



Lactic Acid: A Safe, label friendly way to reduce pH in Baked Goods

Kathy Sargent, Global Strategic Innovation Director, Corbion

Key Areas for Review

- What is Lactic Acid – history and functionality
- Why use Lactic Acid solutions in baking
- Versatility and use across food applications

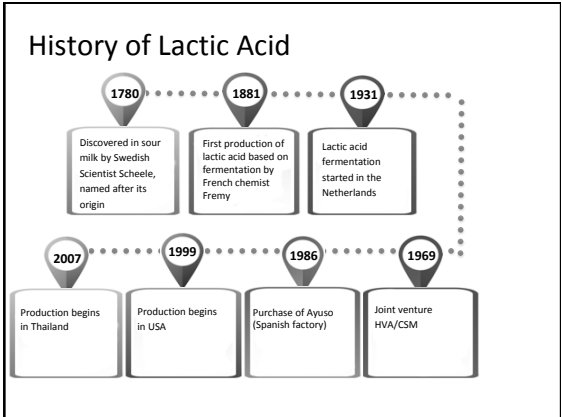
What is Lactic Acid

History and Functionality



Lactic Acid in Bread

Lactic acid bacteria and yeast are abundantly present in flour. When provided water and favorable environmental conditions, fermentation will begin and lactic acid bacteria will form, pH will drop and flavor becomes more sour

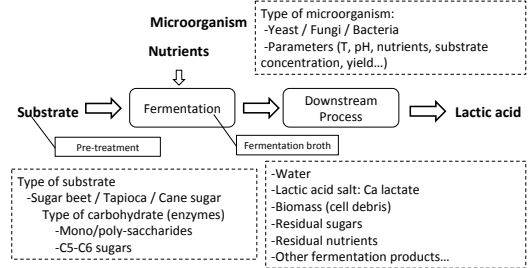


Lactic Acid is naturally present in the human body and in multiple foods

People have consumed lactic acid for centuries, as it is an inherent part of fermented foods. It is naturally produced in the human body's and is an important part of gut health.

Food	% lactic acid	citation	Food	% lactic acid	citation
Beef	0.6-0.7	From Weger et al, 1979	Buttermilk (sweet)	5.7	Hagrine and Afari 1974
Buttermilk (sweet cream)	0.4		Whey (acid cottage)	8.6	
Sour cream	0.6	Atkushi 1973	Pork (horma)	0.9	
Plain yogurt	0.95		Cheese (Gouda)	1.3	Snuders et al, 1988
Condensed buttermilk	5.7		Dry fermented sausage	1.7	
Condensed skim milk	6.8	Hagrine and Afari 1974	Sauerkraut	1.1	
Condensed whey	2.4		Plain soft and Monterey Jack goats cheeses	0.9-1.1	Park and Lee 2000

Lactic acid production



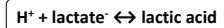
Why Lactic Acid

A **natural antimicrobial**, lactic acid has been extensively studied for its effects against **pathogenic and spoilage bacteria** under both lab and commercial-use conditions. Not only that but lactic acid is also:

- **Naturally present** and **naturally fermented**
- **Safe**, non-toxic, easy-to-use
- Effective for **pathogen reduction**
- Effective **pH reduction**
- **Biobased** and **sustainable**
- **Easily biodegradable** in wastewater treatment plant



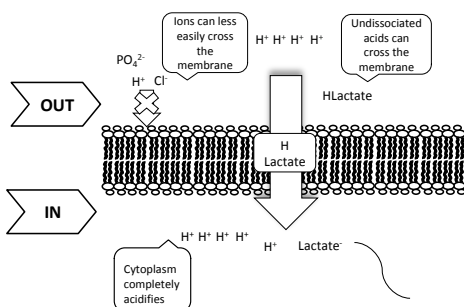
Antimicrobial effect of organic acids



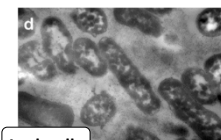
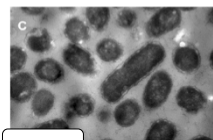
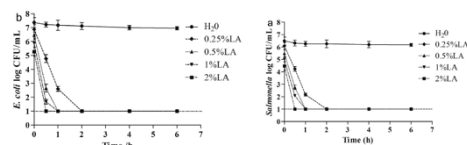
- Weak acids like **lactic** can pass through the cell wall in their whole or **"un-dissociated form"**
- Once there, the acid molecule (H-R) dissociates ($\text{H}^+ + \text{R}^-$) and ultimately causes cell death by **acidifying the cytoplasm**
- **pH is the key**
- While strong acids can lower pH, they readily dissociate and less easily pass into the cytoplasm



