

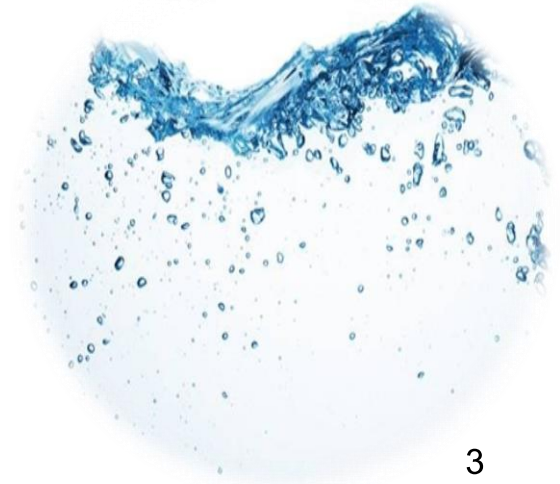
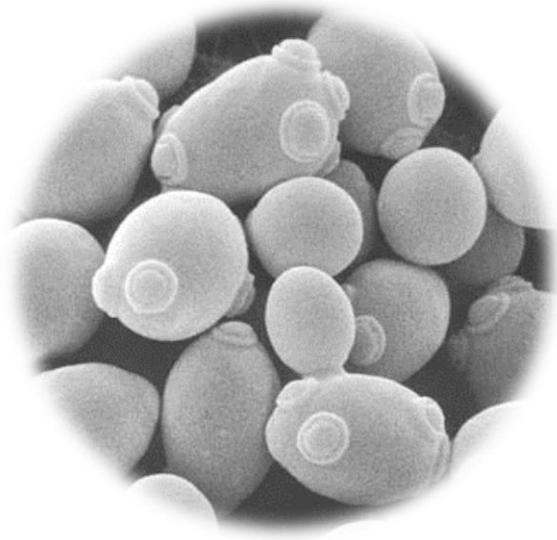
**Effect of Mash and Wort Acidification
Versus
Yeast Pitching Rate
As Parameters to Optimize
Fermentability of Adjunct Worts**

SONGSAK HENGPRATHANEE

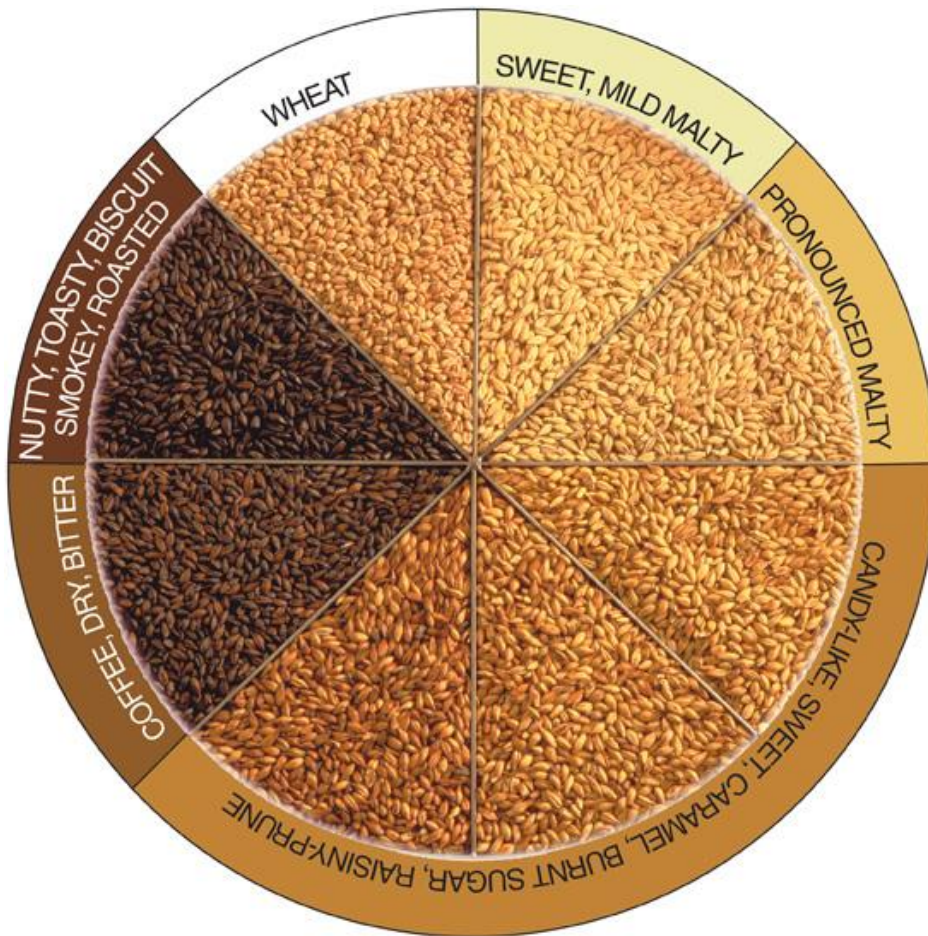
Brewing Process



Raw Materials



Malt



Carbohydrates

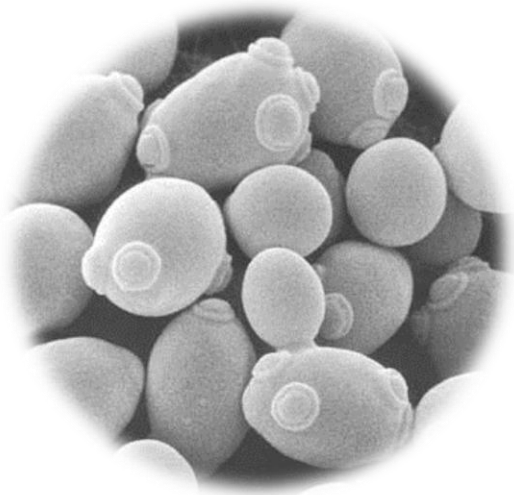
Proteins

Minerals

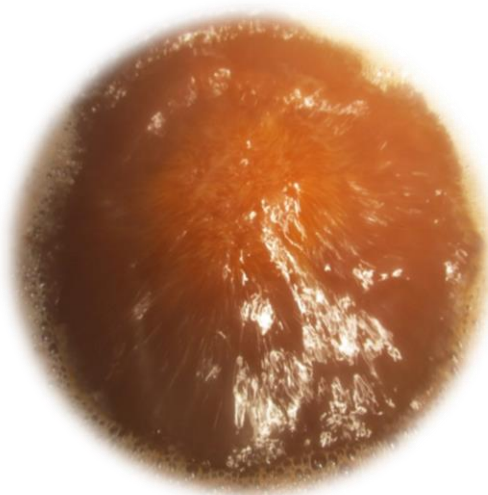
Vitamins

Malt

Why are essential nutrients for yeast so important in brewing?



Yeast

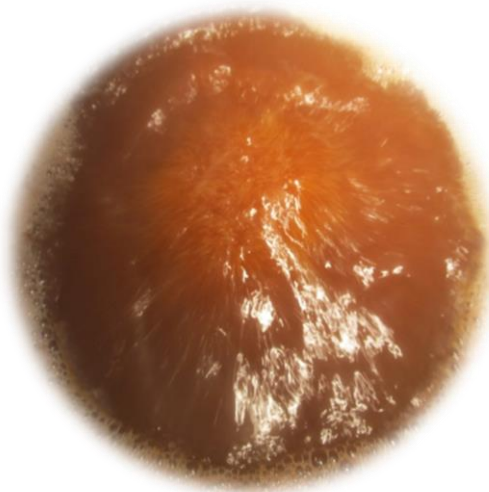
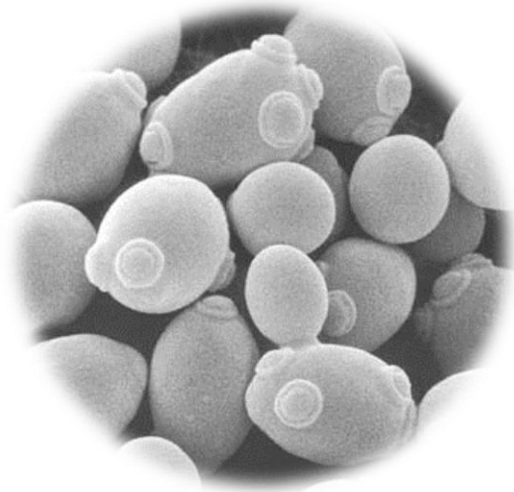


