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# Titratable Acidity vs. pH

## Acid Measurement for Practical Brewing

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Omega Yeast

NanoCon

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# Who are we?

Omega Yeast labs

Chicago, IL / St. Louis, MO

High quality, pitch-ready liquid yeast. Handful of microbiologists, homebrewers, professional brewers and craft beer fans who made it our express purpose to make brewing easier and better for everyone.

- Be Helpful
- Be Creative
- Be Fresh




Chris Bernardo

Innovation Brewer


# TA vs. pH

## Talk Overview

- Understanding sour
- Measuring sourness in beer
- Taste test results

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# Tart Vs. Sour

Sourness is a broad flavor encompassing acidic, tangy, or sharp. Some examples include:

- Yogurt and cheese (lactic acid)
- Wine and vinegar (acetic acid)

Tartness is often associated with foods that are acidic or fermented for example:

- Citrus Fruits
- Fermented foods like sauerkraut, pickles, kimchi
- Sour beers

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# Lactic Acid

- Lactobacillus is a bacteria that produces sour flavors in the form of lactic acid
- Lactic acid is commonly found in:
  - Yogurt
  - Sauerkraut
  - Kimchi
  - Pickles
  - Sourdough
  - Sour beers


- Prefered over acetic acid as the dominant flavor in sour beer styles

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# Acetic Acid

- Acetic acid is the most common acid found in vinegar
  - Part of normal yeast metabolism as it's a key component of ethyl acetate
  - Also produced microbes such as Acetomonas and Acetobacter
- Most commonly perceived as:
  - Vinegar
  - Cider
  - Sour Apples
  - Tangy
  - Acidic



- While it can indicate spoilage, it's accepted in styles such as Belgian flanders red and brown, lambics, German geuze.

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# Acid in Beer

Acid in beers is a sensation caused by acid's hydrogen ions (H+) on the tongue flavor receptors. Some of the most common organic acids found in sour beers are Lactic and Acetic acids. However, depending on the fruit additions, other acids such as malic, tartaring, succinic, and many others can be introduced into your sour beers.

Apple Juice - Malic Acid | TA 5-9 g/L | pH 3.48-3.69

Orange Juice - Citric Acid | TA 5-16 g/L | pH 3.53-3.69


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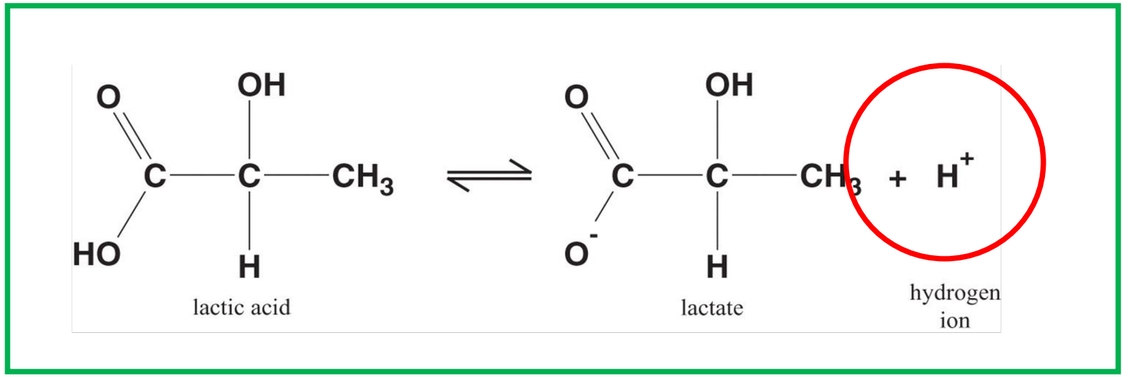
# How do we measure Sour?
# Titratable Acidity vs. pH

- Titratable Acidity
  - Free hydrogen ions **AND** the hydrogen atoms bound to organic acids in beer
  - Reported as g/L of lactic acid as the primary organic acid in kettle soured beer
  - A practical measurement for determining the amount of acid produced
- pH
  - Only the free hydrogen ions
  - Logarithmic scale pH = $-\log_{10}$ [H+]
  - Concentration of H+ relative to pure water
    - 0 = $10^{7}$ H+ ions
    - 7 = $10^{0}$ H+ ions
    - 14 = $10^{-7}$ H+ ions




