Modeling Functionalities of LMPS Mozzarella based on Calcium Balances

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Importance of Calcium in Cheese Functionality

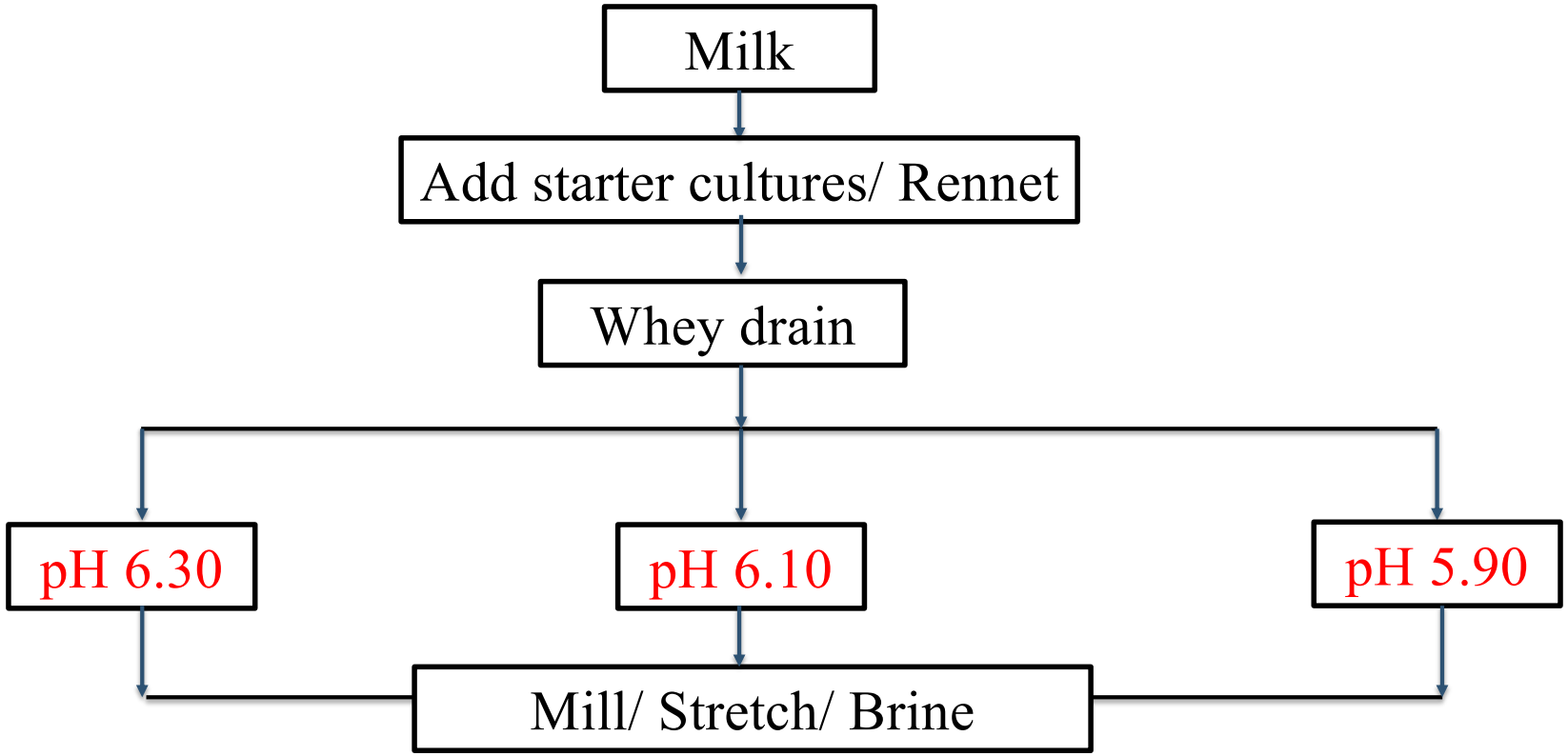
- Total calcium is well known to influence cheese texture
- The insoluble calcium phosphate content is an important indicator of meltability (Lucey and Fox, 1993)
  - Previously thought that all calcium was solubilized at cheese pH (like milk)
- The insoluble calcium phosphate content of cheese decreases during ripening (Hassan et al., 2004)
  - Previously thought that calcium solubilization was done by end of manufacture (no further acid)
- Cheesemakers are often recommended to have more “early” acid if they want to effectively remove calcium to improve melt/curdiness.
  - **Why**?
- **How much calcium is lost at key points in the cheesemaking process?**
- **What are the kinetics of calcium phosphate solubilization during cheesemaking? Does it matter how fast the acid is produced?**