Food



Beer

Fermentation

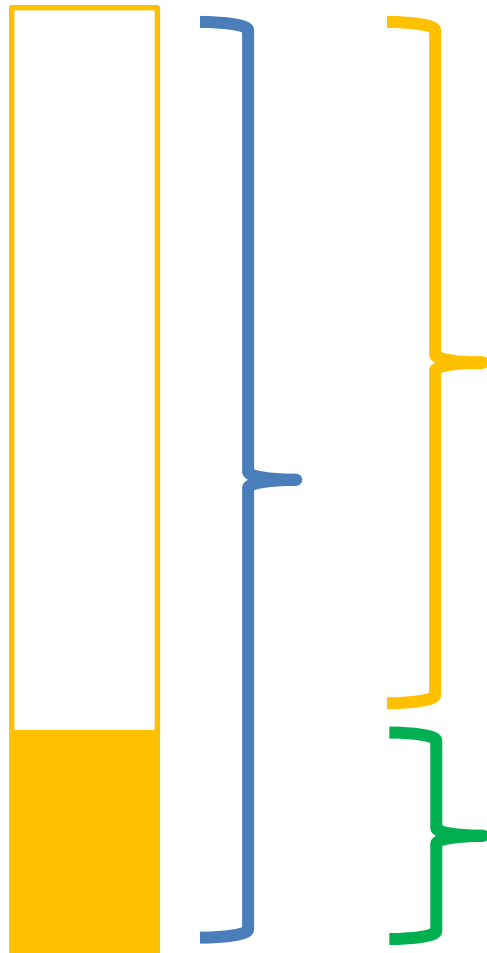


Yeast

**Wort
(Nutrients)**

**Alcohol CO₂
Beer flavour**

Extract



**BH : Original Extract
(Sugars, FAN and etc)**

**Fermentation:
Fermentable Extract**

Residual Extract

Rice (A local raw material)



85-90 % Starch

5-8 % Proteins

**0.2-0.4 % Oil and
Inorganic substance**

Rice & Barley

| Nutrients | Rice | Barley |
|------------------|----------|------------|
| Carbohydrates | 85-90 % | 70-85% |
| Proteins | 5-8 % | 10.5-11.5% |
| Inorganic matter | 0.2-0.4% | 2.0-4.0% |
| Fats or Oils | | 1.5-2.0% |

Brewing **w**ith **R**ice



Some parameters have to be **optimized**

Brewing **w**ith **R**ice

Decoction process

Rice mash was boiled and pumped into malt mash

High gravity brewing

Yeast pitching rate

1.5 million cells / % plato / ml of CW

Overview

Brew house part

Wort Acidification

Fermentation part

pH

pH levels during various stages of the brewing process affect many parameters of the beer.

Extract yield

Foam Stability

Beer Color

Hop yield

pH Temp



Enzyme



Beer
parameters

pH in Mash

| Enzymes | Opt. pH | Affected parameters |
|--------------------|---------|-------------------------------|
| Endopeptidase | 4.9-5.1 | FAN, Foam stability, color |
| Carboxy peptidase | 5.1-5.3 | |
| Dipeptidase | 8.1-8.3 | |
| Aminopeptidase | 7.1-7.3 | |
| β glucanases | 4.7-5.0 | Filtration ability |
| β -amylases | 5.4-5.5 | Extract potential |
| α -amylases | 5.6-5.8 | Extract potential |

Wort Acidification

Organic acid

Lactic acid



Biological

Industrial

Mineral acid

Phosphoric acid

Hydrochloric acid

Sulphuric acid

Trial Design

Trial 1 : “Lactic acid addition”

- Adjust pH in Mash (pH 5.4-5.6)
- Adjust pH in Boiled Wort (pH 5.2-5.4)

Trial 2: “No Lactic acid”