Lactic acid at low acidity can kill bacteria



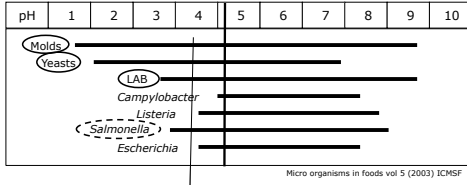
Lactic acid reduces pathogens



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Acidification - pH hurdle

pH hurdle



Micro organisms in foods vol 5 (2003) ICMSF

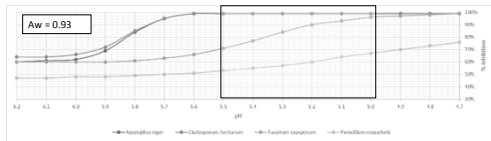
Acidification can be an effective preservation control for some pathogens, but yeast and molds are highly tolerant and able to continue growth among the widest ranges of pH

Value of Using Lactic Acid

In Baked Goods

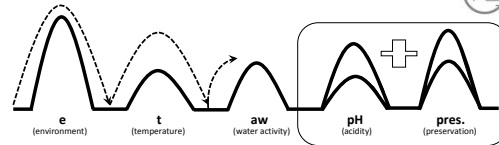
Calcium Propionate (propionic acid) is not completely effective against all common bread molds
Mold Inhibition predictive modeling

For preservation systems to be effective, the system must be in a pH range that allows for activity



We are experts in understanding the effects of hurdle technology as it relates to baked goods

Series of steps, processes & ingredients that help maintain the stability, quality, and safety of food.

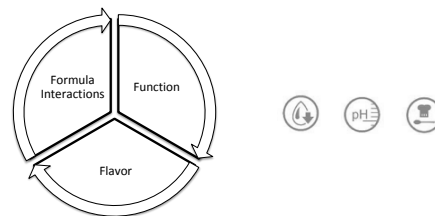


Our lactic acid & fermented solutions allow us to increase the hurdles for microorganisms to develop, making it difficult for mold to cultivate.

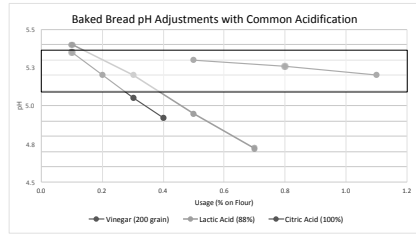
Acid Usage in Baking

- Fumaric – breaks sulfur-to-sulfur bonds in protein network, most common in tortillas.
- Citric – very water soluble with a sharp sourness. Not commonly used in the US.
- Vinegar – common for bakery applications
- Sorbic, malic, lactic, propionic, phosphoric...

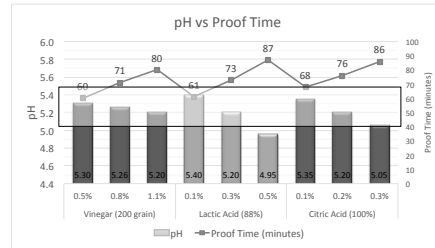
Selecting an acidification system – pH control



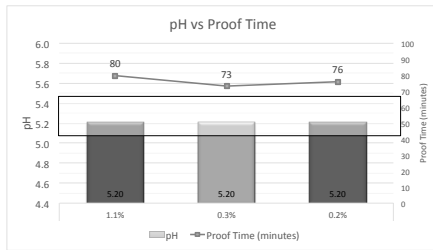
Using Organic Acids to Manage Bread pH



Dough Development and Stability



Dough Development and Stability



Strength and Stability of Dough

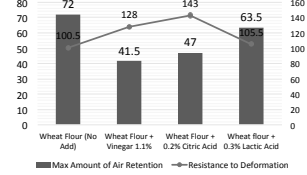
Alveograph:

- Measure flexibility of dough as it relates to flour
- Strength
- Stability

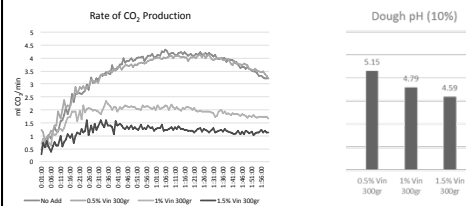


Alveograph Parameters for Bread Dough

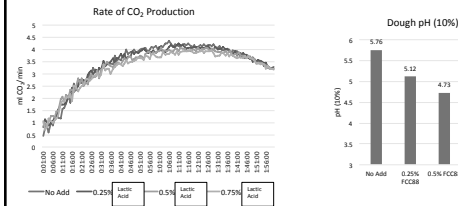
(consistent pH ~5.2 for the treatments)

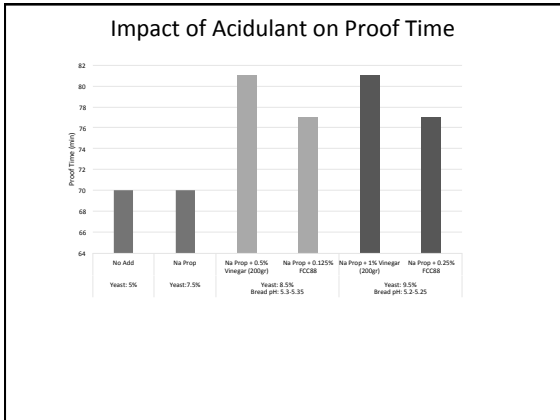


Yeast Activity with Vinegar Risograph Evaluation



Yeast Activity with Lactic Acid Risograph Evaluation





Flavoring with organic acids

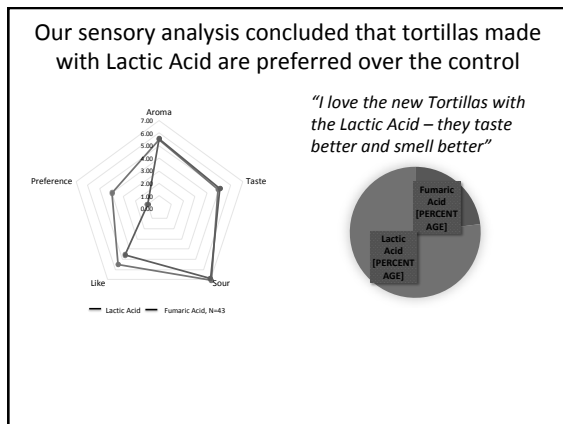
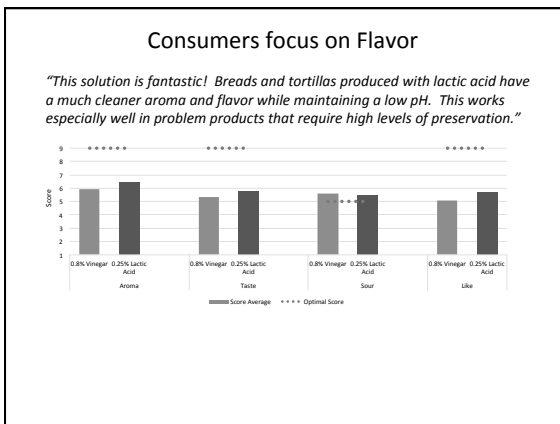
Mild, delayed impact & Masking lingering effects of HIS

- Reduce bitterness in energy drinks

Lactic acid boosting sweet fruity and dairy flavors:

- Red fruits (strawberry, cherry, forest fruits)
- Tropical fruits (peach, mango, passion fruit)
- Dairy (yoghurt, milky flavors)
- Has good fit with cola, vanilla, caramel, coffee

The top graph shows Acid Profile (Y-axis) vs. Lasting Time (X-axis) for Acetic acid, Tartaric acid, Citric acid, Malic acid, and PULAC. The bottom graph shows Sweetness (Y-axis) vs. Lasting Time (X-axis) for Saccharin, Sucrose, Aspartame, and Intensive sweetener, with Citric acid and PULAC also indicated.