*Which is a stronger acid, acetic acid or lactic acid?*

Different acids are different strengths (pKa)

Lactic acid pKa 3.86 ☐ stronger
Acetic acid pKa 4.76 ☐ weaker

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# Titratable Acidity

$$M_{acid}V_{acid} = M_{base}V_{base}$$

$$M_{acid} = \frac{M_{base}V_{base}}{V_{acid}}$$

$$TA\ (g/L) = \frac{M_{NaOH} \times V_{NaOH} \times \text{correction factor}}{V_{beer}}$$

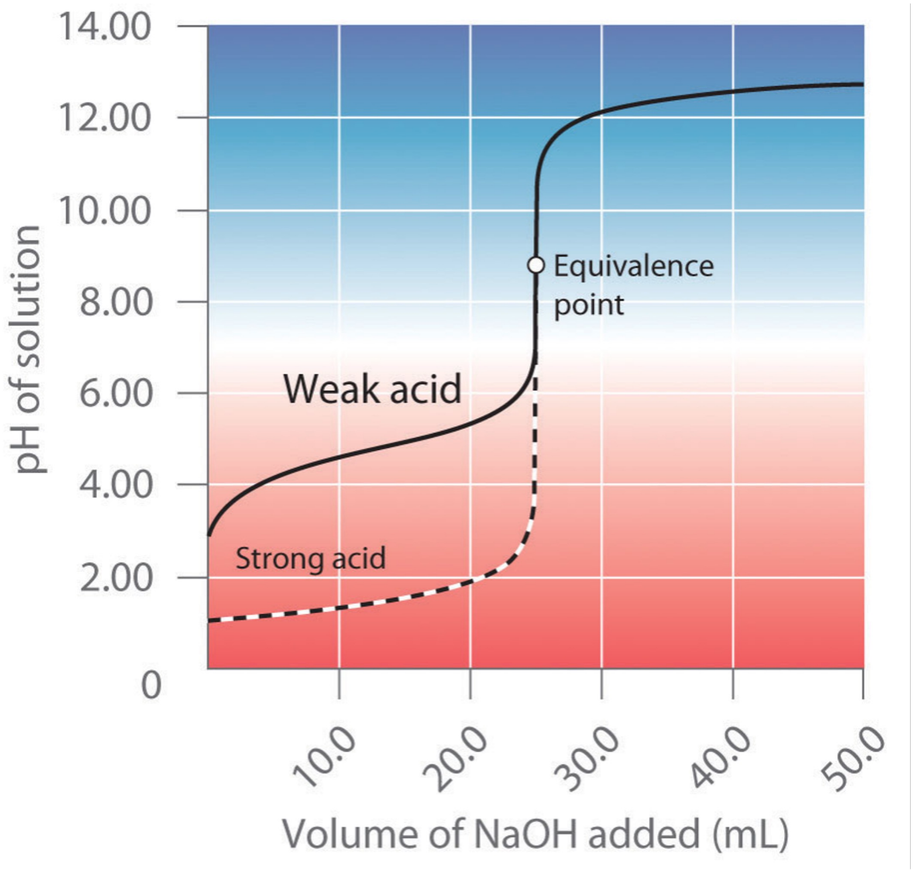
Convert to g/L by multiplying by the molecular weight of the acid divided by the number of protons.

