The Control of Higher Alcohol and Ester Production in High Temperature Fermentation

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Asahi's Beer Brands

year	2003	2013
full year	13	20
seasonal	0	6
selective distribution	0	5
total	**13**	**31**

Premium

Regular

Low calorie

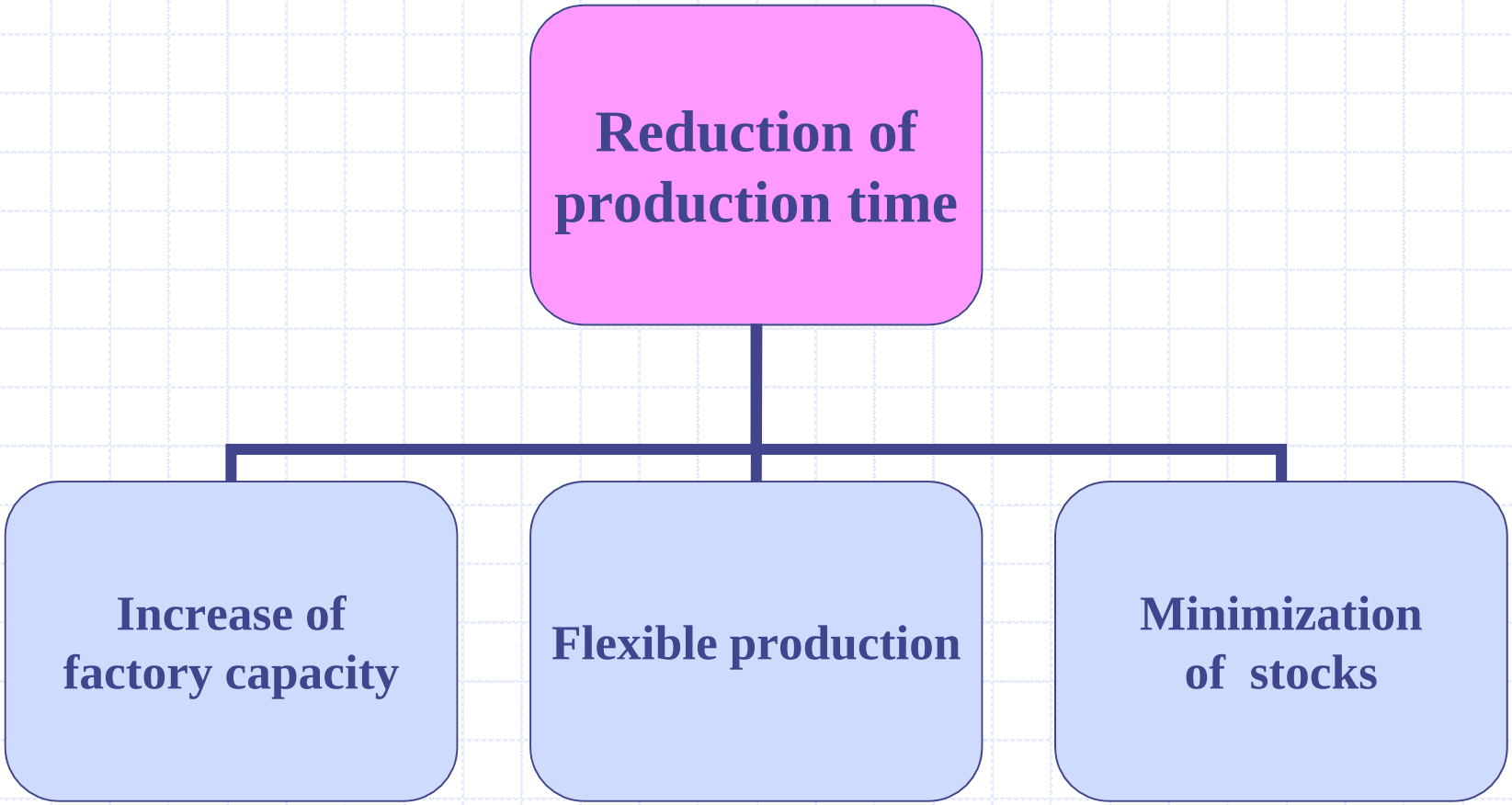
Beer mix

Non-alcohol

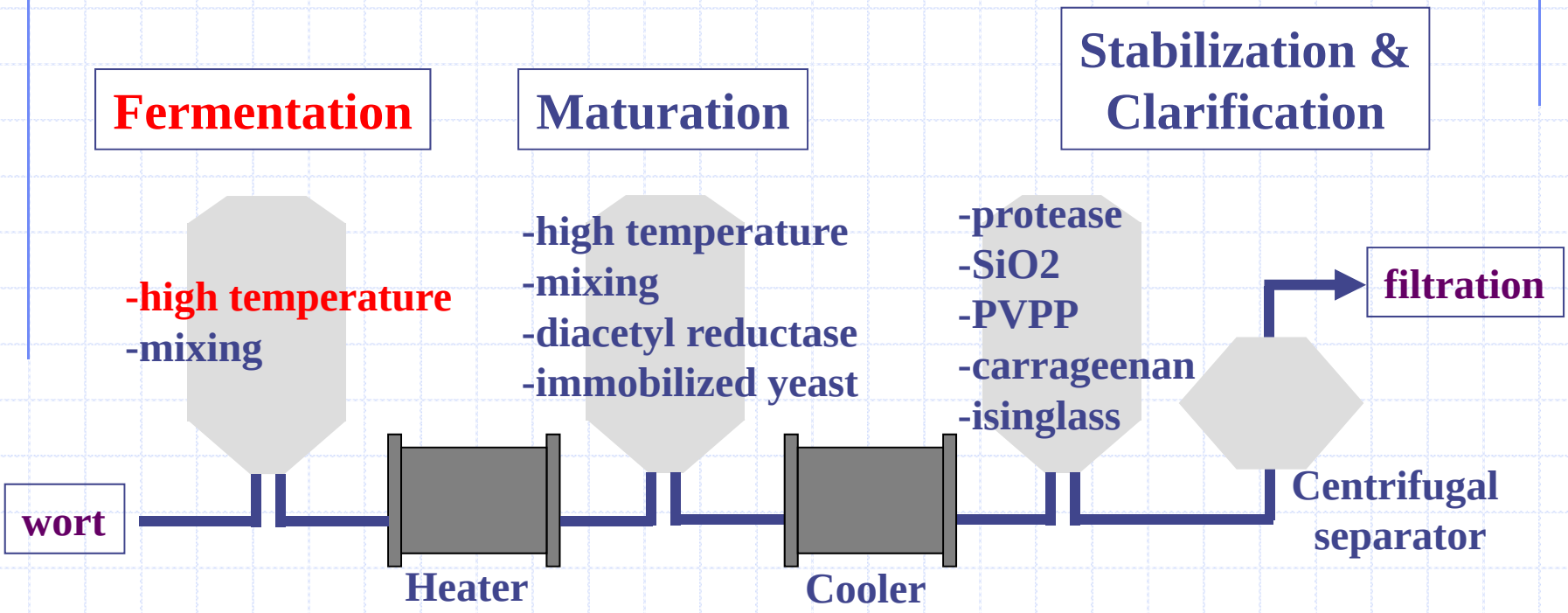
Beer Production

Past	Now
Small variety	Large variety
Large quantity	Small quantity
Few new products	Frequent new products
Productive	Less-productive