Preliminary Cheese Make in Pilot plant

Whey Drain Study

CDR Pilot Plant

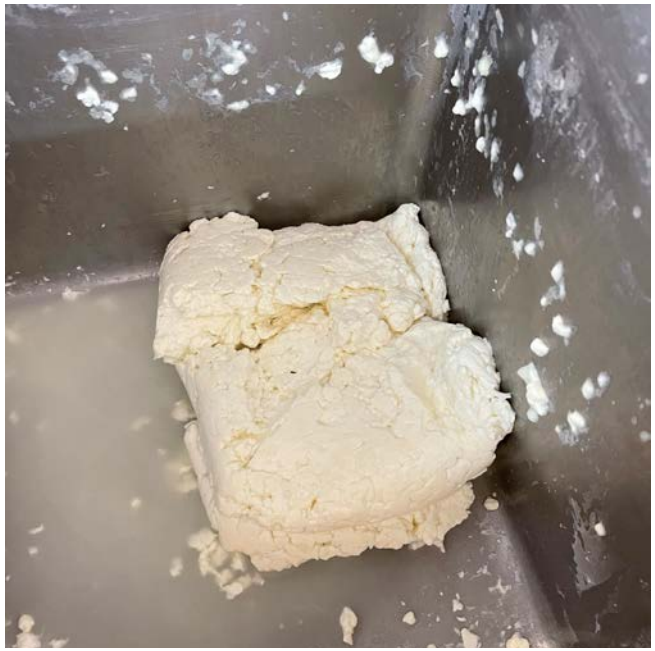
Experimental Design



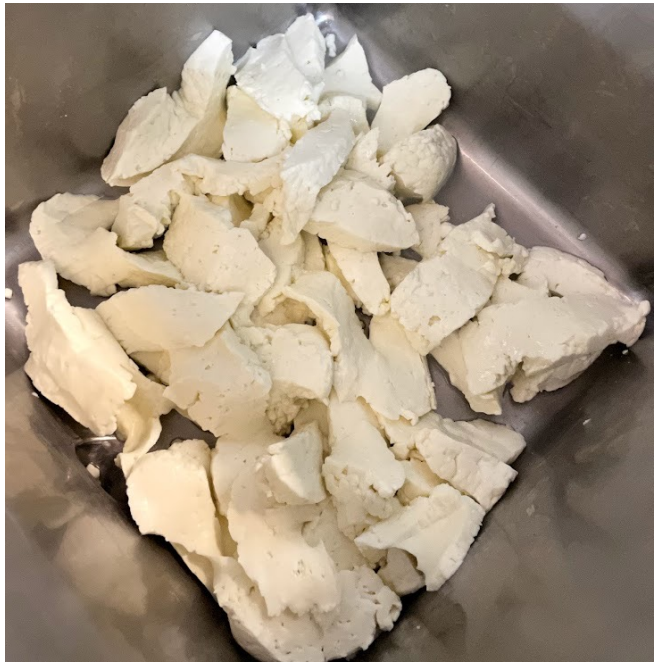
LMPS Mozzarella Manufacture

1. Initial milk

2. After whey drain



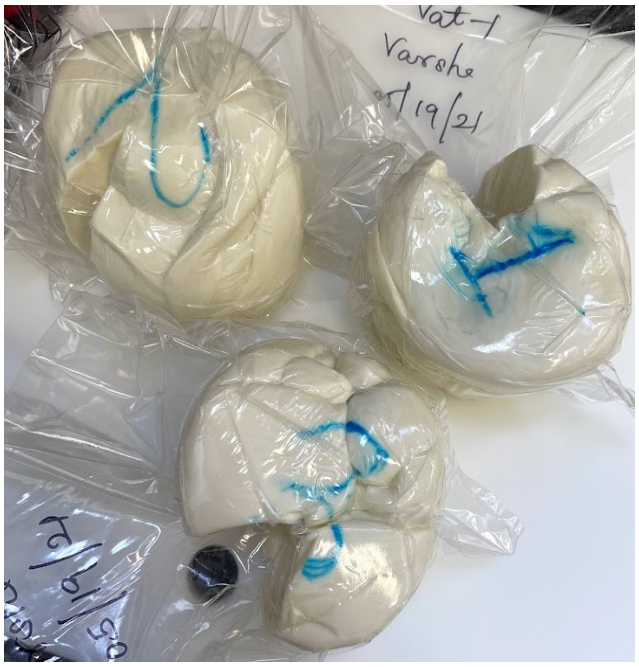
3. Milled curd



LMPS Mozzarella Manufacture

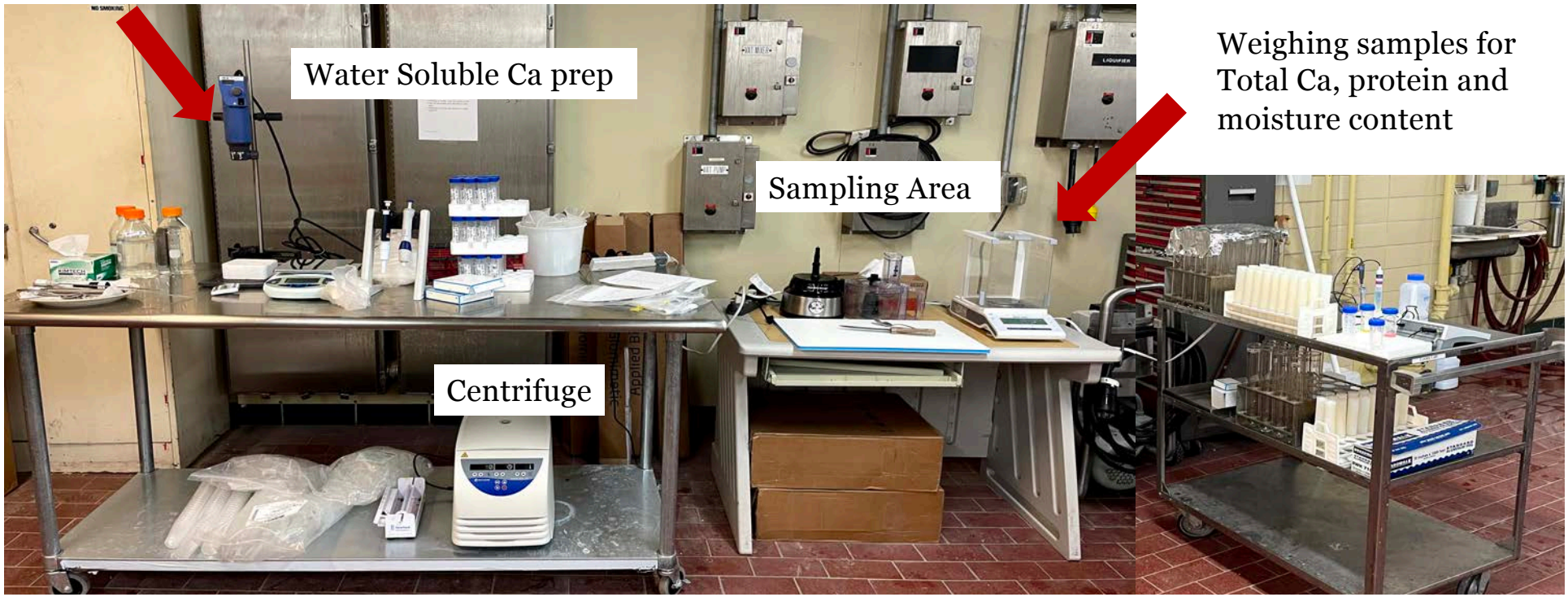