Lactic acid = 90 g/mol / 1 proton = 90

Acetic acid = 60 g/mol / 1 proton = 60

Tartaric acid = 150 g/mol / 2 proton = 75

Citric acid = 192 g/mol / 3 protons = 64



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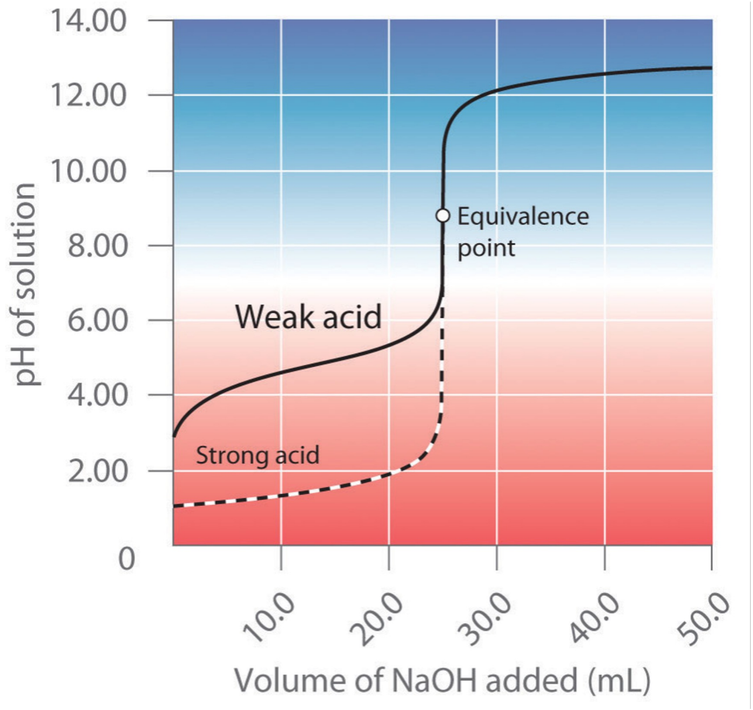
# Titratable Acidity with pH Meter


Add incremental amounts of 1N NaOH until solution reaches pH 8.2



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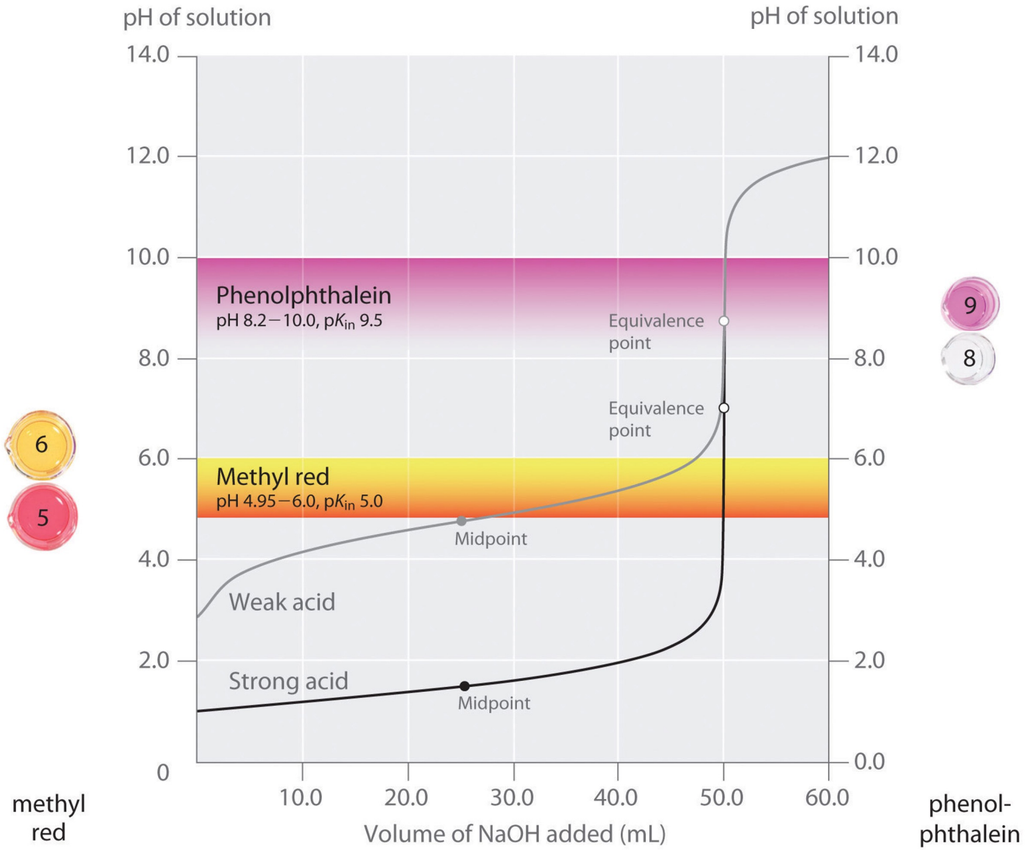
# Titratable Acidity with Phenolpthalein Indicator