How to make various products without decreasing productivity?



How to shorten production time?



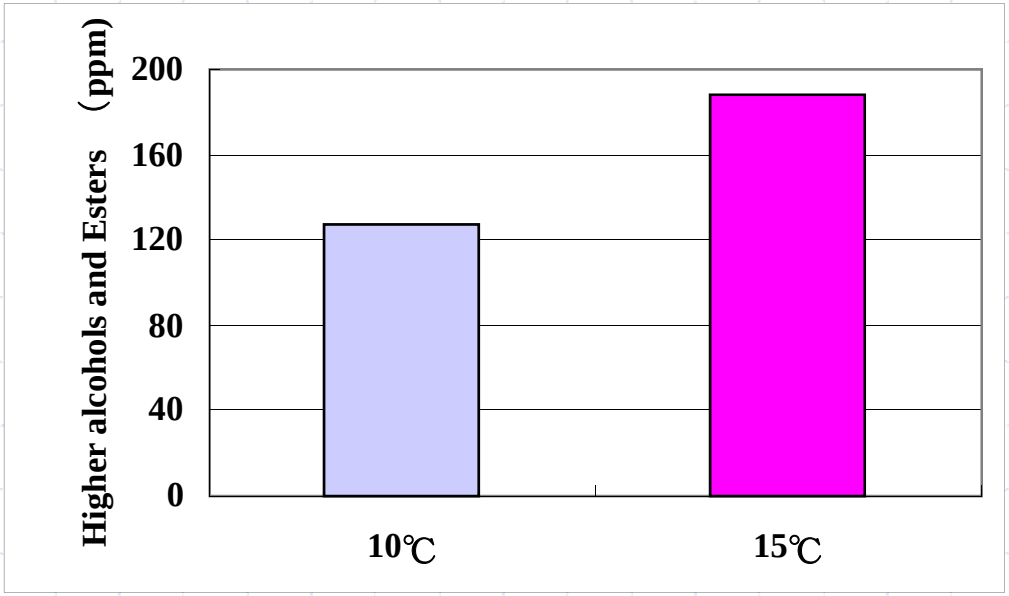
Method for reducing fermentation time is limited, due to the big impact on beer character.

High Temperature Fermentation

- high fermentation speed
- short fermentation time
- often adopted for high gravity brewing
- big impact on beer flavor
  (especially **higher alcohol** and **ester**)

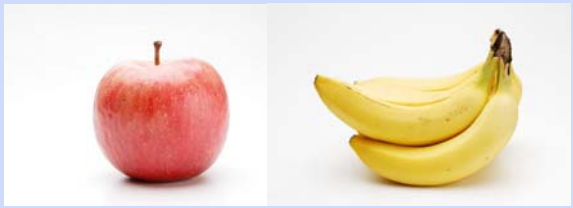
High temperature accelerates higher alcohol and ester production