4. Stretched curd

5. Curds after brining



Analysis Area in the Pilot Plant

Hand-held mixer



Weighing samples for Total Ca, protein and moisture content

Analysis Area

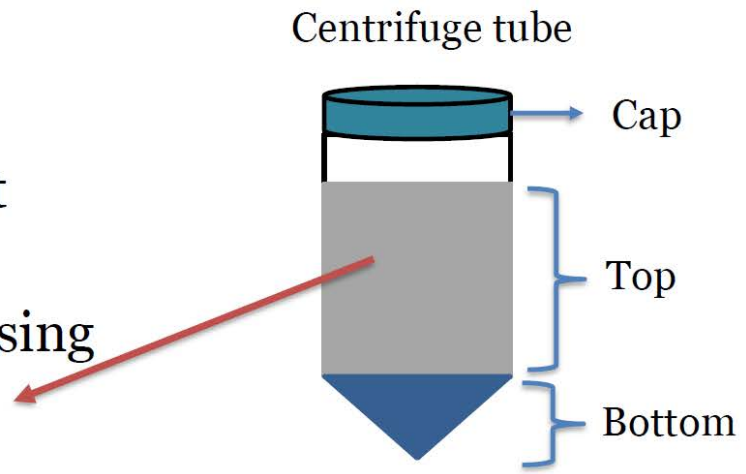
Analyses

- Milk composition
- Cheese composition
- Titrations and soluble Ca in milk (rennet gel)
- Total and insoluble Ca in curds during manufacture-ICP