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# Titratable Acidity Example

$$M_{acid}V_{acid} = M_{base}V_{base}$$

$$M_{acid} = \frac{M_{base}V_{base}}{V_{acid}}$$

$$TA\ (g/L) = \frac{M_{NaOH} \times V_{NaOH} \times \text{correction factor}}{V_{beer}}$$

Convert to g/L by multiplying by the molecular weight of the acid divided by the number of protons.

Lactic acid = 90 g/mol / 1 proton = 90

Acetic acid = 60 g/mol / 1 proton = 60

Tartaric acid = 150 g/mol / 2 proton = 75

Citric acid = 192 g/mol / 3 protons = 64

50 ml of beer required 5 ml of 1M NaOH to reach pH 8.2

$$\text{TA g/L lactic acid} = \frac{M_{NaOH} \times V_{NaOH} \times 90}{V_{beer}}$$

$$\text{TA g/L lactic acid} = \frac{(5\text{ ml})(1\text{M NaOH})(90)}{50\text{ ml of Beer}}$$

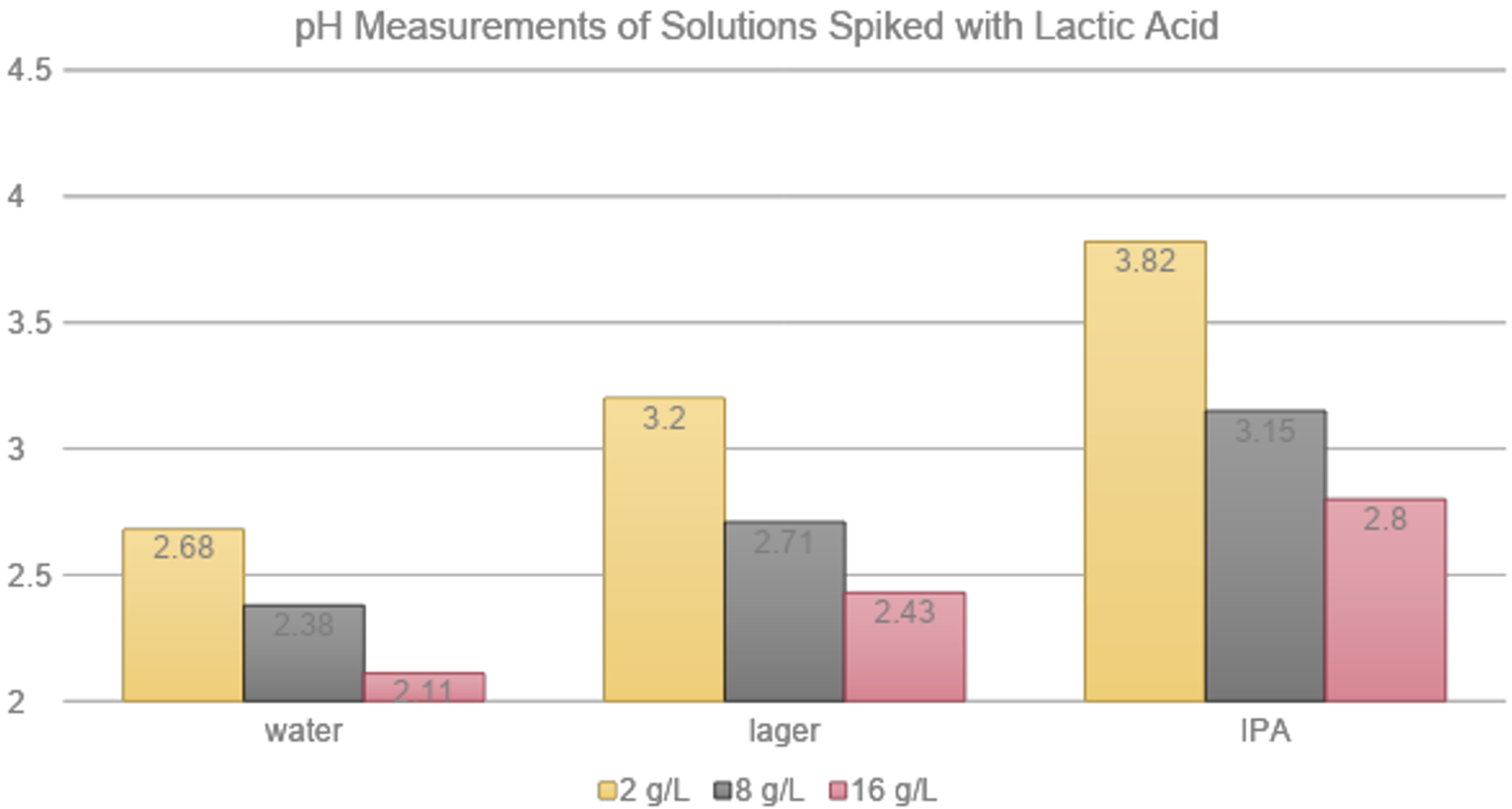
= 8.9 g/L of lactic acid

$$\text{TA g/L acetic acid} = \frac{M_{NaOH} \times V_{NaOH} \times 60}{V_{beer}}$$

$$\text{TA g/L acetic acid} = \frac{(5\text{ ml})(1\text{M NaOH})(60)}{50\text{ ml of Beer}}$$

= 5.94 g/L of acetic acid

# The beer style can have a dramatic impact on pH

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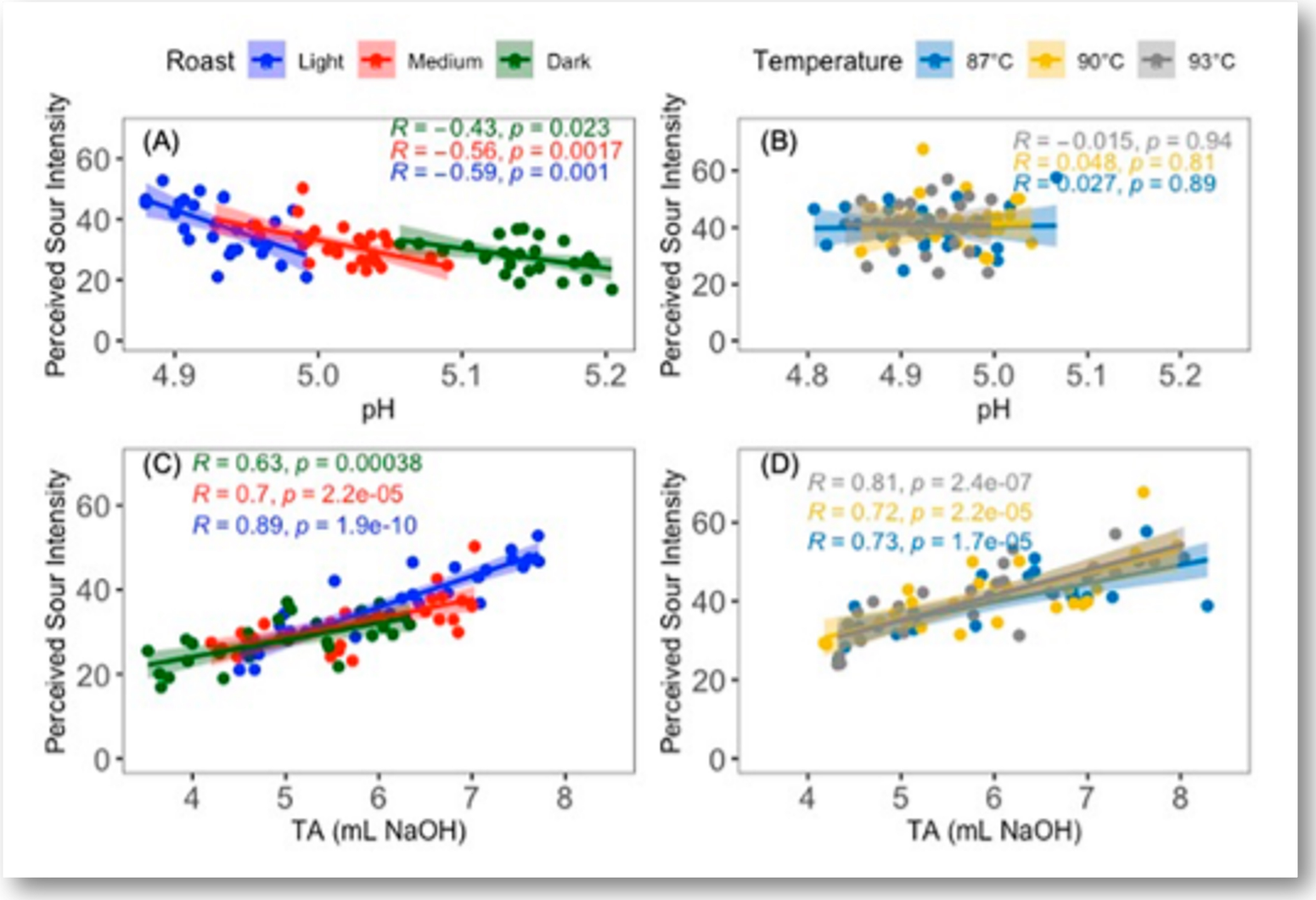


