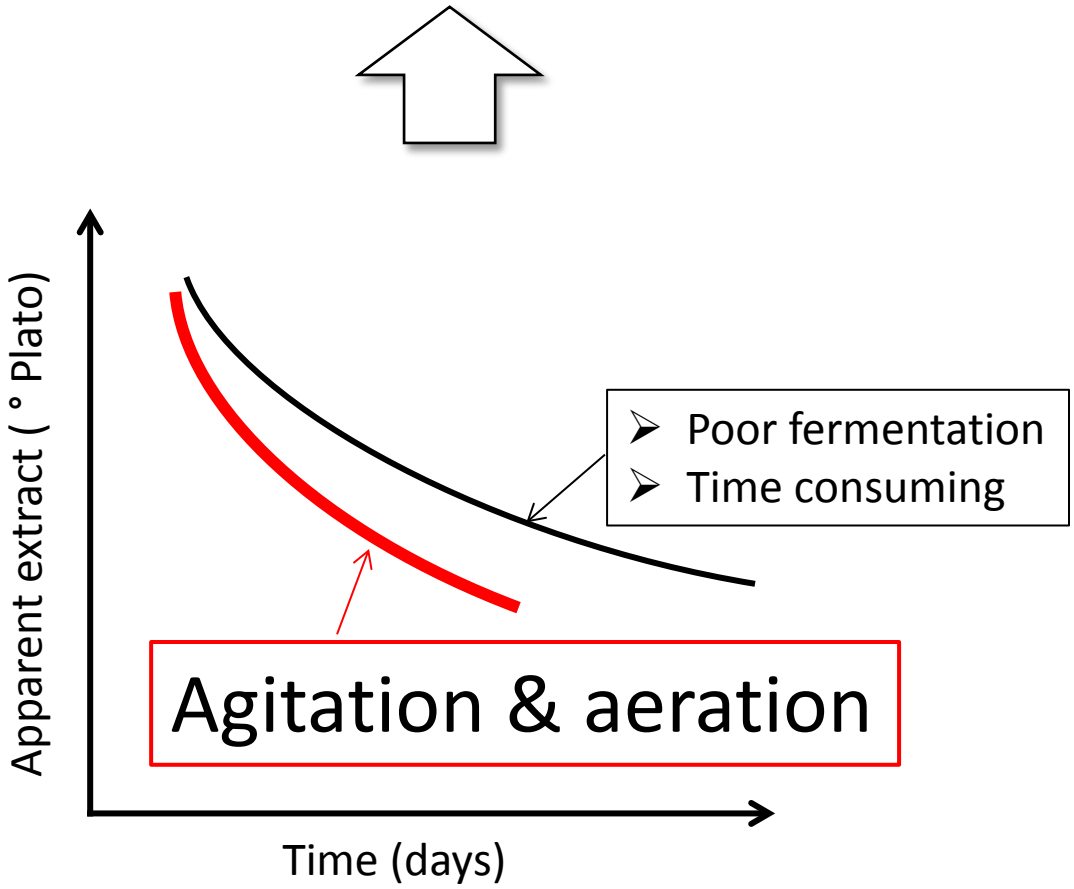
Fermentation in 30 ° Plato wort is likely to complete within eight days



Outline

I. Introduction

II. Results

- Fermentative efficiency by combination of agitation and aeration
- Effects of those processes on beer quality

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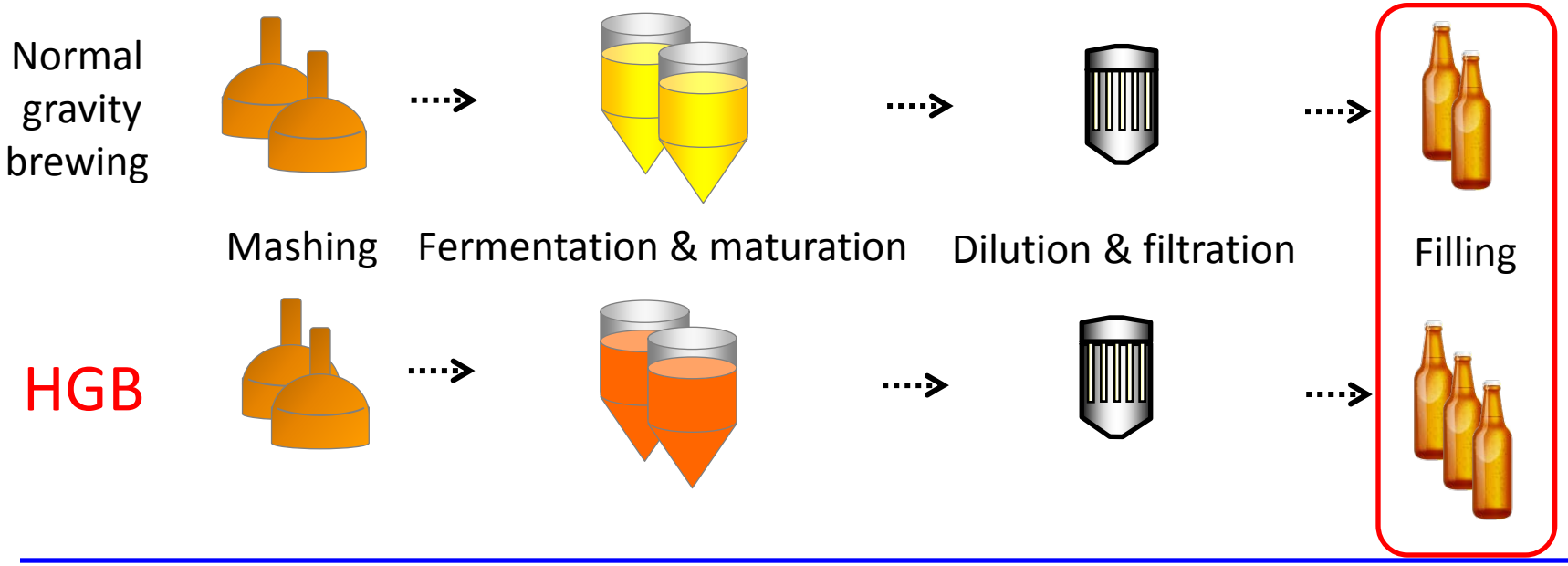
What is high gravity brewing (HGB)?

- Increases productivity without expanding existing brewing facilities

- Decreases in energy consumption



High gravity brewing: 16-18 ° Plato
Very high gravity brewing: 20-30 ° Plato

What are the disadvantages?