- Protein content-Kjeldahl
- Total solids-Loss on drying

Method Developed to Monitor State of Ca during Cheesemaking

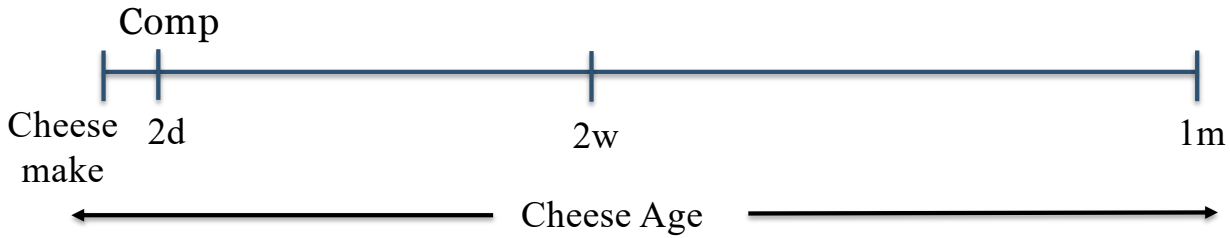
Sample preparation

- 4 g of sampled curds in 40 g of water at temp-55°C
- Homogenized for 2 minutes
- Centrifuged for 10 minutes at 10,000 rpm
- Supernatant- Ca measured using ICP– Water soluble calcium