Higher alcohol and ester production at 10 and 15 ºC

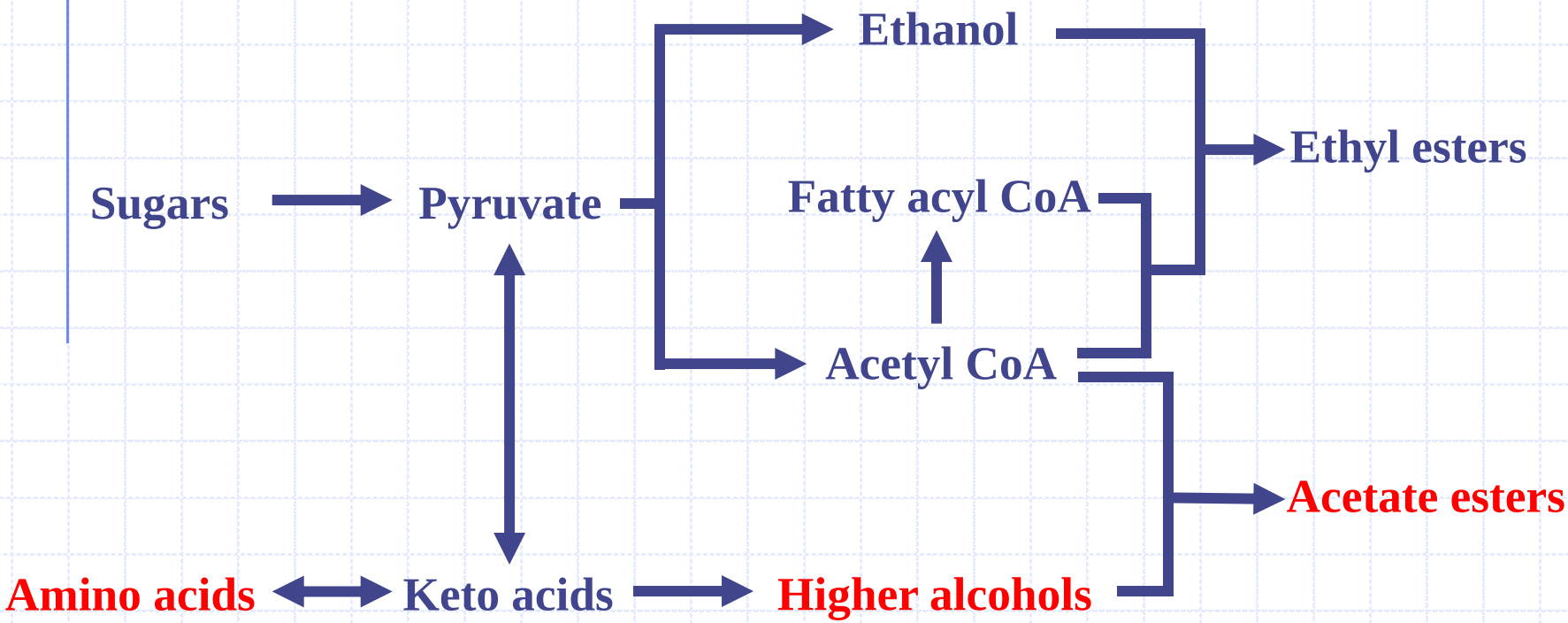


Flavor character of higher alcohol and ester

- Alcoholic
- Sweet
- Solvent-like
- Fruity
- Banana
- Apple



Higher Alcohol and Ester Production by Yeast



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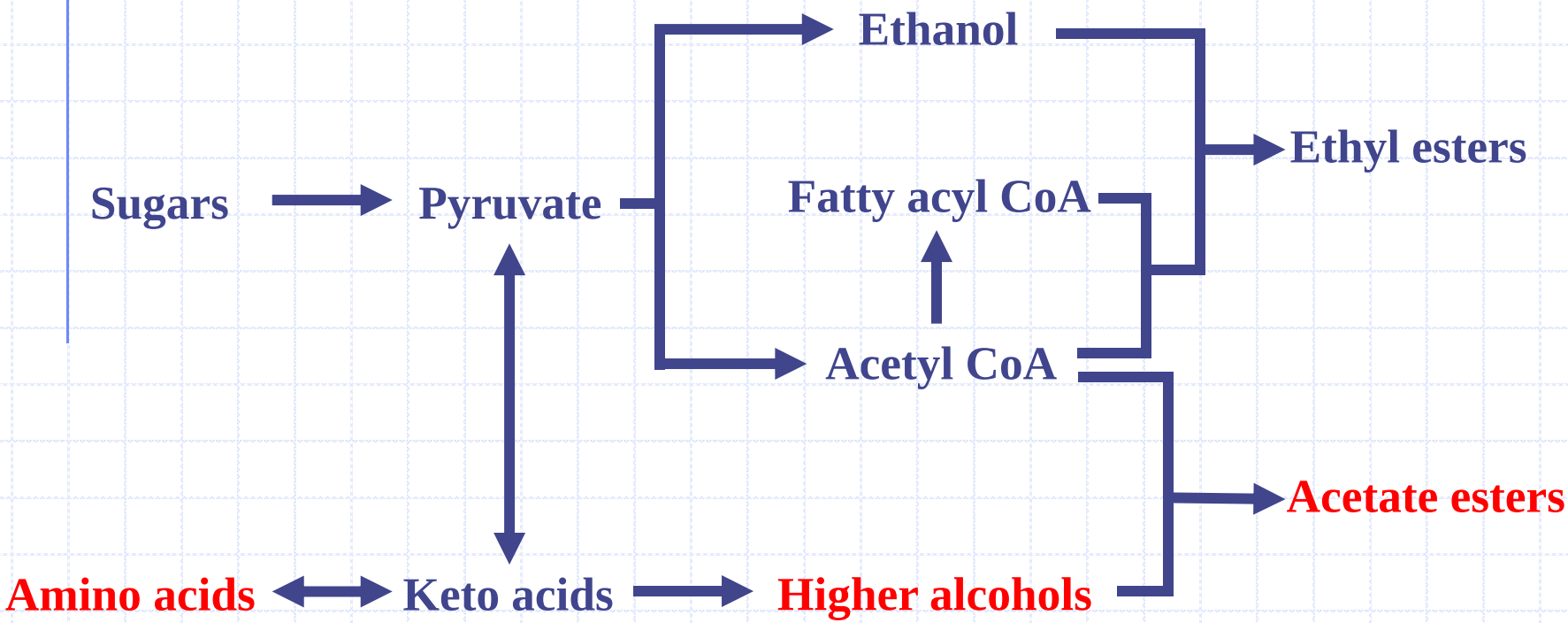
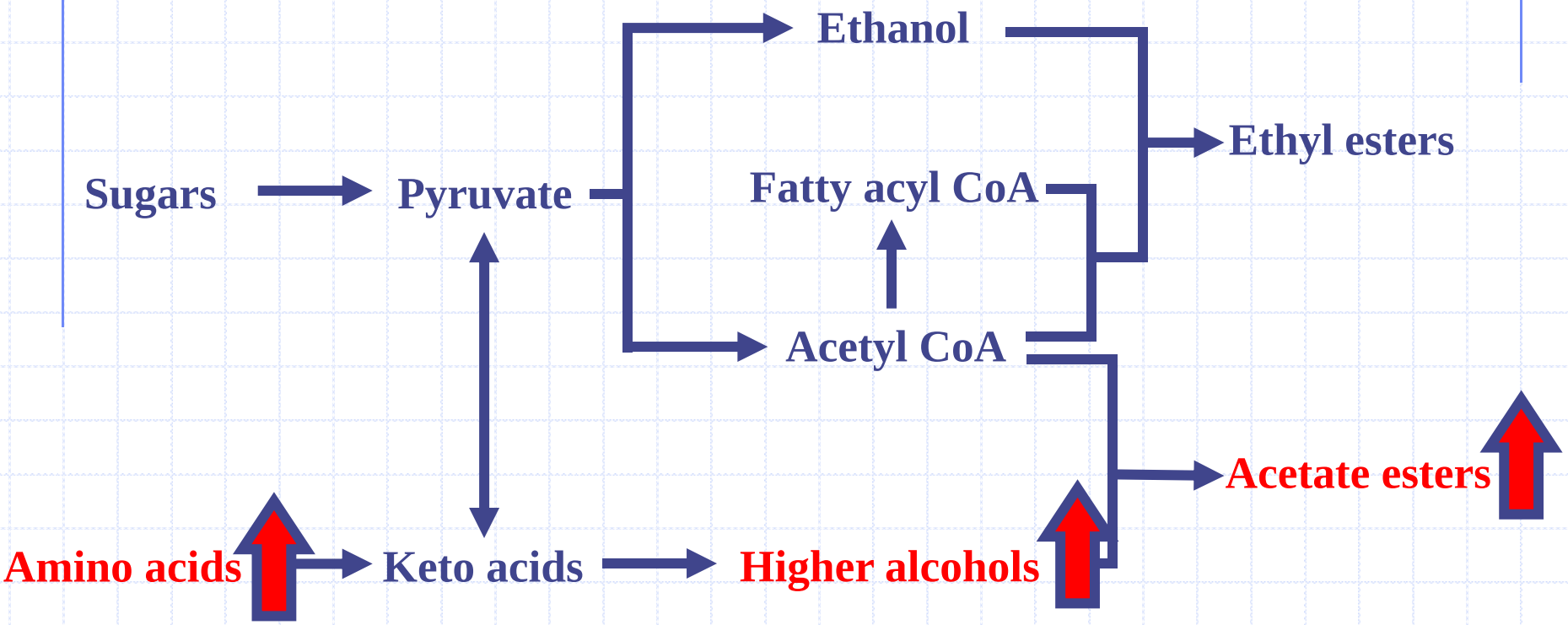