Titratable Acidity, Perceived Sourness, and Liking of Acidity in Drip Brewed Coffee
Mackenzie Batali, Andrew Cotter, Scott Frost, William Ristenpart, and Jean-Xavier Guinard
ACS Food Sci. Technol. 2021, 1, 559-569

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# The Test:

- 4 beer samples were dosed with different concentrations of lactic acid and acetic acid
- pH and TA were measured
- Panelists tasted, compared, and judged samples based on perceived sourness

| Sample | Acid + beer style | pH | TA |
|---|---|---|---|
| A | Acetic + lager | 3.20 | 8g/L |
| B | Lactic + lager | 3.20 | 2g/L |
| C | Lactic + lager | 2.71 | 8g/L |
| D | Lactic + IPA | 3.15 | 8g/L |

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# Different Acids and Same pH

- TA correlates with perceived sourness better than pH
- Acetic acid is a weak acid and lactic acid is a strong(er) acid
  - Strong acids completely dissociate -> more $H^+$ ion in solution -> lower pH at same volume of acid.

| Sample | Acid Spike | pH | TA |
|---|---|---|---|
| A | Acetic Lager | 3.20 | 8 g/L |
| B | Lactic Lager | 3.20 | 2 g/L |

Panelist found sample A to be intense in sourness while finding sample B to have a more pleasant, slight sourness

# Different TA and pH and Same Acid

- Sour perception does not increase in line with concentration.