- Poor fermentation performance
- Flavor profile changes
- Decreasing of beer foam stability

To overcome poor fermentation performance

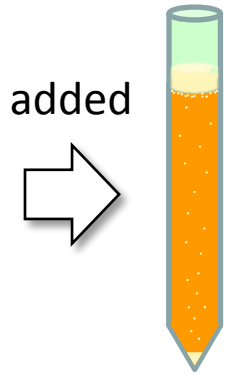
- Maintain yeast performance

Various yeast nutrient

- ✓ Fatty acids
- ✓ Sterols
- ✓ Free amino nitrogen

and so forth

added



- Determination of the optimal oxygenation of initial wort
- Isolation of yeast improved fermentation performance

Few study about effects of processes on fermentation

Objectives of this study

- Investigation of fermentative efficiency by combination of agitation and aeration
- Understanding effects of these processes on beer quality

Why agitation and aeration?

Increases contact frequency of yeast and nutrient by agitation

Enhances tolerance of yeast to ethanol stress by aeration

⇨ Increases free ergosterol content in yeast by aeration

⇩

We examined whether fermentative efficiency can be improved

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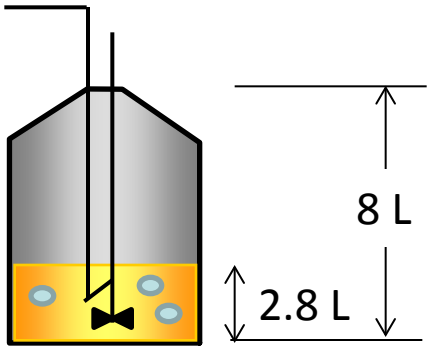
2.8 L-scale fermentation test

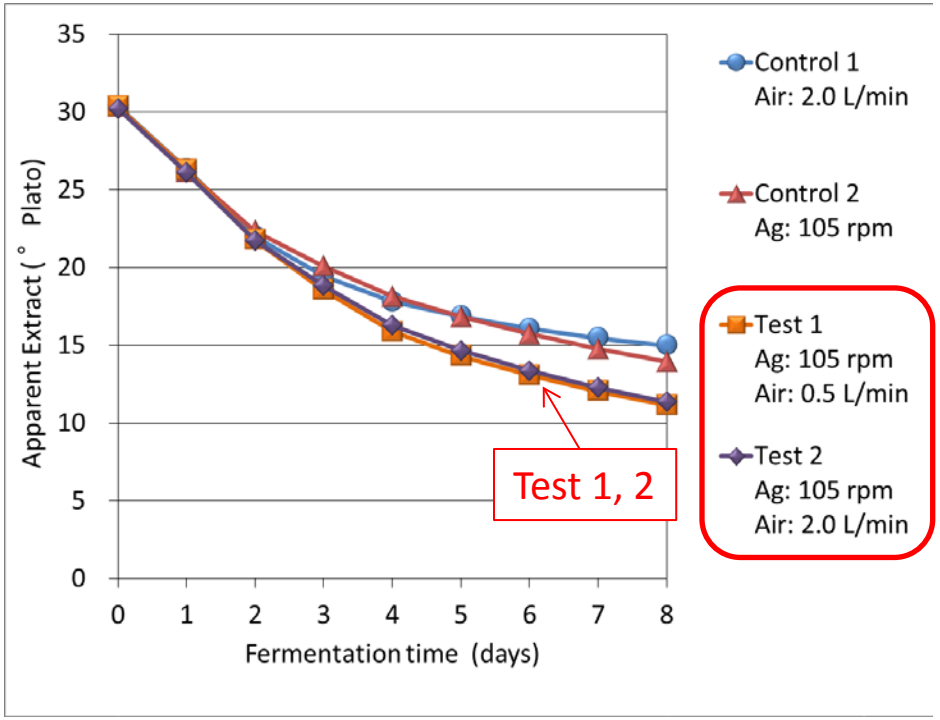
Wort	All-malt 12 ° Plato wort added corn syrup
Wort gravity	30 ° Plato
Yeast	Bottom-fermenting yeast W34/70
Temperature	15 ° C (59 ° F)

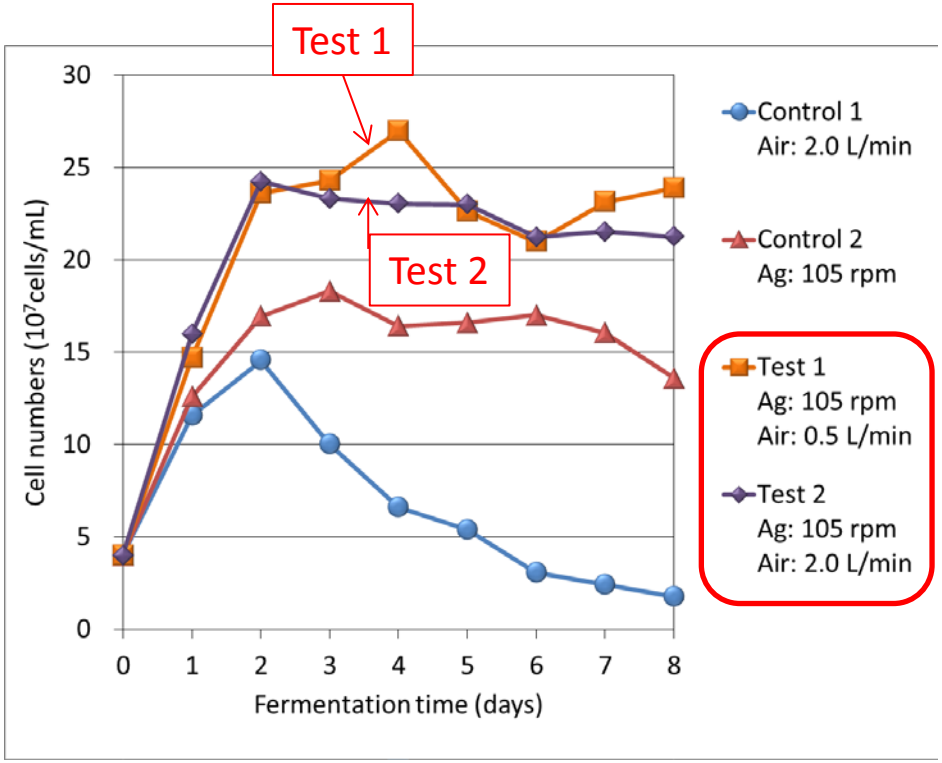


Jar fermentor

	Pitching rate (cells/mL)	Aeration		Agitation	
		Supply (L/min)	Time (days)	Condition (rpm)	Time (days)
Control 1	4.0×10^7	2.0	four	-	-
Control 2		-	-	105	eight
Test 1		0.5	four	105	eight
Test 2		2.0			