Leucine → Isoamyl alcohol → Isoamyl acetate

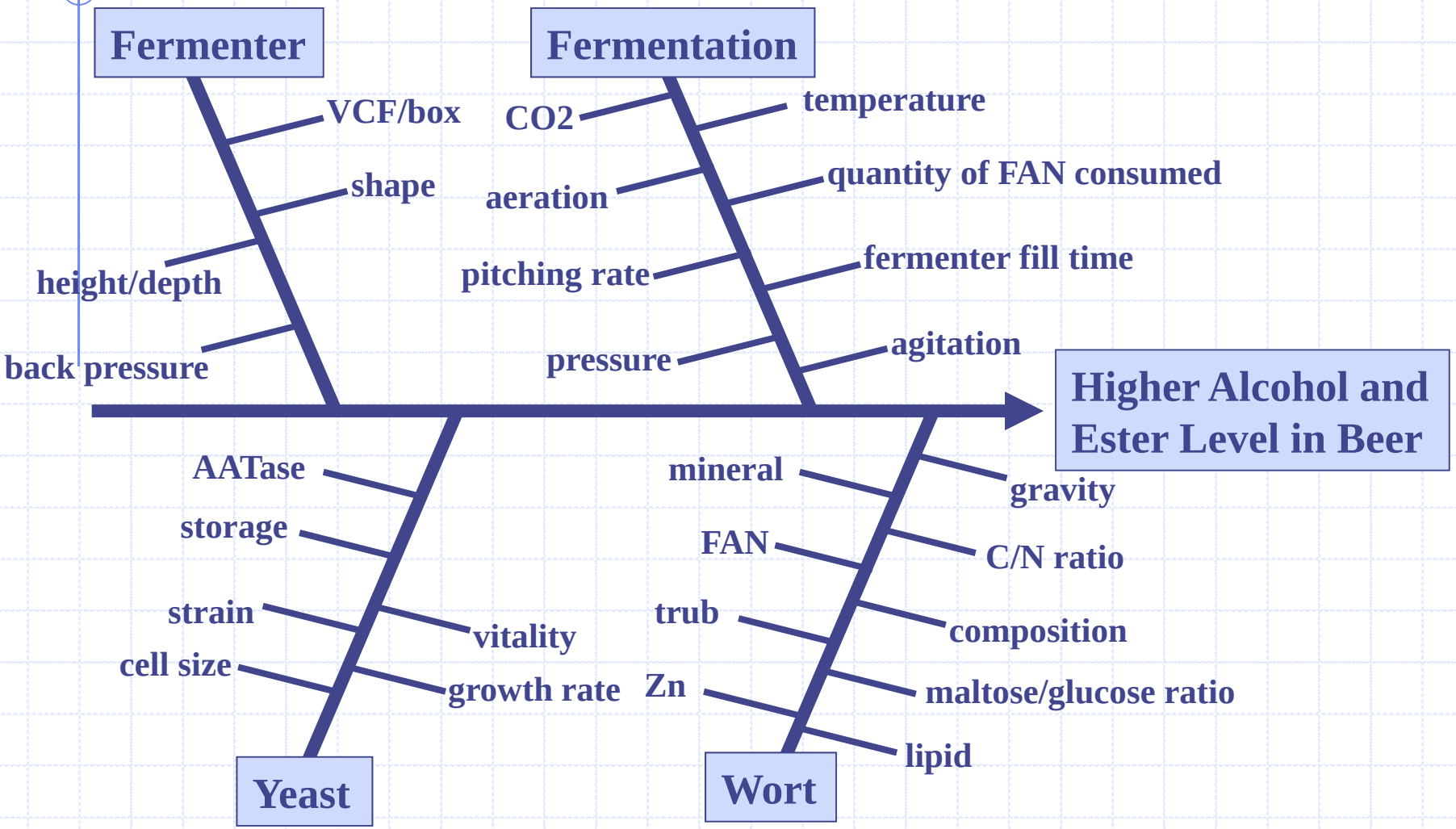
Phenylalanine → 2-Phenylethanol → 2-Phenylethyl acetate

Higher Alcohol and Ester Production by Yeast



High temperature accelerates amino acid uptake and production of higher alcohol and ester.

How to control higher alcohol and ester production?