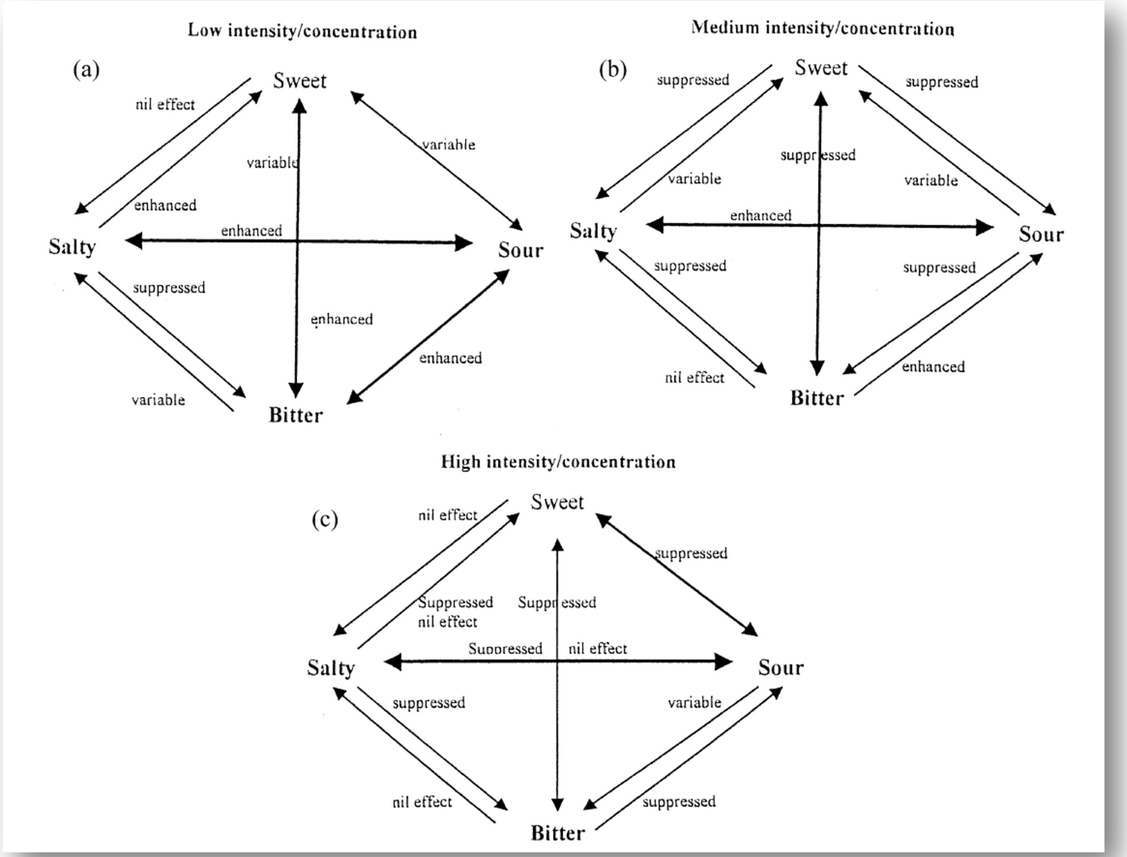
| Sample | Acid Spike | pH | TA |
|---|---|---|---|
| B | Lactic Lager | 3.20 | 2 g/L |
| C | Lactic Lager | 2.71 | 8 g/L |

Panelists didn’t perceive a fourfold increase in sourness despite what the data suggests

# Different Beer and Same Acids and TA

- Buffering Capacity
  - IPA is a better buffer than lager (less free hydrogen ions)
- Interactions
  - At *low* bitterness sourness *increases*
  - At *mid* bitterness sourness *increases*
  - At *high* bitterness sourness *decreases*

| Sample | Acid Spike | pH | TA |
|---|---|---|---|
| C | Lactic Lager | 2.71 | 8 g/L |
| D | Lactic IPA | 3.15 | 8 g/L |




An overview of binary taste-taste interactions
Russell S.J. Keast, Paul A.A. Breslin
Food Quality and Preference 14 (2002) 111-124

# Sour Sensory Summary

- A and B – Different acids, same pH
  - TA correlates with perception better than pH
- B and C – Different TA, same acid
  - Sour perception does not increase in line with TA
- A and C – Different acids, same TA
  - Different acids have unique perceptions
- C and D – Different beer, same acid and TA
  - Beer matrix matters
    - Buffering capacity
    - Flavor interactions

| Sample | Acid Spike | pH | TA |
|---|---|---|---|
| A | Acetic Lager | 3.20 | 8 g/L |
| B | Lactic Lager | 3.20 | 2 g/L |
| C | Lactic Lager | 2.71 | 8 g/L |
| D | Lactic IPA | 3.15 | 8 g/L |

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# In Summary

- pH and TA both have their place in the brewery, but TA gives a more complete picture of total acidity
- With a TA measurement, achieving true to brand beers and maintaining consistency batch to batch becomes more accurate
- Developing a solid sensory program along with a quality control program is key in consistency
- pH changes throughout fermentation however TA remains the same
- Always taste your beer! Sensory data reinforces quantitative data!

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# THANKS!

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## Stay in touch

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