2.8 L-scale fermentation of 30 ° Plato wort





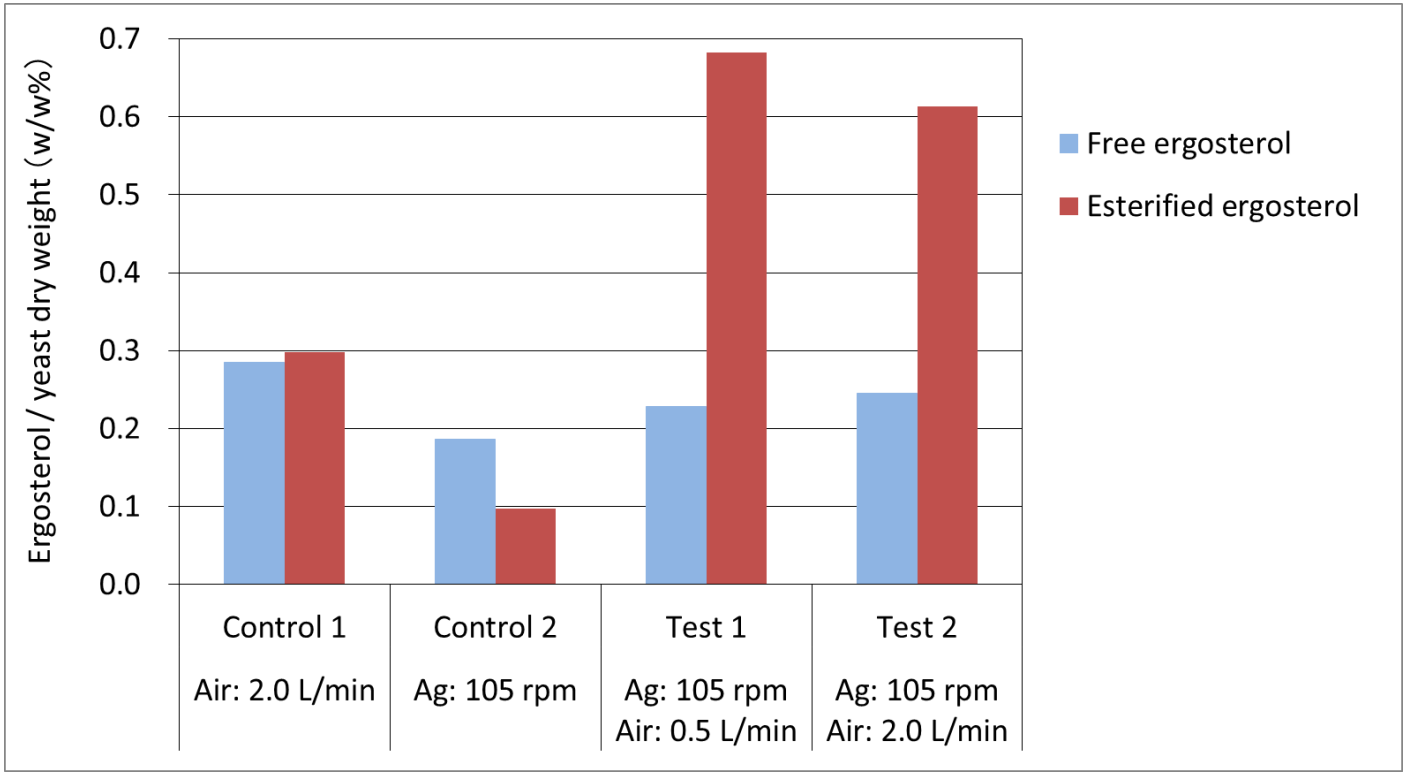
- Fermentative efficiency was improved by combination of agitation and aeration (Test 1, 2)

Alcohol, OG, RE and AE at the end of fermentation

		Control 1 Air: 2.0 L/min	Control 2 Ag: 105 rpm	Test 1 Ag: 105 rpm Air: 0.5 L/min	Test 2 Ag: 105 rpm Air: 2.0 L/min
Alcohol	v/v%	9.48	10.04	11.43	11.15
Original gravity	° Plato	30.15	30.14	29.81	29.57
Real extract	w/v%	19.09	18.17	15.54	15.66
Apparent extract	w/w%	14.84	13.87	11.09	11.28

- It was possible to produce up to 11 % alcohol by both agitation and aeration within eight days (Test 1, 2)

Free and esterified ergosterol content in yeast at the end of fermentation

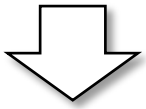


Free ergosterol is localized at the plasma membrane
Esterified ergosterol is stored in the lipid granule

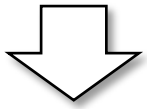
- The amount of free ergosterol was similar among those

Summary: fermentative efficiency by combination of agitation and aeration

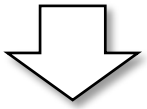
Free ergosterol content in yeast was similar among those