Classification of 20 Amino Acids

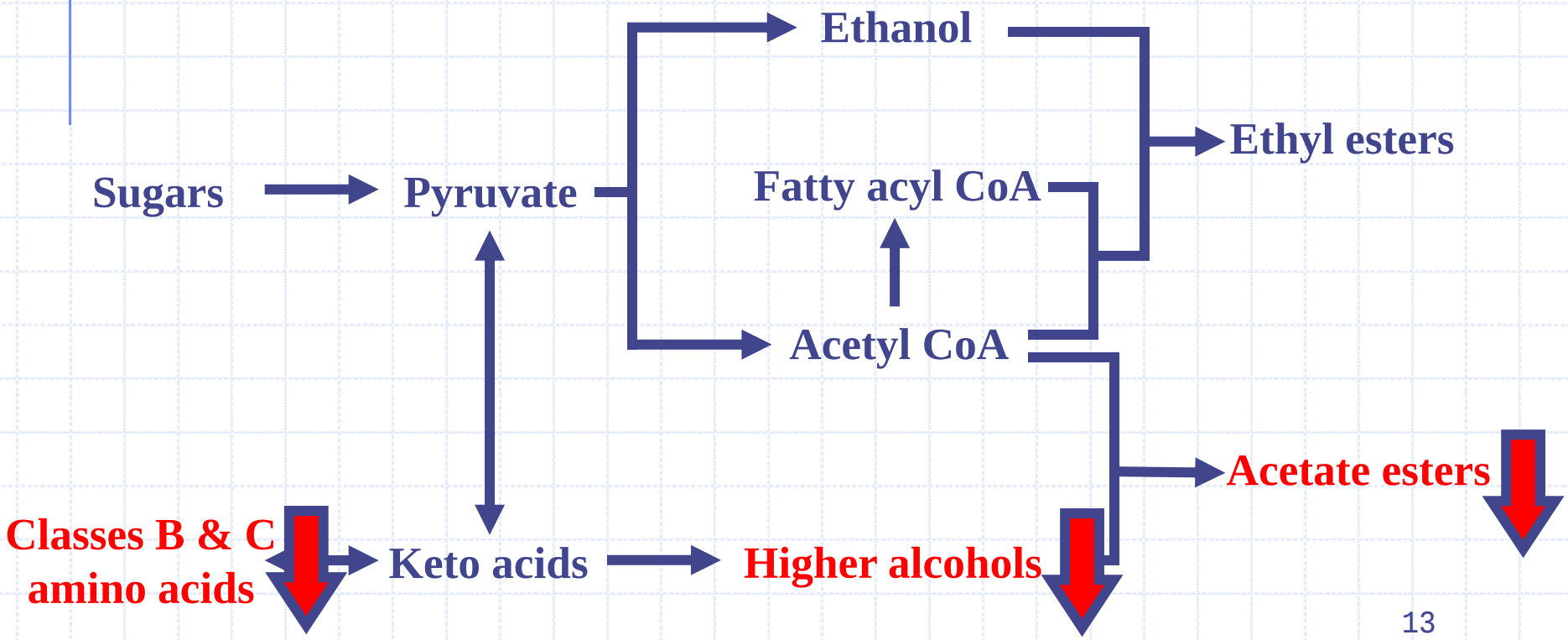
Class A	Class B	Class C	Class D
Arginine Asparagine Aspartate Glutamate Glutamine Lysine Serine Threonine	Histidine Isoleucine Leucine Methionine Valine	Alanine Ammonia Glycine Phenylalanine Tryptophan Tyrosine	Proline
Uptake starts immediately after pitching.	Uptake stars at the beginning of fermentation, but slowly.	Uptake doesn't start until class A has disappeared.	Yeast doesn't utilize under anaerobic condition.

Pierce 1987

Principal higher alcohols are by-products of amino acids in class B and C (shown in red).

Hypothesis

The addition of class A amino acids prevents the uptake of class B & C amino acids, and the production of higher alcohols and esters.



Test Brews

	Purpose	Conditions			
		Amino acids	Addition rates	Scale	Temp.
Test 1	Evaluation of various class A amino acids	Gln, Glu, Asn, Asp, Ser	1.0 kg/kl	2 L	15 ºC
Test 2	Evaluation of addition rates	Gln	0.2 - 2.0 kg/kl	2 L	15 ºC
Test 3	Large scale test	Gln	1.0 kg/kl	50 HL	15 ºC

Higher Alcohols and Esters in Beer

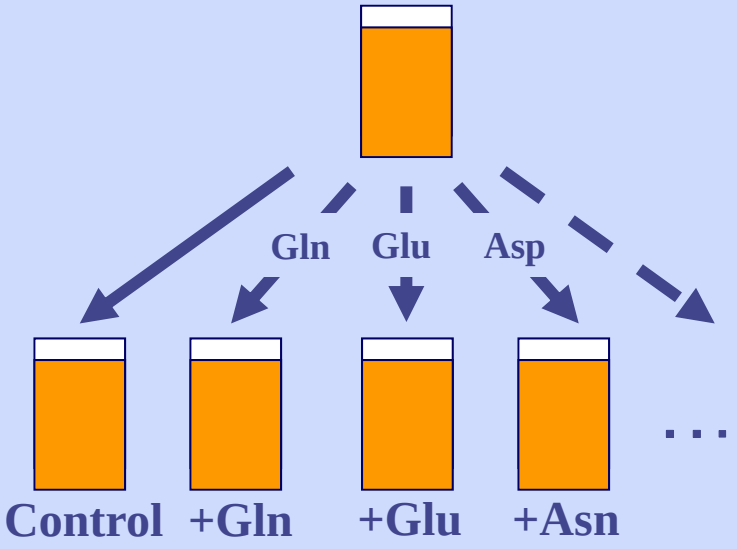
	Higher alcohol	Ester	
		Ethyl ester	Acetate ester
Components in beer	around 50	more than 100	
Principal components	Isobutanol Isoamyl alcohol Amyl alcohol 2-Phenylethanol Tyrosol Tryptophol	Ethyl acetate Ethyl caproate Ethyl caprylate	Isoamyl acetate 2-Phenylethyl acetate

Higher alcohols and esters analyzed in this research are shown in red.