Control : Same Brewing Procedure

Analysis Parameters

Chemical Analysis

- pH
- Extract
- VDK
- Flavor profile

Microbiological Analysis

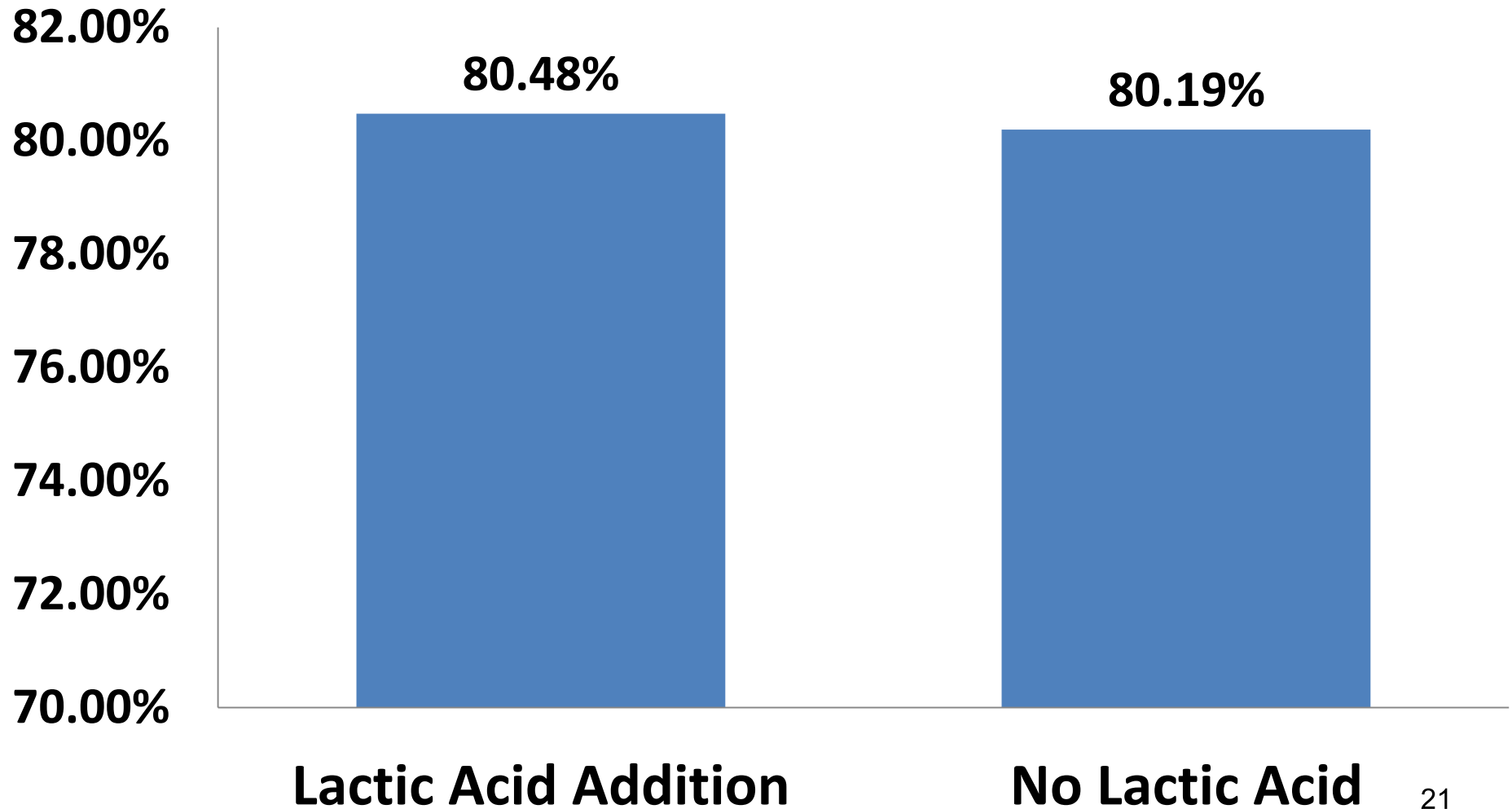
- Yeast cell count
- % dead

Sensory Analysis

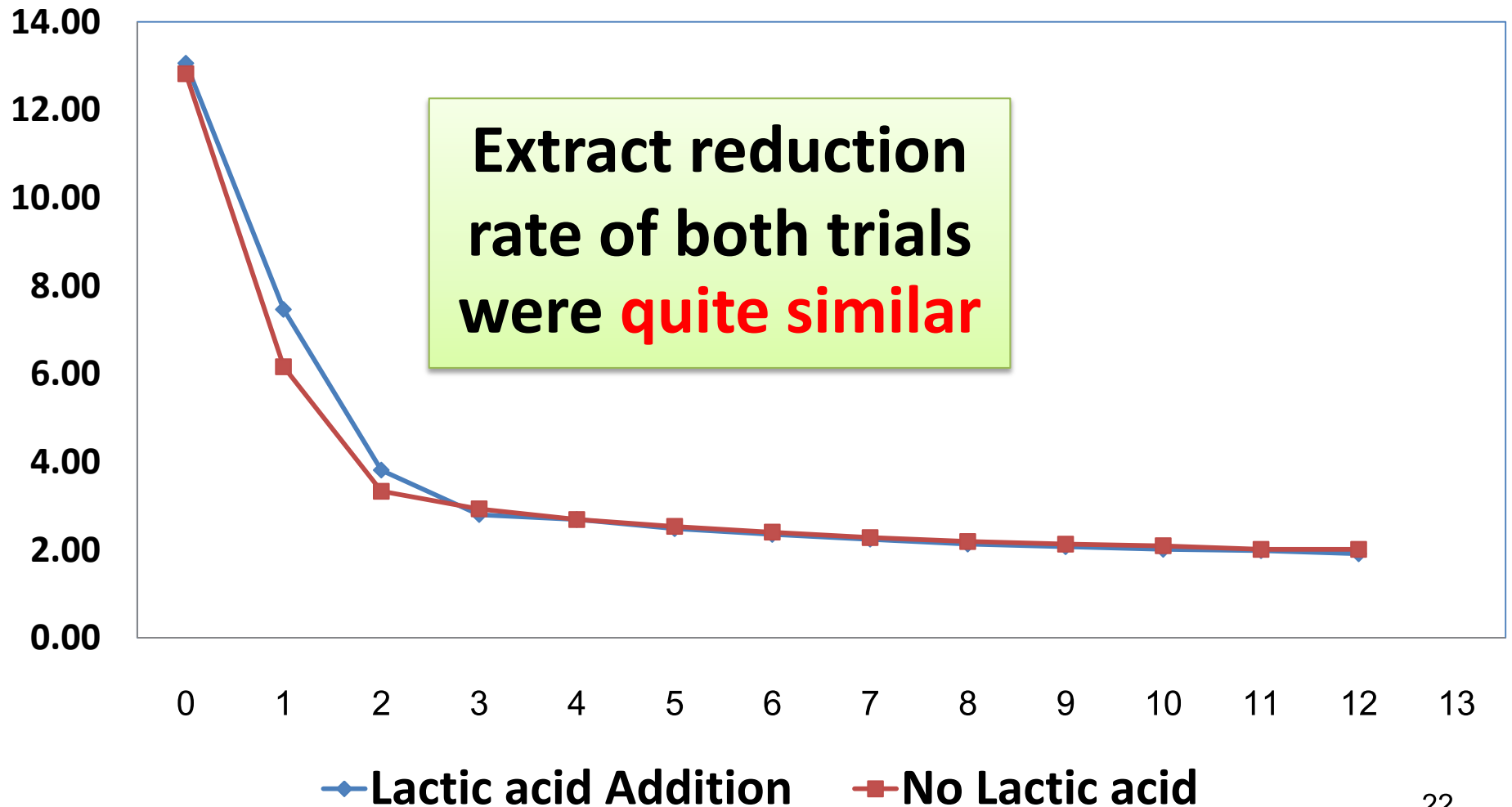
Wort Result

| Trial | Lactic acid addition | No Lactic acid |
|------------------|----------------------|----------------|
| Original extract | 13.63 | 13.66 |
| pH of Mash | 5.53 | 5.72 |
| pH of Cold wort | 5.34 | 5.53 |
| Bitterness of AW | 28.0 | 29.0 |
| FAN | 115.4 | 102.1 |