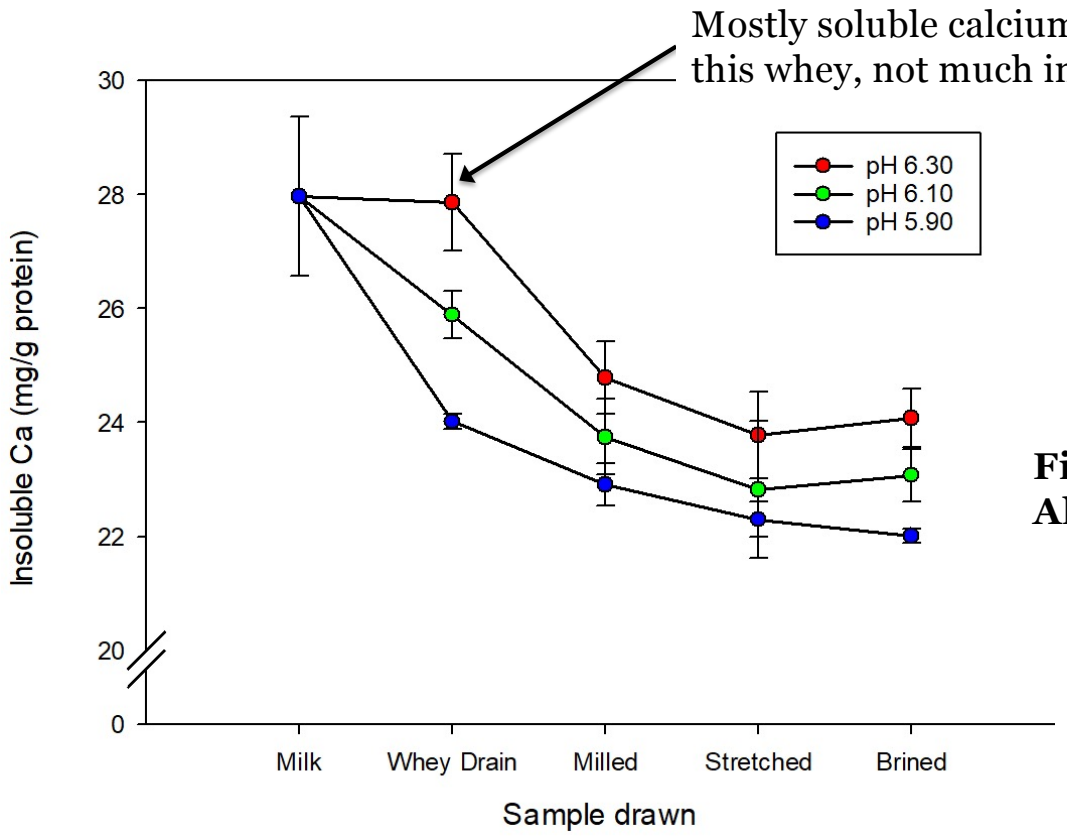


Top layer- soluble Ca
Bottom layer- Insoluble Ca

Sampling and Analyses



Calcium Balances During Manufacture



Final pH ~5.3
All cheeses

Current Work

- Bench top experiments
  - To study the effects of rate of acidification on calcium balances in milk
  - Glucono-delta-lactone (GDL) would be used to acidify the milk
    - Same concentration of GDL would hydrolyze faster at higher temperatures (~40 ºC) and acidify the milk faster as compared to lower temperatures
    - This property of GDL can be used to vary the rates of acidification in milk and to study its effects on calcium balances when pre-acidified to desired pH
  - Low heat non-fat dry milk (NFDM) as sample

Initial trial- Rate of Acidification

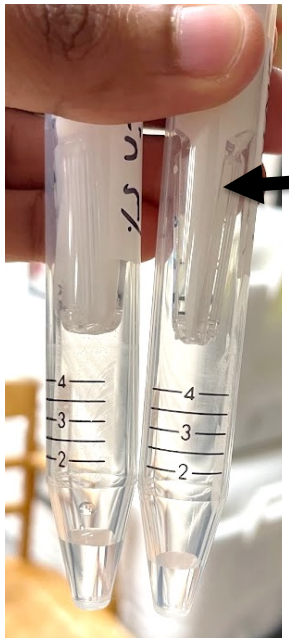
10% NFD (Protein- 3.47%)