Test 1

Evaluation of various class A amino acids

◆ Wort preparation



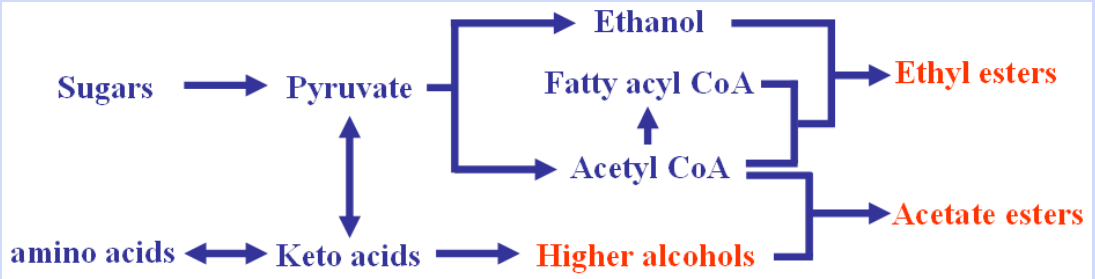
Addition rate : 1.0 kg/kl

◆ Fermentation

- Lager strain
- 15ºC
- 5 days
- 2 L scale

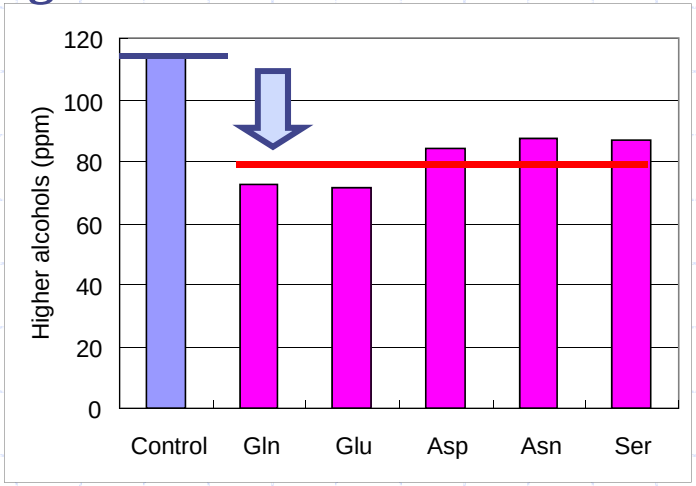
◆ Analysis

- Higher alcohol
- Acetate ester
- Ethyl ester

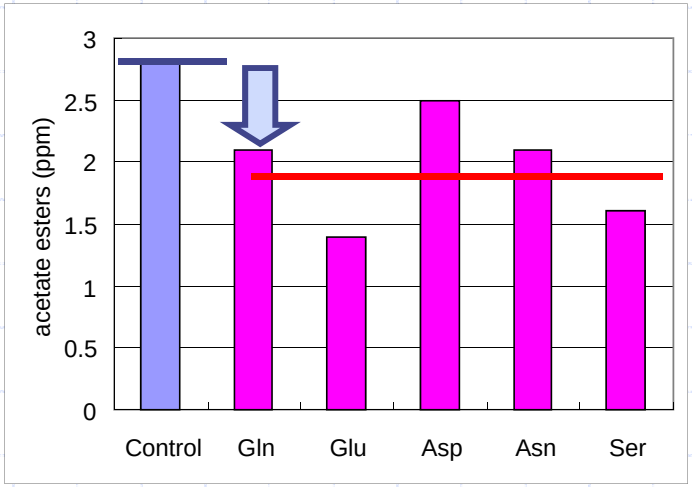


Test 1
Evaluation of various class A amino acids

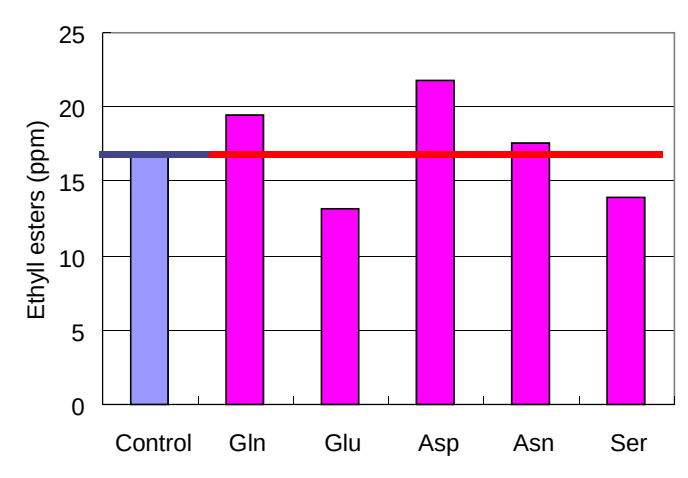
Higher alcohols



Acetate esters



Ethyl esters



Control

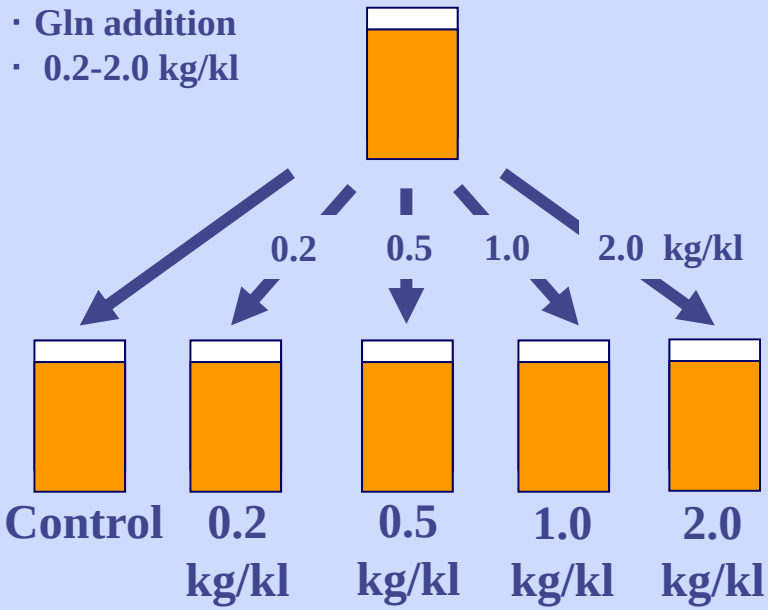
Class A amino acid addition

Addition rate 1.0 kg/kl

Test 2
Evaluation of addition rates

◆ Wort preparation

- Gln addition