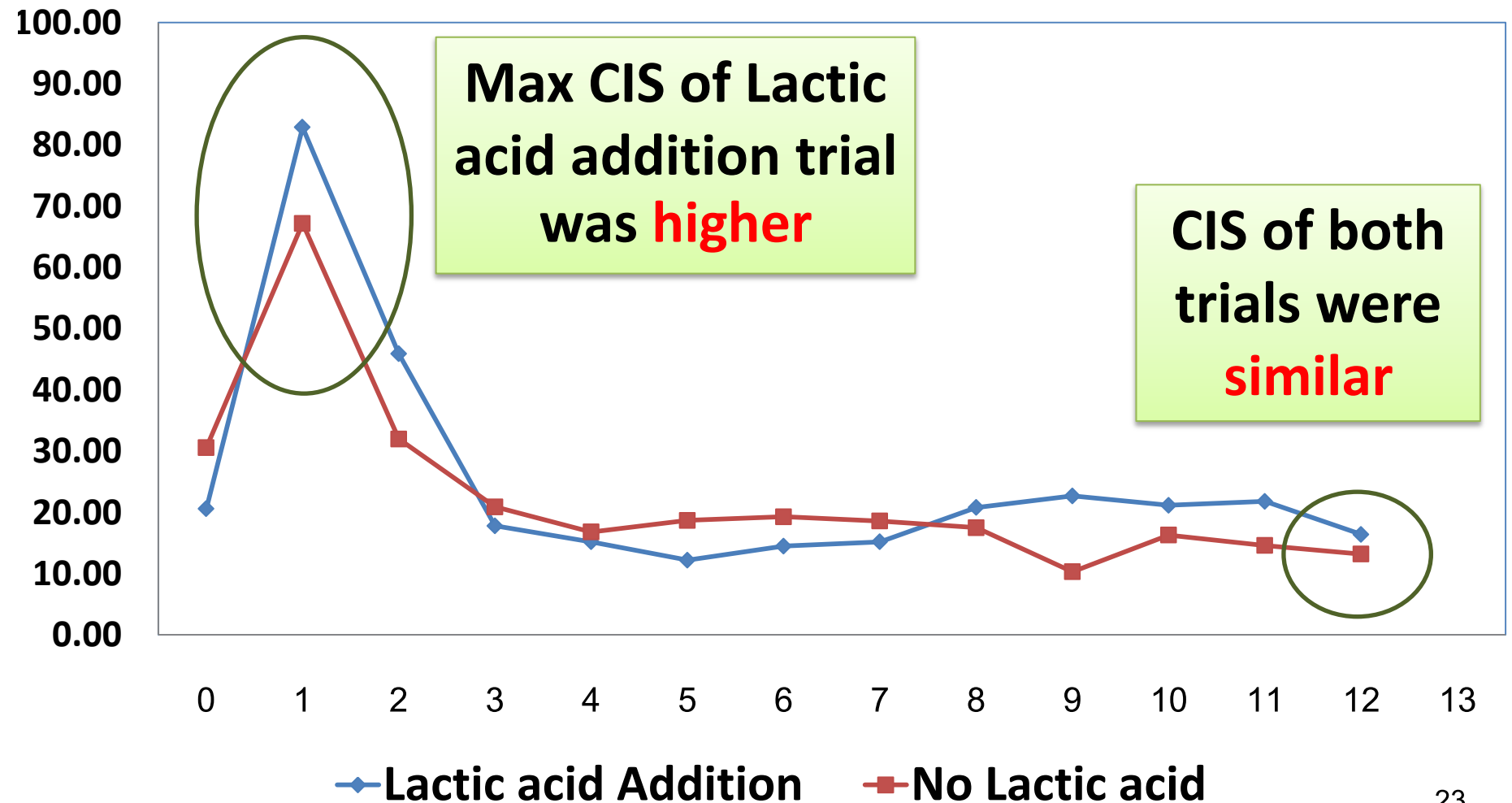
Brew House Yield



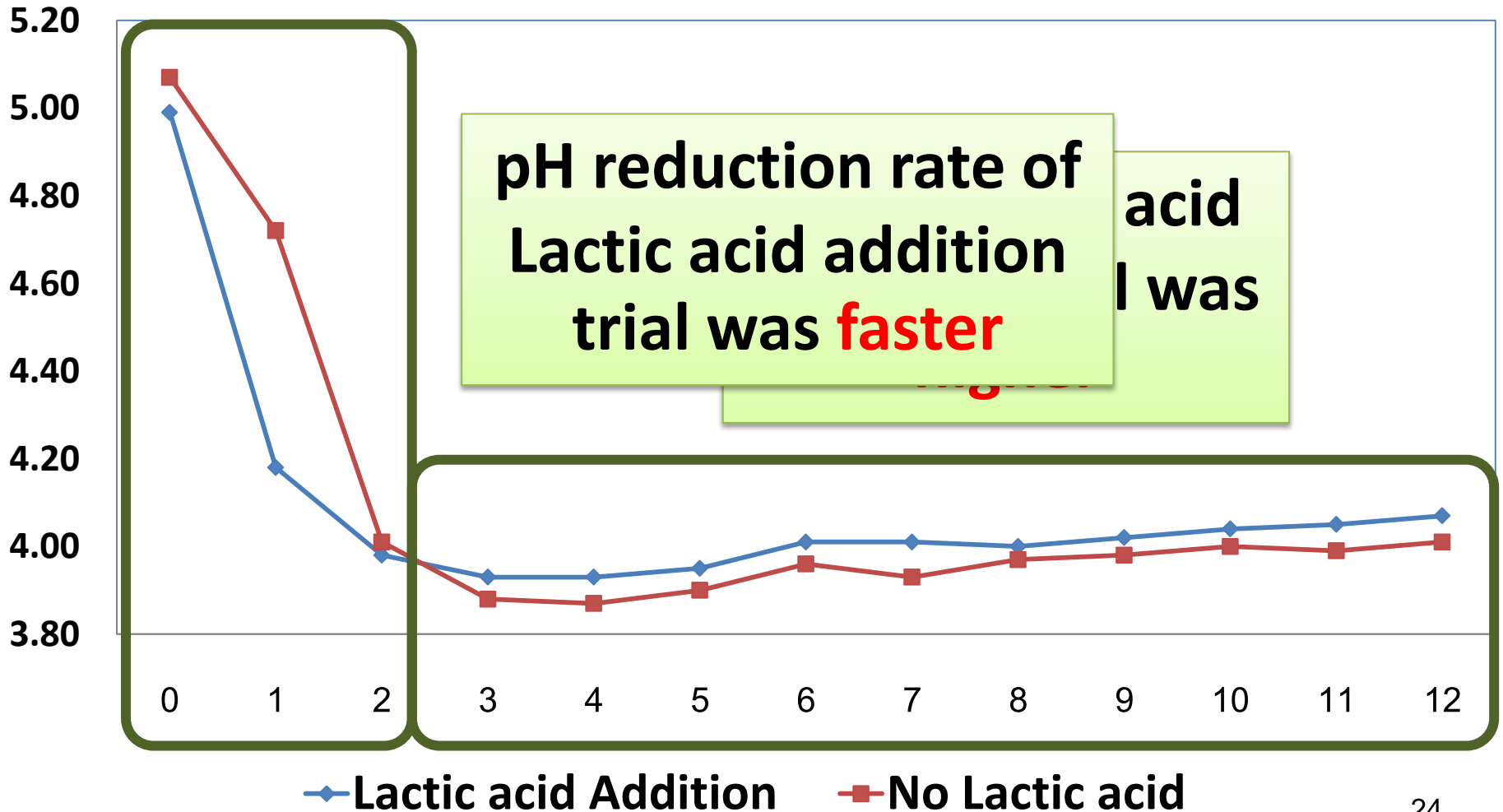
App Extract (%)



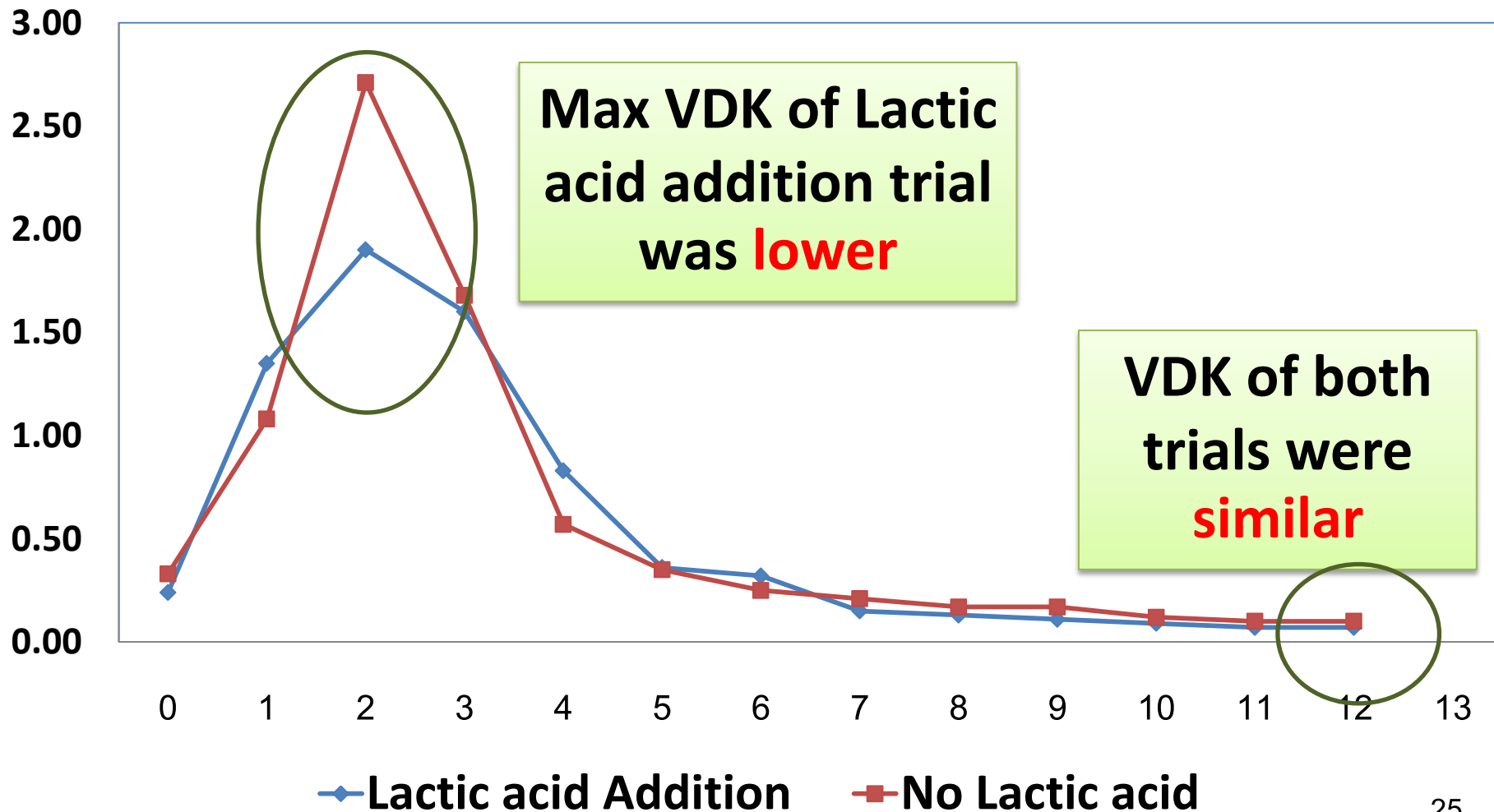
Cell In Suspension (mio/ml)



pH



VDK (mg/l)



Fermentation End

| FT | Lactic acid addition | No Lactic acid |
|-----------------------|----------------------|----------------|
| Fermentation time (D) | 12 | 12 |
| Residual Extract (%) | 1.91 | 2.01 |
| Attenuation limit(%) | 1.90 | 2.00 |
| pH | 4.07 | 4.00 |