This result may not be accounted for increasing the ethanol tolerance



Yeast grew effectively by the synergy of agitation and aeration



Improved fermentative efficiency

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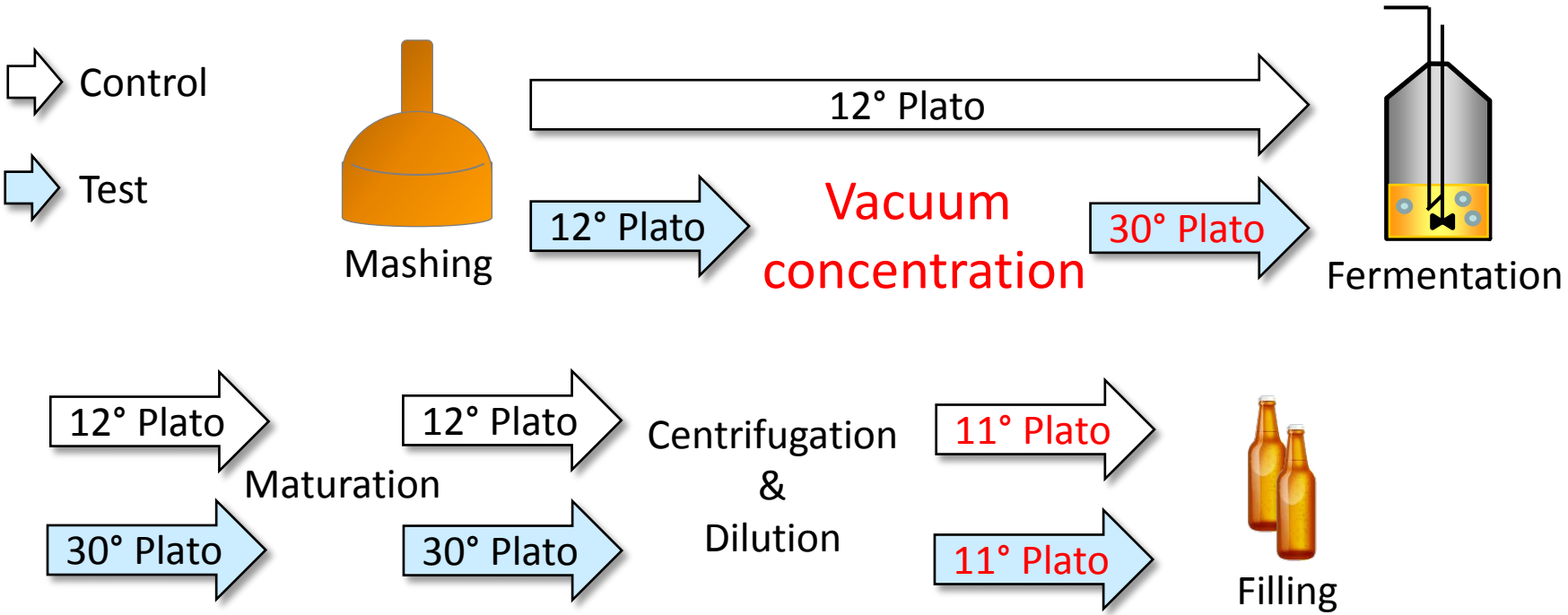
Very high gravity brewing using vacuum concentrated all-malt wort

Objective:

- To investigate effects of agitation and aeration during fermentation on beer quality



Results of wort analysis

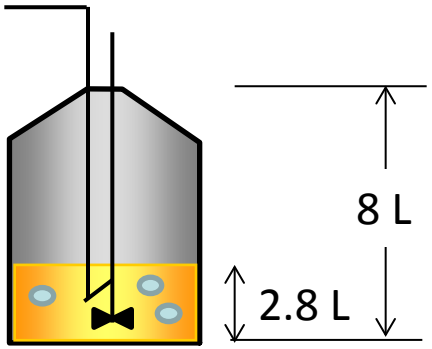
Vacuum concentrated all-malt wort

		Control	Test
Wort gravity	°Plato	12.25	29.14
FAN	mg/L	235	581
Zinc	ppb	138	406
IBU	-	42.4	91.5

- Wort was concentrated to about 2.5 times compared to the control

2.8 L-scale fermentation test

Wort	All-malt type
Wort gravity	Control : 12 ° Plato
	Test 1, 2, 3 : 30 ° Plato
Yeast	Bottom-fermenting yeast W34/70
Temperature	Control : 12 ° C (53.6 ° F)
	Test 1, 2, 3 : 15 ° C (59 ° F)