- 0.2-2.0 kg/kl

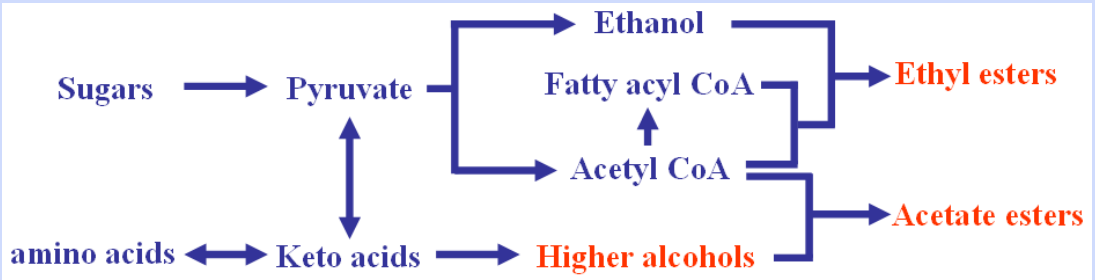


◆ Fermentation

- Lager strain
- 15ºC
- 5 days
- 2 L scale

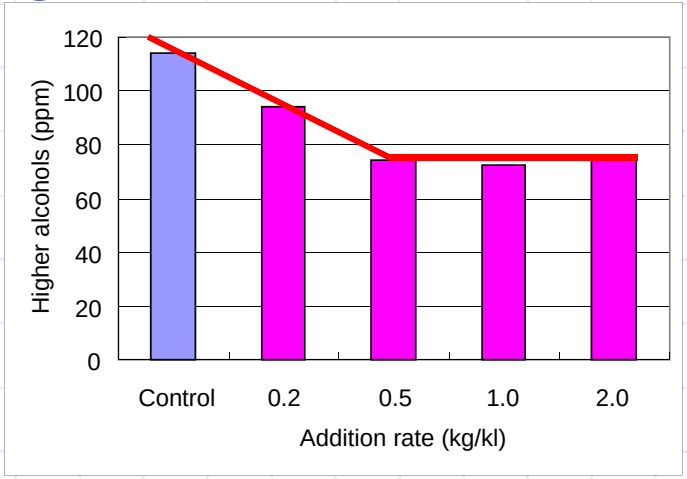
◆ Analysis

- Higher alcohol
- Acetate ester
- Ethyl ester

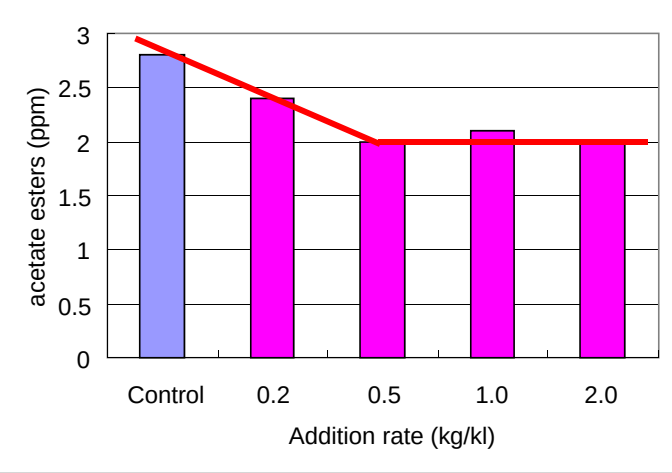


Test 2
Evaluation of addition rates

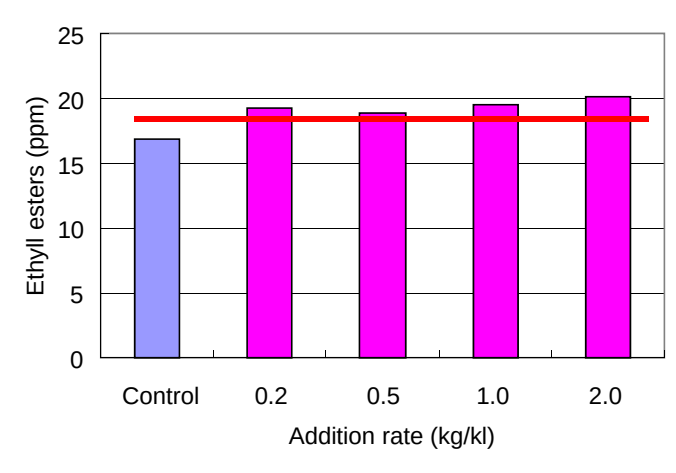
Higher alcohols



Acetate esters



Ethyl esters

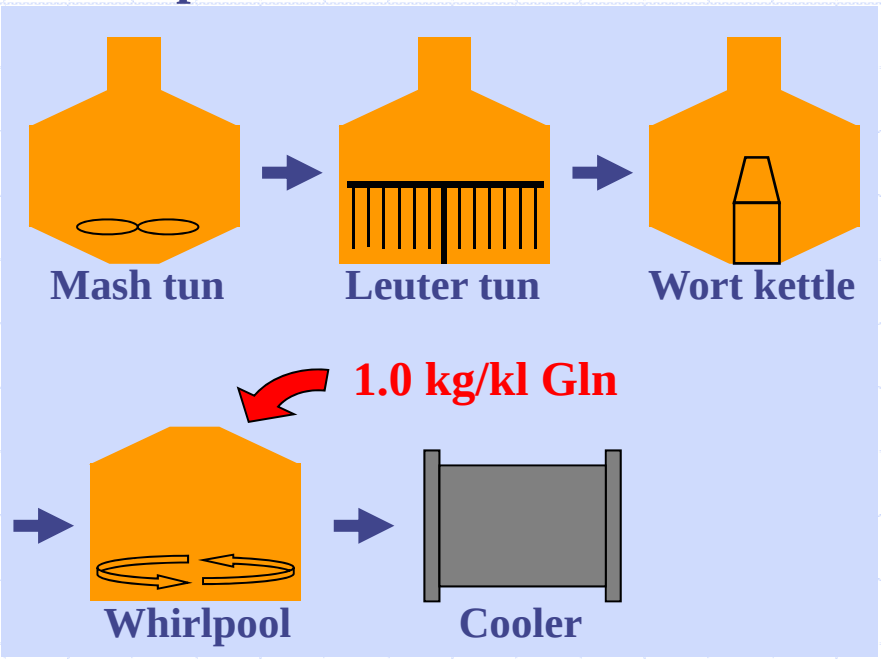


Control

Glutamine addition

Test 3
50HL scale test

◆ Wort production

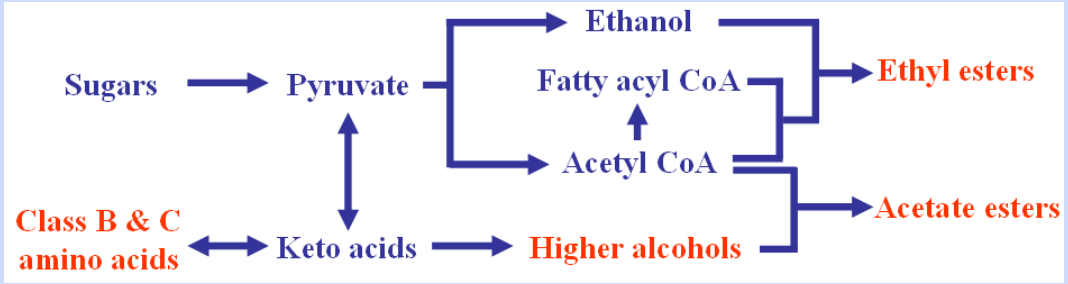


◆ Fermentation

	Control		test
	1	2	
Temp.	10°C	15°C	15°C
Gln	-	-	+
days	7	5	5
Scale	50HL	50HL	50HL