Fermentation End

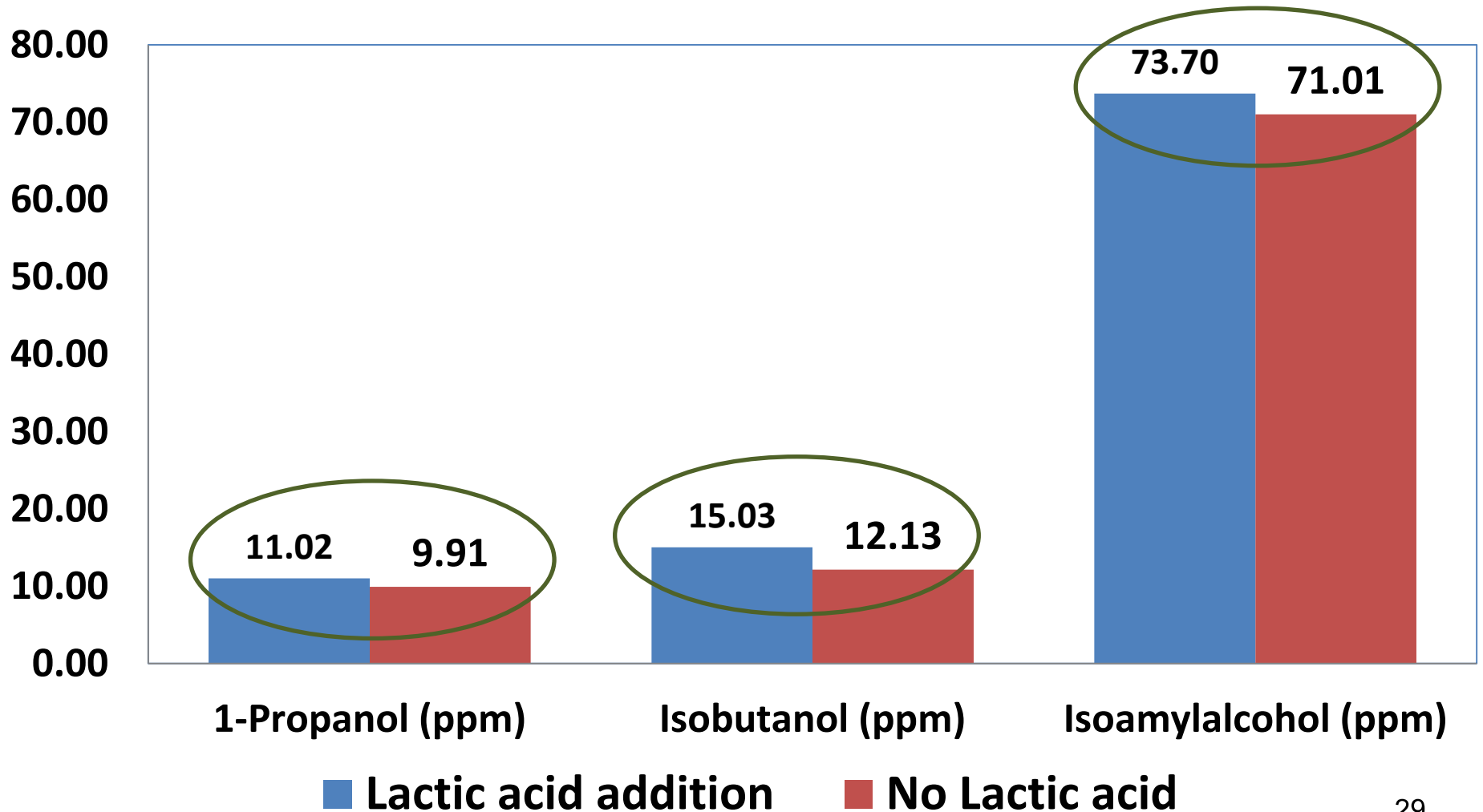
| FT | Lactic acid addition | No Lactic acid |
|--------------------------------|----------------------|----------------|
| Yeast cropping ratio | 2.47 | 2.23 |
| Dead cell of Cropped yeast (%) | 6.30 | 8.50 |

Finish Goods

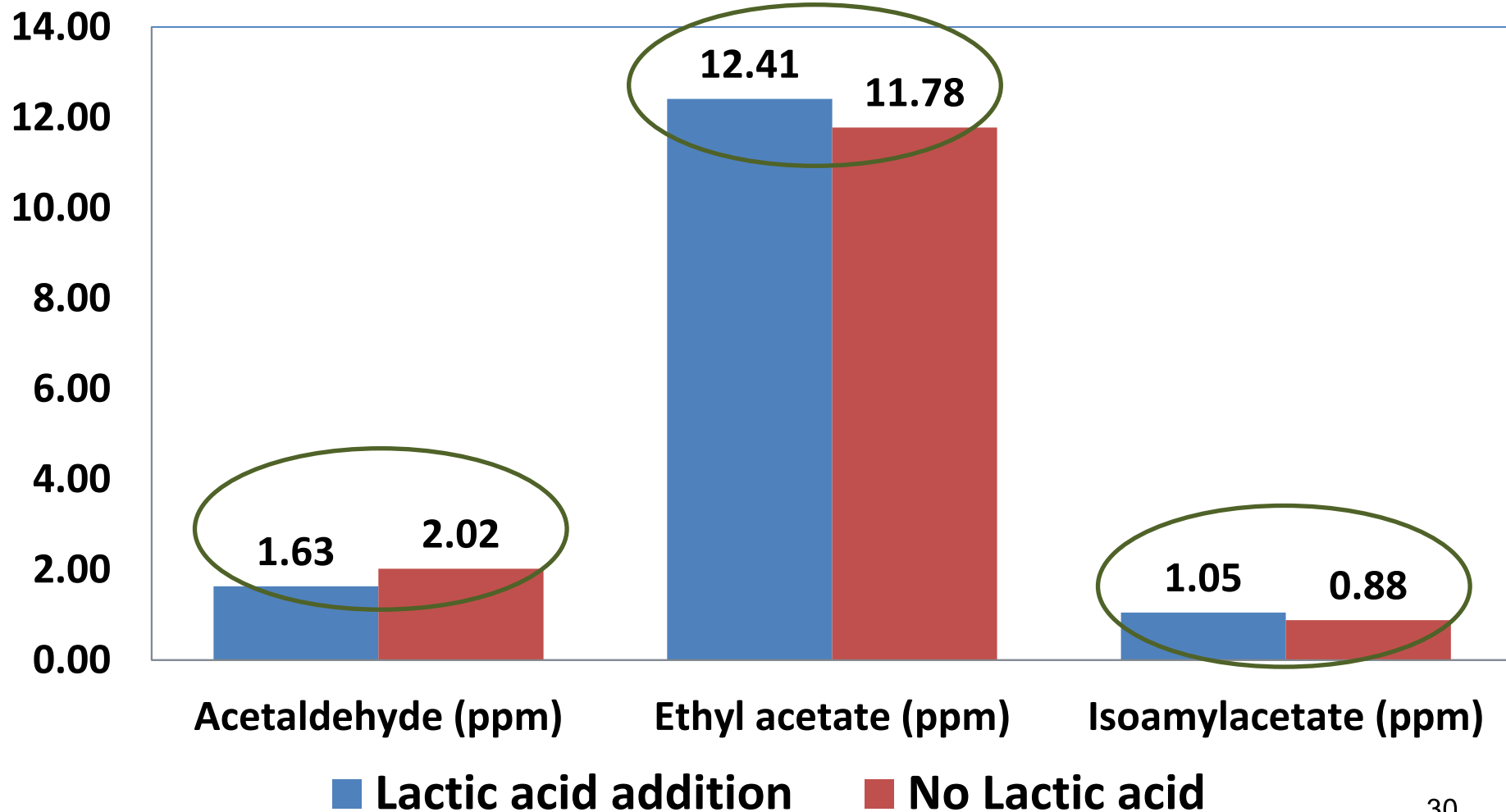
| Trial | Alcohol (% v/v) | App Ext (%w/w) | pH | ADF* (%) |
|---------------------------------|--------------------|-------------------|------|-------------|
| Lactic acid addition | 5.00 | 1.51 | 4.08 | 86.21 |
| No Lactic acid | 4.99 | 1.59 | 4.04 | 85.65 |

*ADF = Apparent Degree of Fermentation

Higher Alcohol



Aldehyde and Ester



Sensory Test

Triangle test

Sample A : Trial 1 (Addition lactic acid)

Sample B&C : Trial 2 (No lactic acid)

| Sample's code | Difference sample | Correct | Wrong | Result |
|---------------|-------------------|---------|-------|--------|
| A/B/C | A | 1 | 7 | ns. |

Statistic for different test is triangle test at 95% significance.
Panelists couldn't detect difference of trials.

Lactic acid addition

Lower Residual extract

Higher pH in beer

Higher yeast cropping ratio and lower dead Cell

A little lower Acetaldehyde

A little more Ester and Higher Alcohol

Overview

Brew house part

Wort Acidification

Trial 1 : Lactic acid Addition

Trial 2 : No Lactic acid

Fermentation part

Yeast pitching rate



Yeast Pitching Rate

Yeast pitching rate is too Low

- Yeast get stressed
- Produce undesirable by product
- Incomplete fermentation

Yeast Pitching Rate

Yeast pitching rate is too High

- Lower growth rate
- Lower yeast viability

Adjunct Wort

Protein in Rice is Lower than Malt



FAN is Lower



Should Yeast pitching rate be lower?