Versatility and Use Across Food Applications

Micro organisms are everywhere!

- Soil
- Water
- Air
- Surfaces
- Manure
- Hide

Infographic courtesy of the Centers for Disease Control and Prevention

Lactic acid spray used for carcass surface treatment

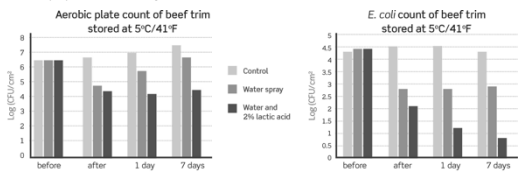


- Used already for a long time as an antimicrobial intervention
- CFU reduction of *E. coli*, *Salmonella*, *Enterobacteriaceae* and others
- Biobased, sustainable product
- Safe chemical for humans
- Safe chemical for the environment
- Easily biodegradable in wastewater treatment plant

PURAC FCC 88

Impact on APC and E. coli over time

- Effect on aerobic plate count (APC) and general *E. coli* count
- Water spray results in 1.5-2 log reduction
- Lactic acid treatment increased initial reduction with additional +/- 0.5 log cfu
- Residual effect seen over time > 2 log cfu



Aerobic plate count of beef trim stored at 5°C/41°F

Time	Control	Water spray	Water and 2% lactic acid
before	~7.5	~7.5	~7.5
after	~7.0	~5.5	~5.0
1 day	~6.5	~5.0	~4.5
7 days	~6.0	~4.5	~4.0

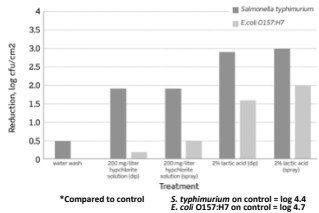
E. coli count of beef trim stored at 5°C/41°F

Time	Control	Water spray	Water and 2% lactic acid
before	~4.5	~4.5	~4.5
after	~4.0	~2.5	~2.0
1 day	~3.5	~2.0	~1.5
7 days	~3.0	~1.5	~1.0

Pathogen Control Study (I)

Results for whole cantaloupes (Alvarado-Casillas et al)

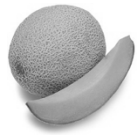
Salmonella typhimurium and *E. coli* O157:H7 reductions* on whole cantaloupes with chlorine and lactic acid



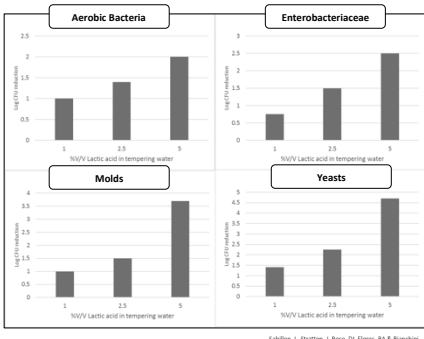
*Compared to control

Treatment:

- 1. *S. typhimurium* on control = log 4.4
- 2. *E. coli* O157:H7 on control = log 4.7

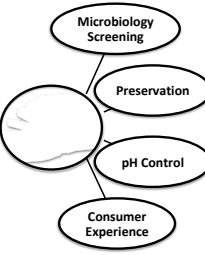


Lactic acid in tempering water



A 2006, "Reduction in microbial load of wheat by tempering with organic acid and saline solutions." *Cereal Chemistry*, vol 83, no. 5, pp. 638-646. DOI: 10.1094/CHEM-05-26-0333-R

Preservation requires a deep understanding of microbiology and the use of different technologies



Microbiology Screening	Full Screening and insulation of the major microorganisms if food systems
Preservation	Use of current knowledge and development of new fermented solutions to fight microorganisms: - Propionate Ferments - Special Vinegars - Other organic compounds
pH Control	Selection of most effective and clean label pH control solutions that can work in synergy with inhibitors: - Vinegar, Lactic Acid, Etc.
Consumer Experience	We optimize our solutions by selecting the combinations that maximize function while balancing taste and quality - Natural Flavors

Final Takeaway

- proven performance
- Why use Lactic Acid solutions in baking – flavor, pH stability, compatibility to development
- Versatility and use across food applications – industry growth with multi-functional benefits