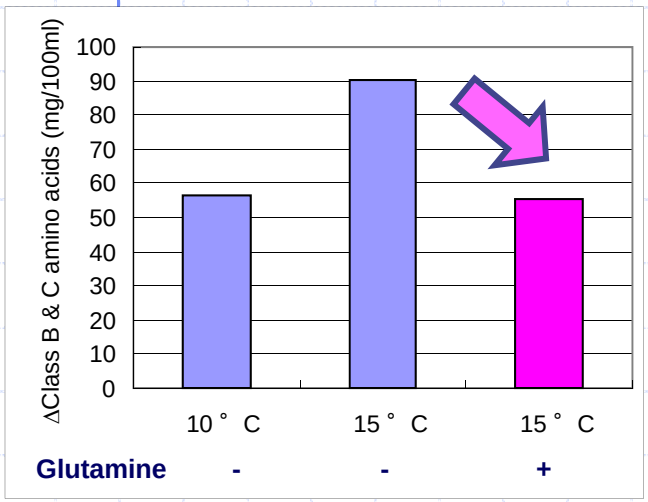
◆ Analysis

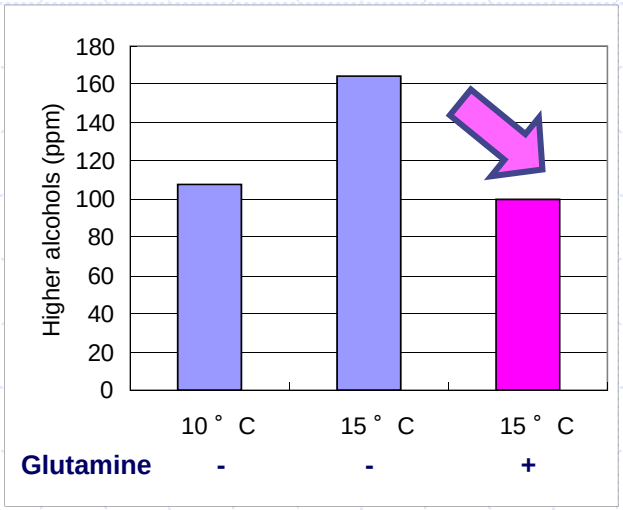
- Amino acid
- Higher alcohol
- Acetate ester
- Ethyl ester

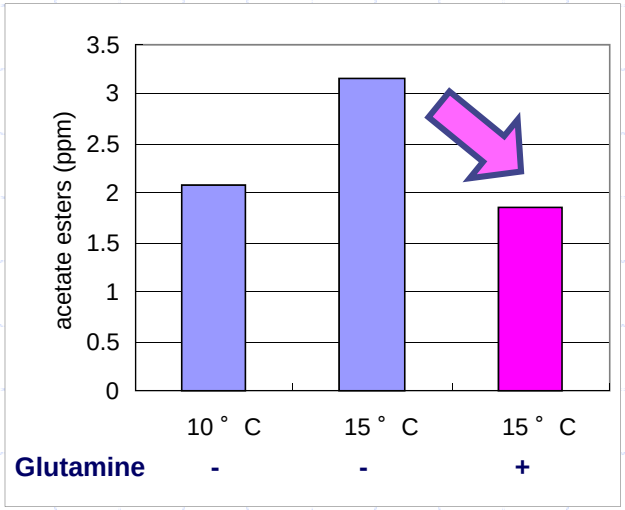


Test 3
50HL scale test

Δ class B &C amino acids → Higher alcohols → Acetate esters



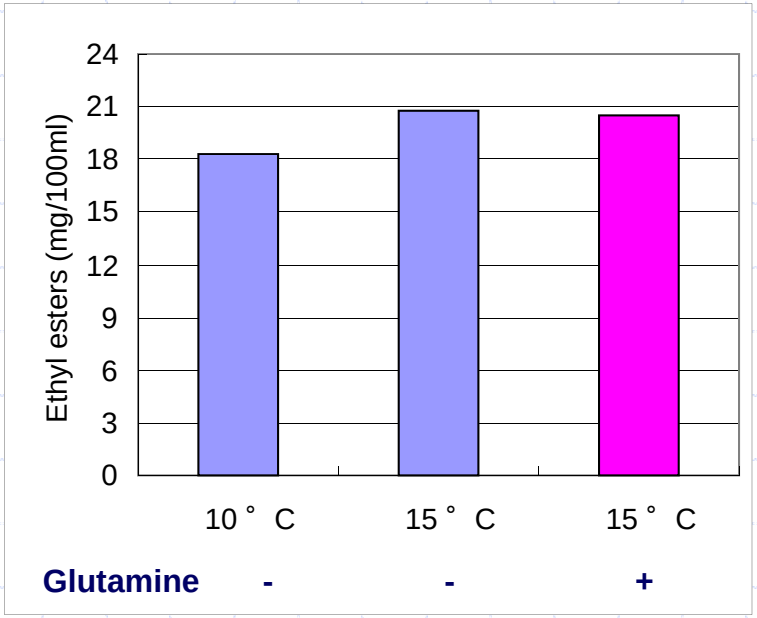




Control Glutamine addition (1.0 kg/kl)

Test 3
50HL scale test

Ethyl esters



Control Glutamine addition (1.0 kg/kl)

Test 3
50HL scale test

Sensory tests of final beer by trained panels

- **10 ºC vs 15 ºC**
  Significant difference in flavor strength

- **10 ºC vs 15 ºC + Glutamine**
  No significant difference in flavor strength

- **No defective flavor was mentioned**

Conclusion

- Addition of class A amino acids prevents the production of higher alcohols and esters in high temperature fermentation.
- The more class A amino acids were added (up to 0.5 kg/kl), the more flavor production was prevented.
- No defective flavor was mentioned.

Thank you for your kind attention!