Trial Design

Trial 3 : “Lower yeast pitching rate”

Yeast pitching rate: 1.0×10^6 cells/%Plato/ml cw

Trial 4 : “Ref. yeast pitching rate”

Yeast pitching rate: 1.5×10^6 cells/%Plato/ml cw

Control : Same Brewing Procedure

Analysis Parameters

Chemical Analysis

- pH
- Extract
- VDK
- Flavor profile

Microbiological Analysis

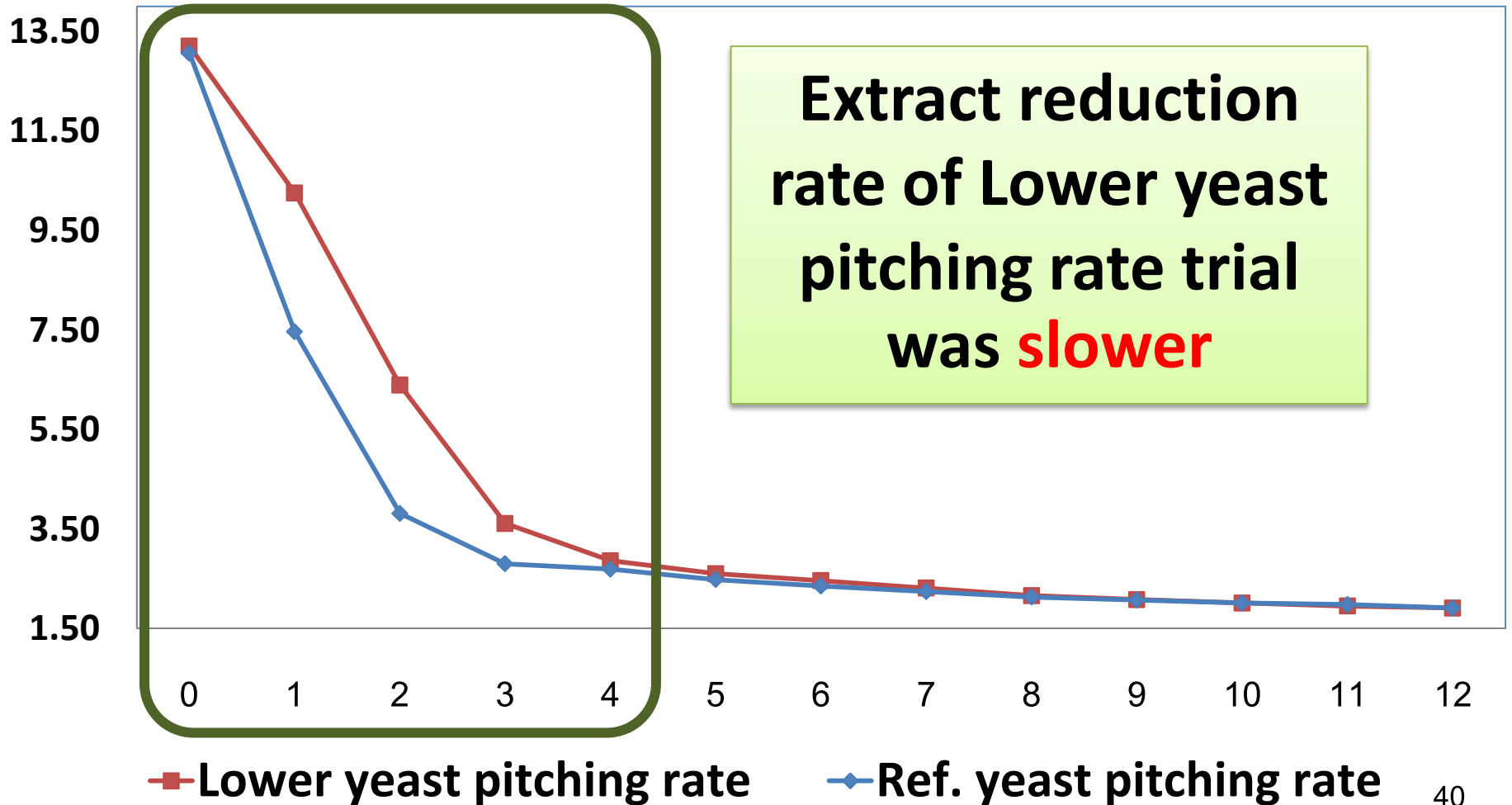
- Yeast cell count
- % dead

Sensory Analysis

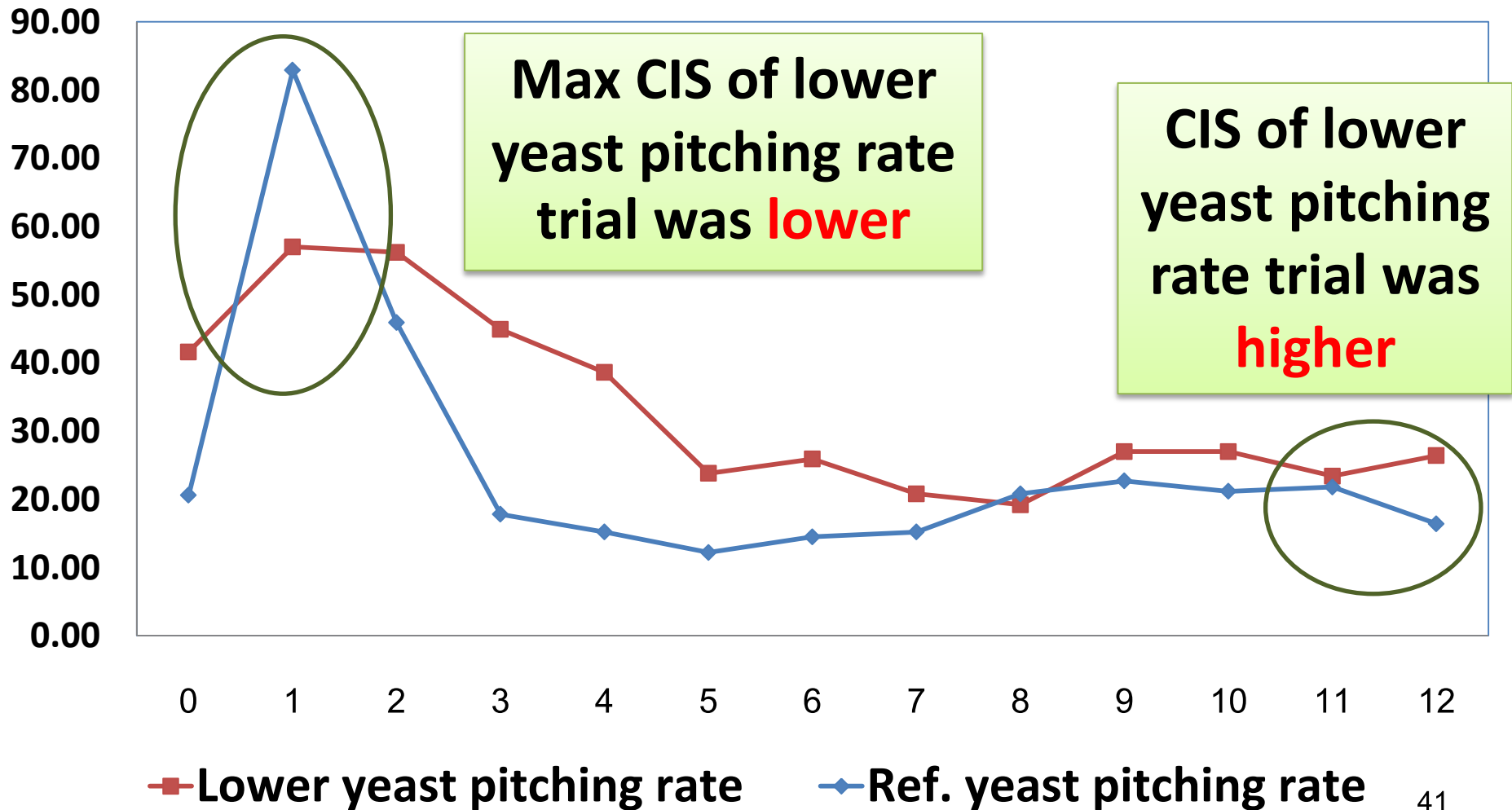
Wort Result

| Trial | Lower yeast pitching rate | Ref. yeast pitching rate |
|------------------|---------------------------|--------------------------|
| Original extract | 13.66 | 13.63 |
| pH | 5.33 | 5.34 |
| FAN | 115.0 | 115.4 |