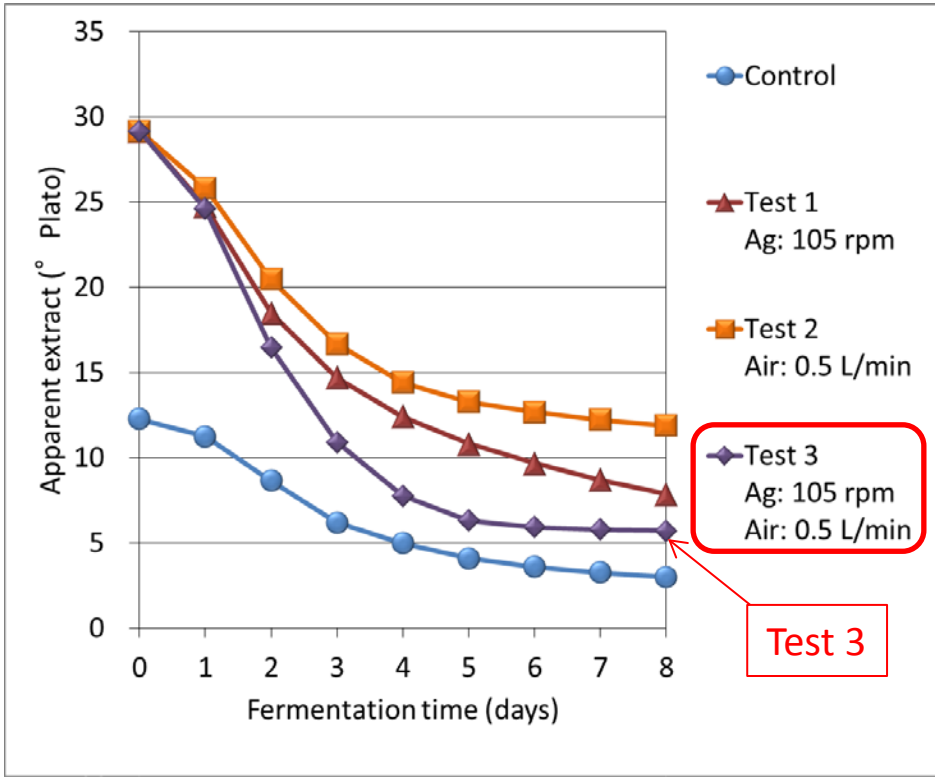


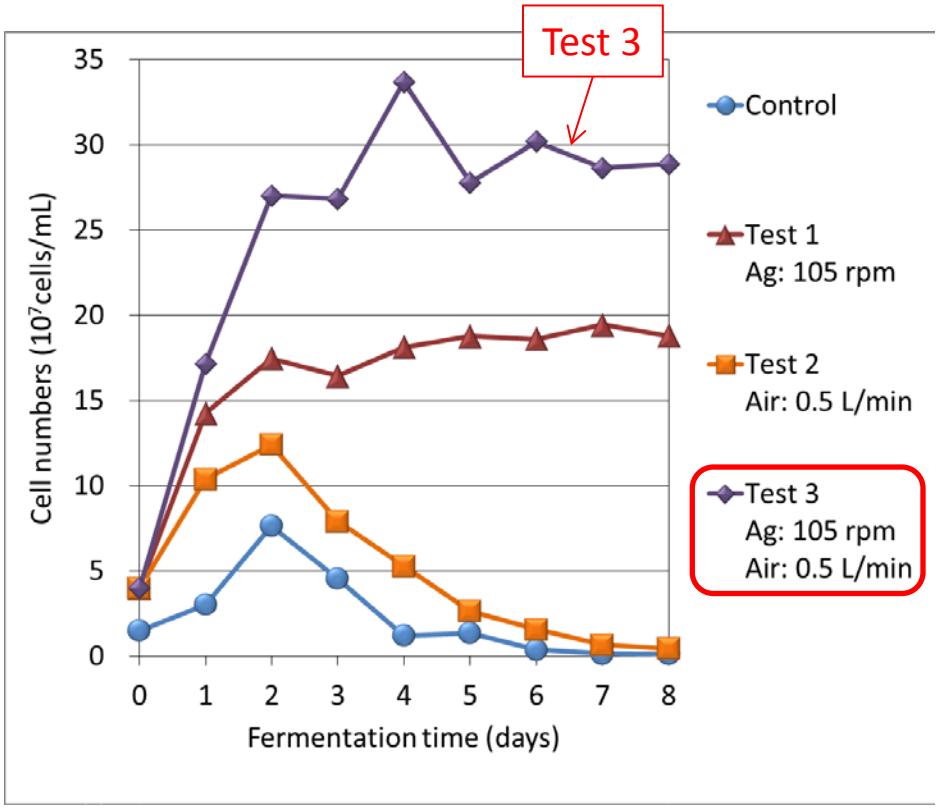
Jar fermentor

	Wort Gravity (° Plato)	Pitching Rate (cells/mL)	Aeration		Agitation	
			Supply (L/min)	Time (days)	Condition (rpm)	Time (days)
Control	12	1.5×10^7	-	-	-	-
Test 1	30	4.0×10^7	-	-	105	eight
Test 2			0.5	four	-	-
Test 3			0.5		105	eight

Test 1, 2 and 3 were used vacuum concentrated all-malt wort

Results of 2.8 L-scale fermentation





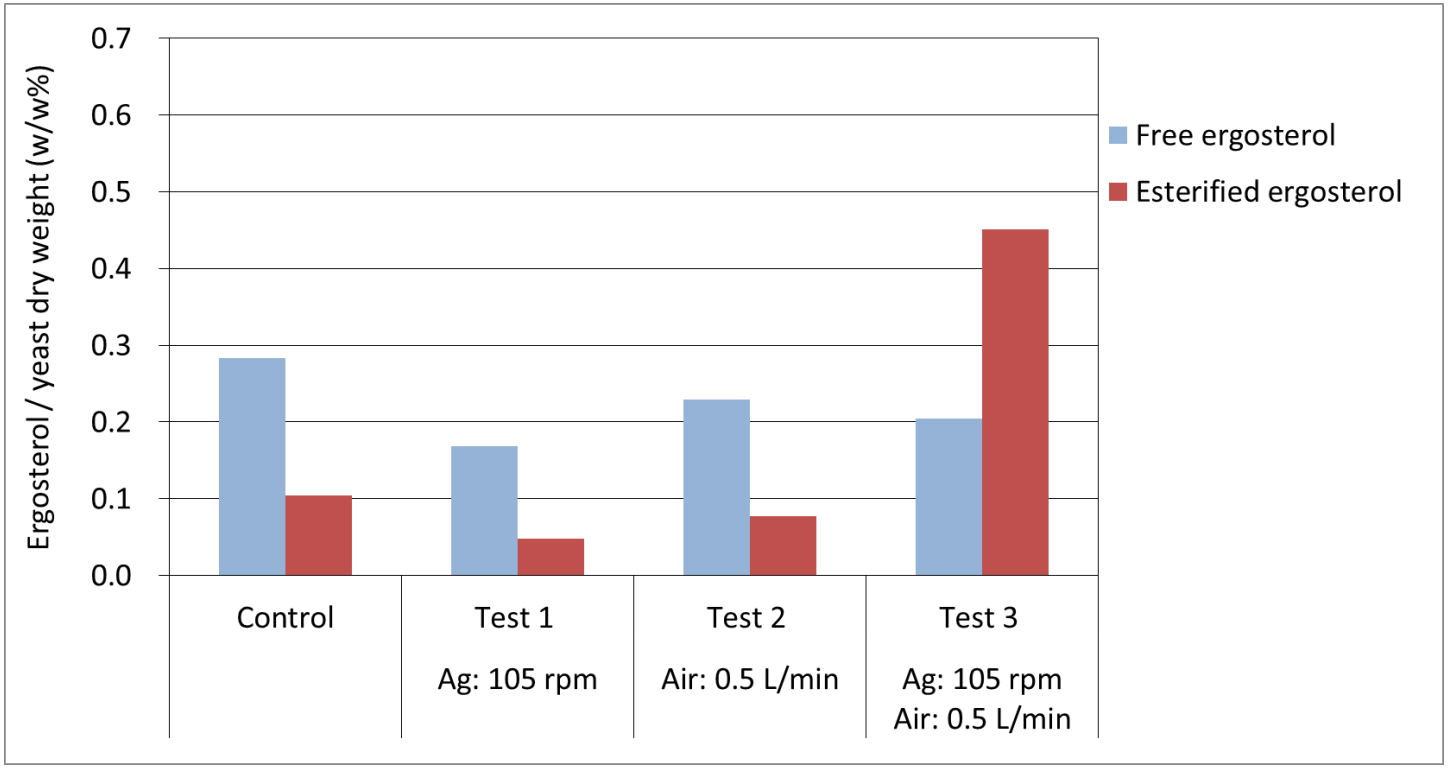
- Fermentative efficiency was improved by combination of agitation and aeration (Test 3)

Alcohol, OG, RE and AE at the end of fermentation

		Control	Test 1 Ag: 105 rpm	Test 2 Air: 0.5 L/min	Test 3 Ag: 105 rpm Air: 0.5 L/min
Alcohol	v/v%	5.19	12.88	10.82	13.84
Original gravity	° Plato	12.48	29.06	29.09	28.90
Real extract	w/v%	4.71	12.24	15.57	10.48
Apparent extract	w/w%	2.77	7.62	11.29	5.68

- It was possible to produce up to 13 % alcohol by both agitation and aeration within eight days (Test 3)

Free and esterified ergosterol content in yeast at the end of fermentation



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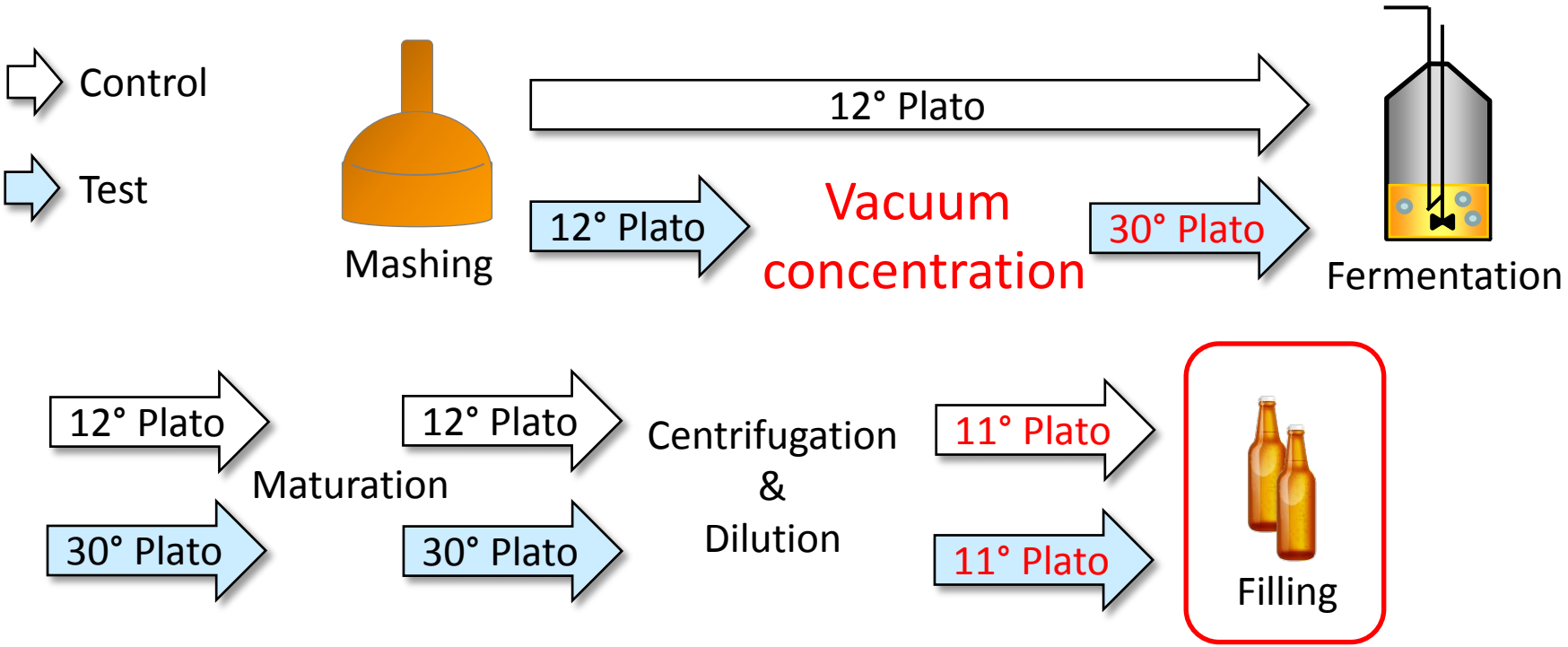
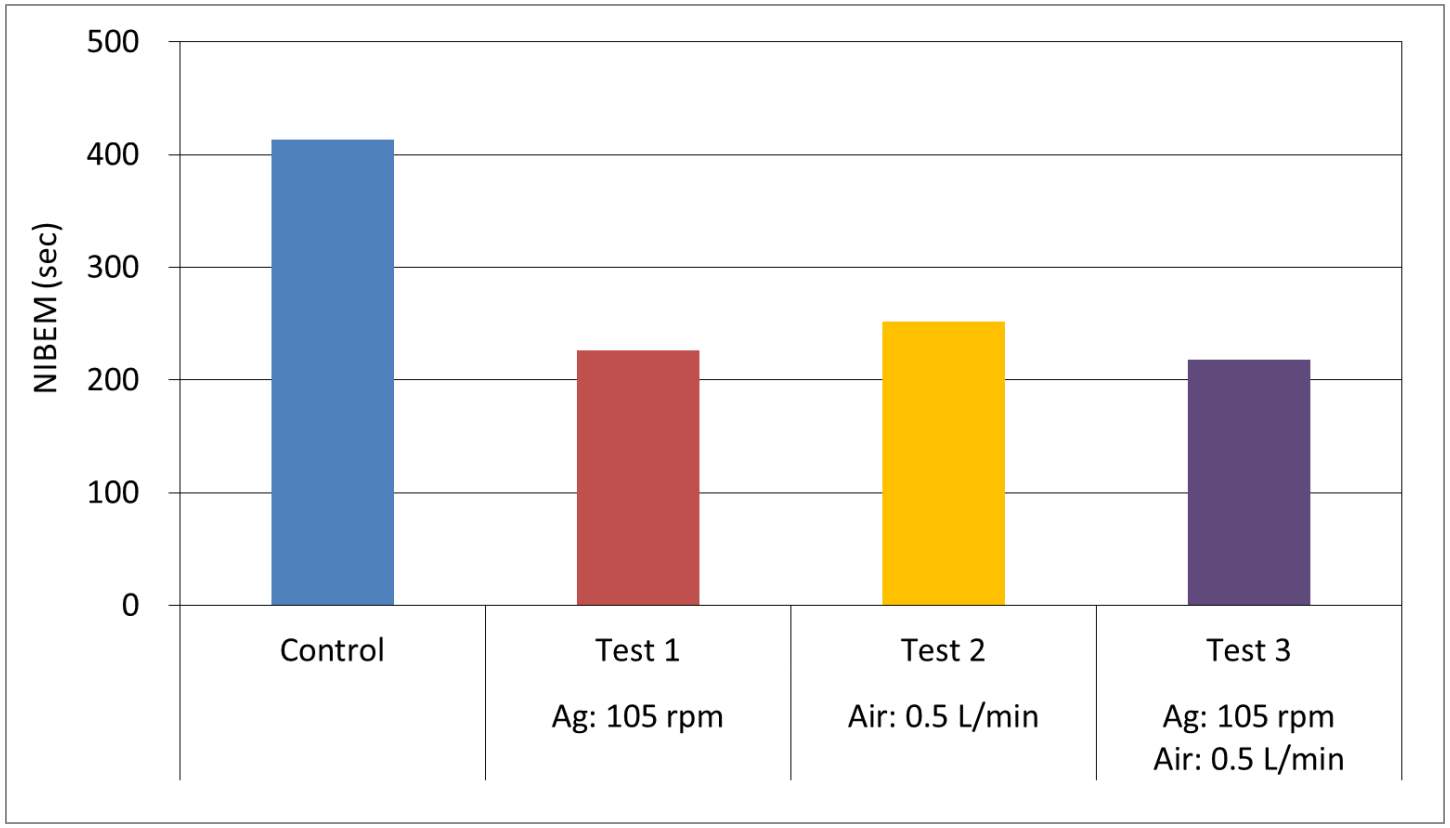
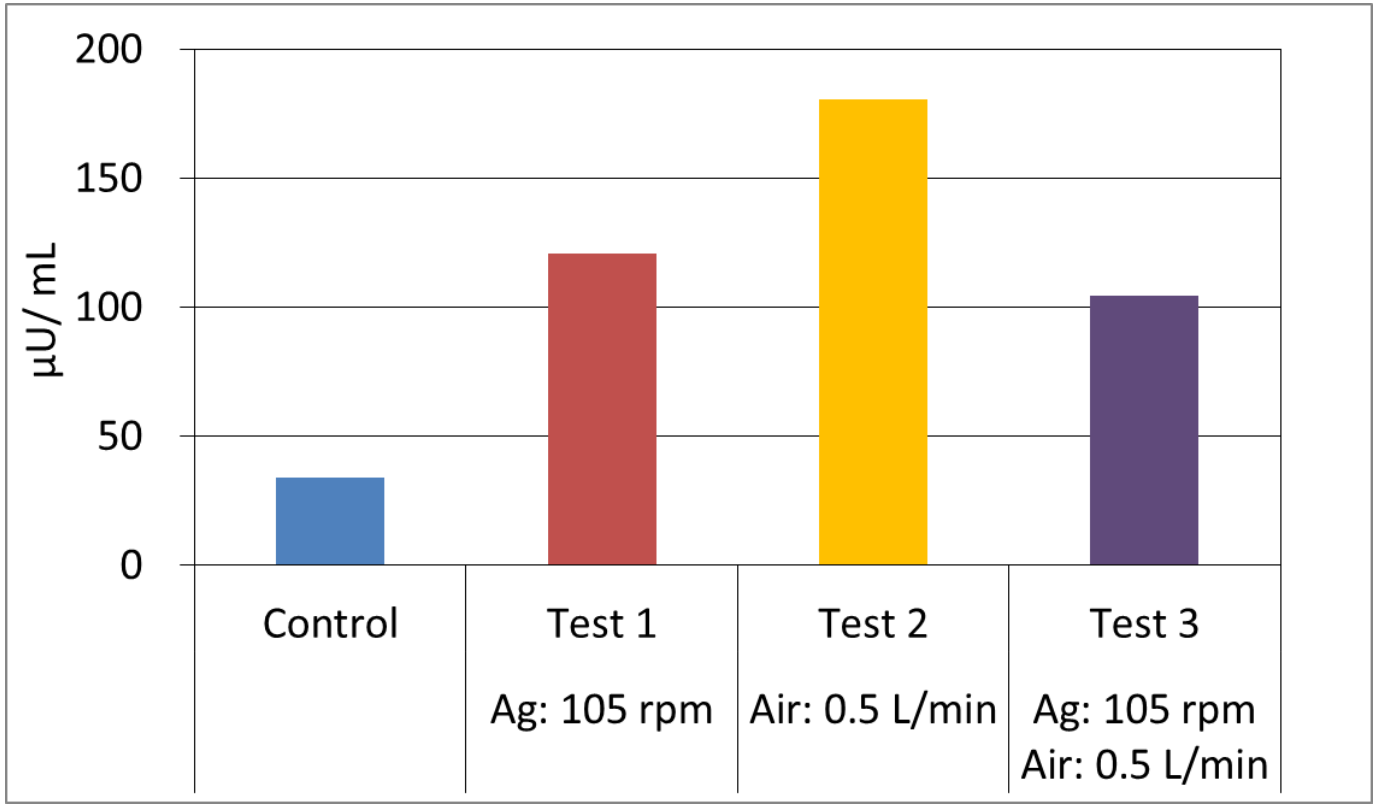