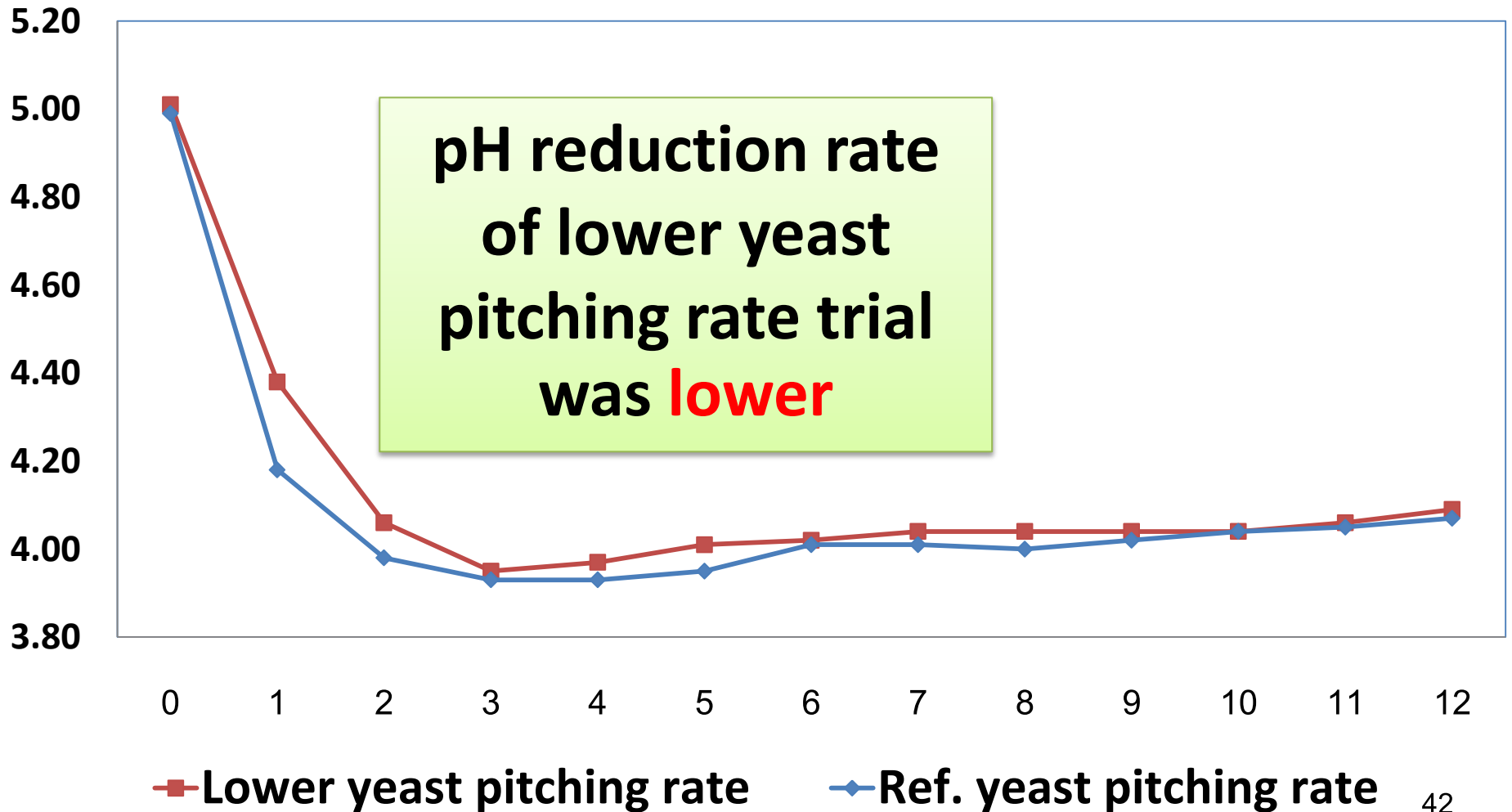
App Extract (%)



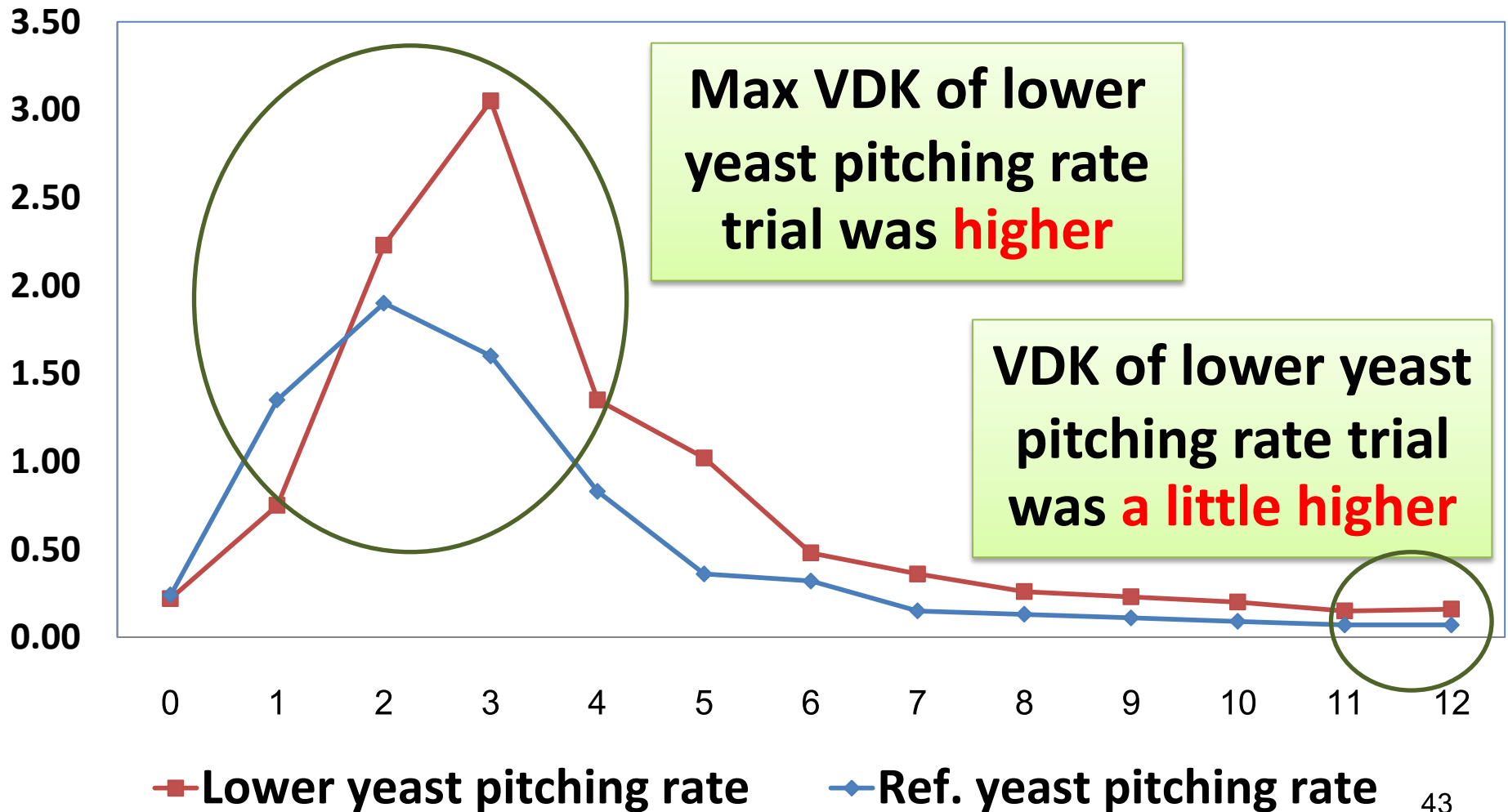
Cell In Suspension (mio/ml)



pH



VDK (mg/l)



Fermentation End

| FT | Lower yeast pitching rate | Ref. yeast pitching rate |
|-----------------------|---------------------------|--------------------------|
| Fermentation time (D) | 12 | 12 |
| Residual Extract (%) | 1.91 | 1.91 |
| Attenuation limit (%) | 1.90 | 1.90 |
| pH | 4.06 | 4.00 |