Effect of very high gravity brewing on beer foam stability



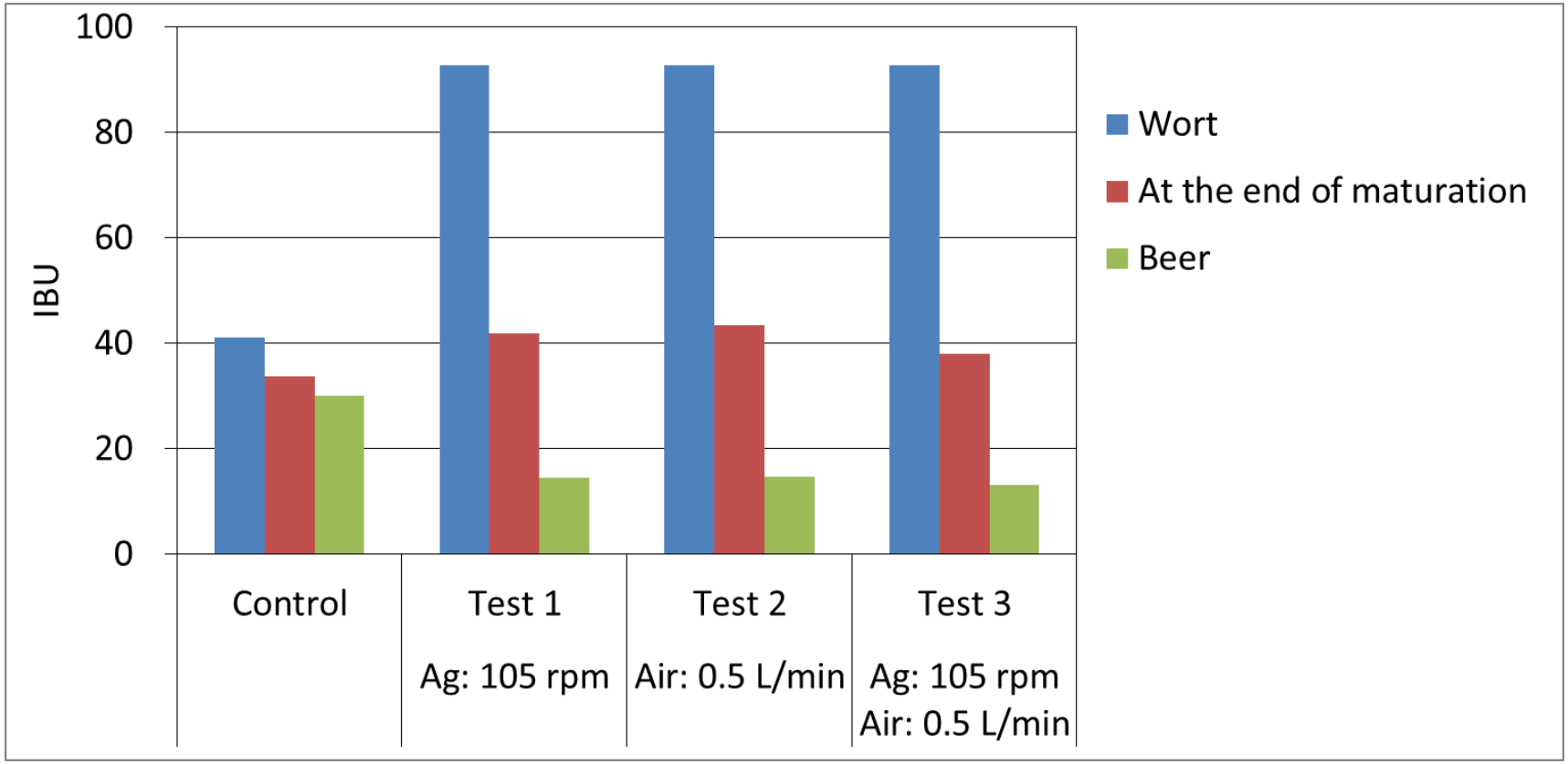
- NIBEM on beer decreased by very high gravity brewing

Extracellular PrA (Proteinase A) activity at the end of maturation



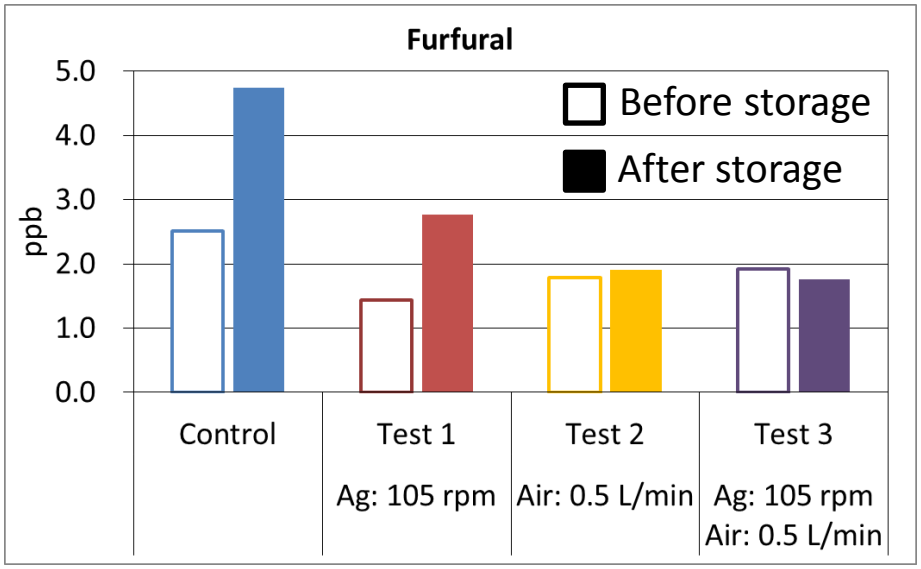
- Extracellular PrA level increased by very high gravity brewing

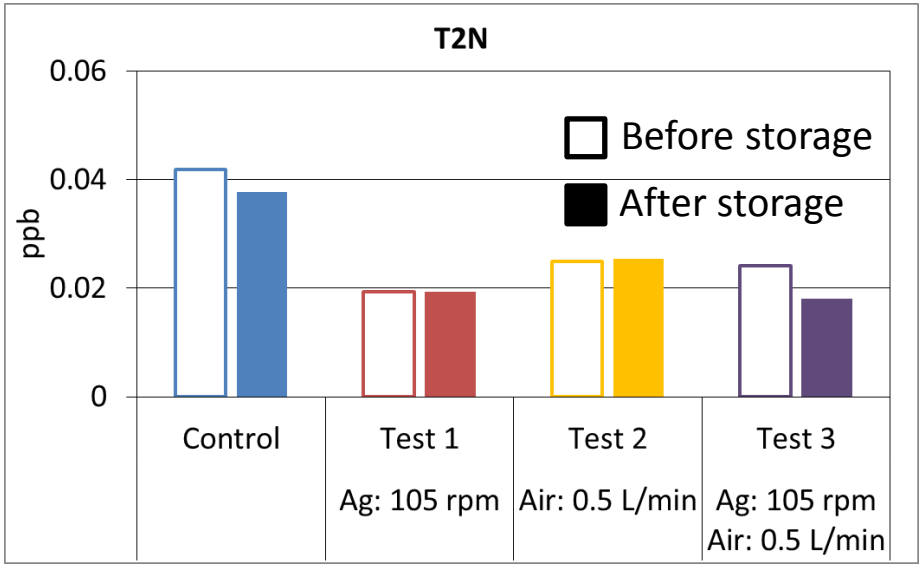
Change of IBU from wort to beer



- IBU of beer decreased by very high gravity brewing compared to the control

Effect of agitation and aeration during fermentation on beer flavor stability





Beers stored for one month at 20 ° C (68 ° F)

- Agitation and aeration may not influence on beer flavor stability

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Summary

- Very high gravity brewing fermentation is likely to achieve within a shorter period of time because yeast grows effectively by the synergy of agitation and aeration.

- NIBEM on beer might be decreased because extracellular PrA level increased and IBU decreased by very high gravity brewing. We will investigate proteins associated with foam stability.

- Agitation and aeration during fermentation may not influence on beer flavor stability.

We conclude that combination of agitation and aeration is useful for very high gravity brewing fermentation.

Thank you for your attention

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