Fermentation End

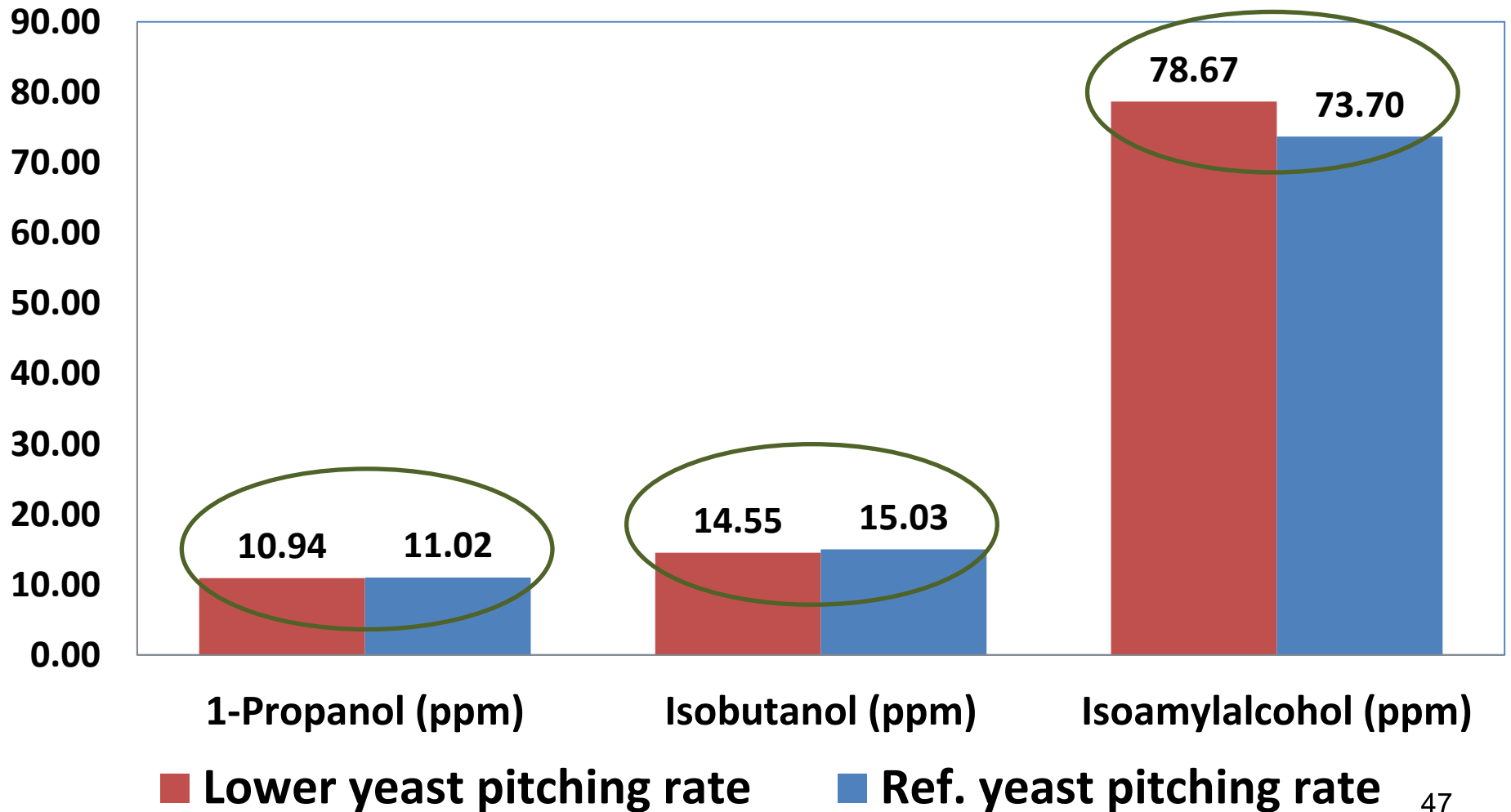
| FT | Lower yeast pitching rate | Ref. yeast pitching rate |
|--------------------------------|---------------------------|--------------------------|
| CIS (million cells/ml) | 24.5 | 17.8 |
| Yeast cropping ratio | 2.08 | 2.47 |
| Dead cell of Cropped yeast (%) | 14.8 | 6.30 |

Finish Goods

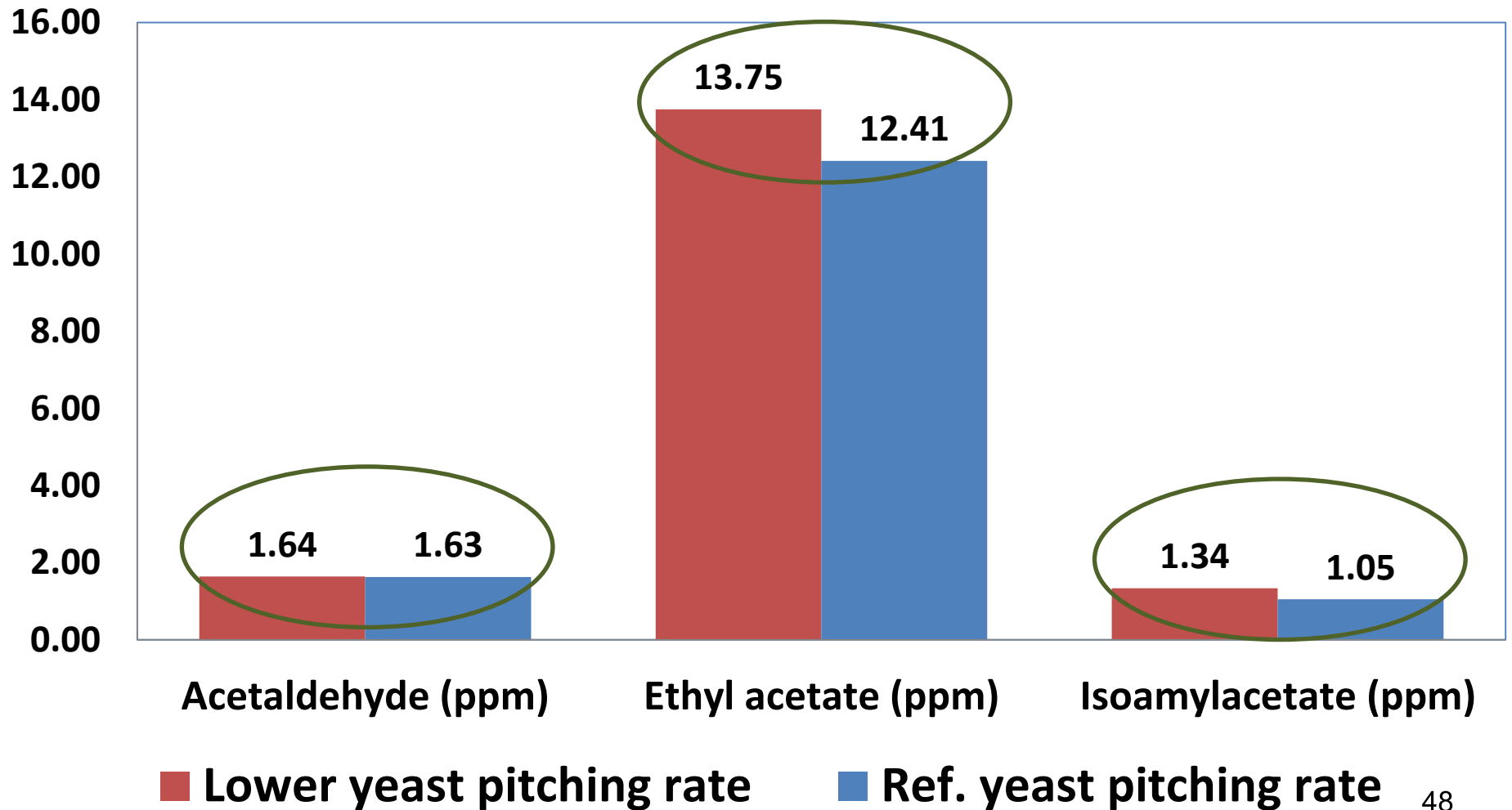
| Trial | Alcohol (% v/v) | App Ext (%w/w) | pH | ADF* (%) |
|---------------------------|-----------------|----------------|------|----------|
| Lower yeast pitching rate | 4.97 | 1.50 | 4.11 | 86.32 |
| Ref. yeast pitching rate | 5.00 | 1.52 | 4.07 | 86.21 |

*ADF = Apparent Degree of Fermentation

Higher Alcohol



Aldehyde and Ester



Sensory Test

Triangle test

Sample G : Trial 3 (Lower yeast pitching rate)

Sample H&I : Trial 4 (Ref. yeast pitching rate)

| Sample's code | Difference sample | Correct | Wrong | Result |
|---------------|-------------------|---------|-------|--------|
| G/H/I | G | 8 | 0 | Sig |

Statistic for different test is triangle test at 95% significance. Panelists could detect difference of samples.

Lower Yeast Pitching Rate

Little higher pH in beer

Higher VDK during fermentation

Lower yeast cropping ratio and higher dead cell

More ester and Iso-amylalcohol

Sensory test is difference

Overview

Brew house part

Lactic acid Addition

Fermentation part

Yeast pitching rate

Trial 3 : Lower yeast pitching rate

Trial 4 : Ref. yeast pitching rate

Summary

Brew house part

Lactic acid Addition

Fermentation part

Yeast pitching rate

1.5×10^6 cells/%Plato/ml_{cw}