- GDL concentration- 0.05 %
- Temp (20, 30, 40ºC)
- pH drop measured
- Samples were drawn at pH 6.30 and 6.10 at each of the temperatures for insoluble calcium measurement
  - Amicon 10 kDa centrifugal filters were used to extract the soluble calcium

Need a rapid method to measure changes in soluble Ca during acidification of milk

- Amicon tubes with 10 kDa filter: quickly generates permeate

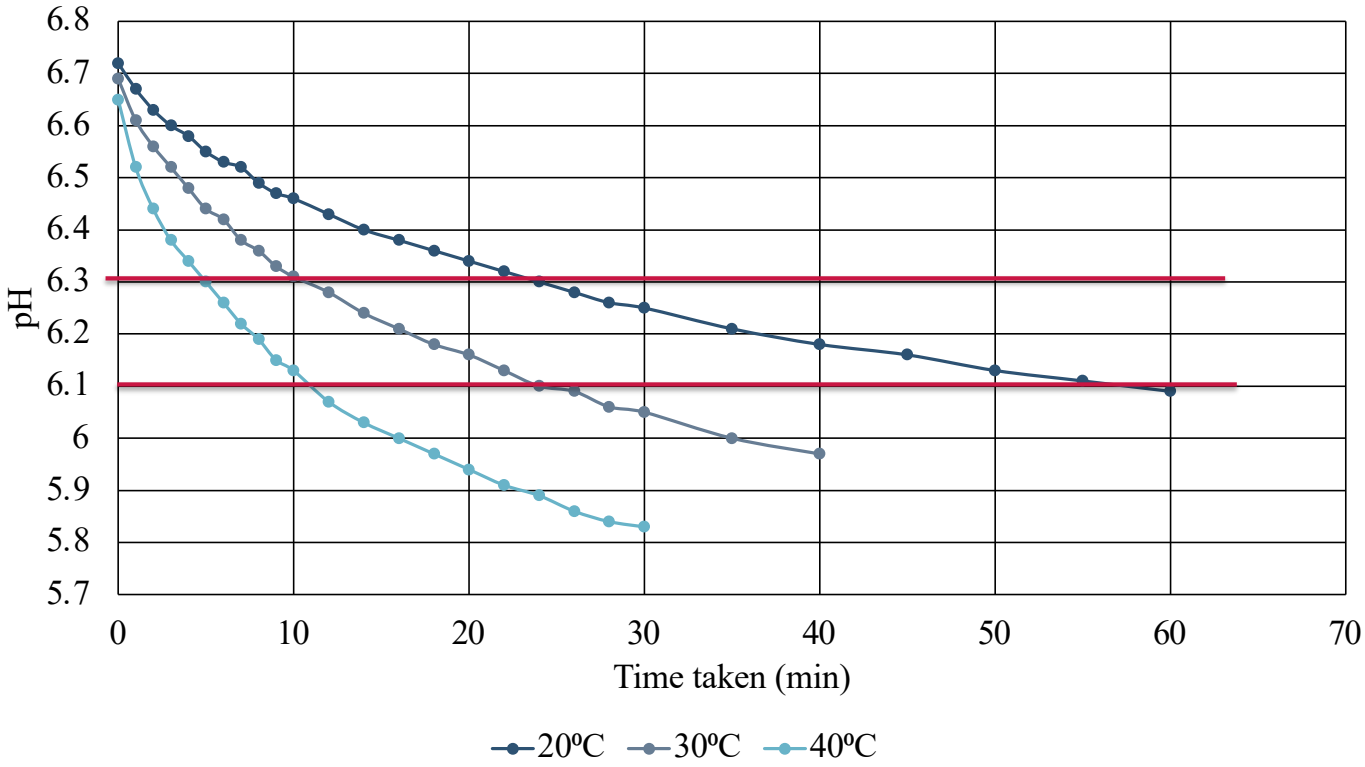
10000 × g for 5 min



10000 × g for 10 min

15000 × g for 10 min

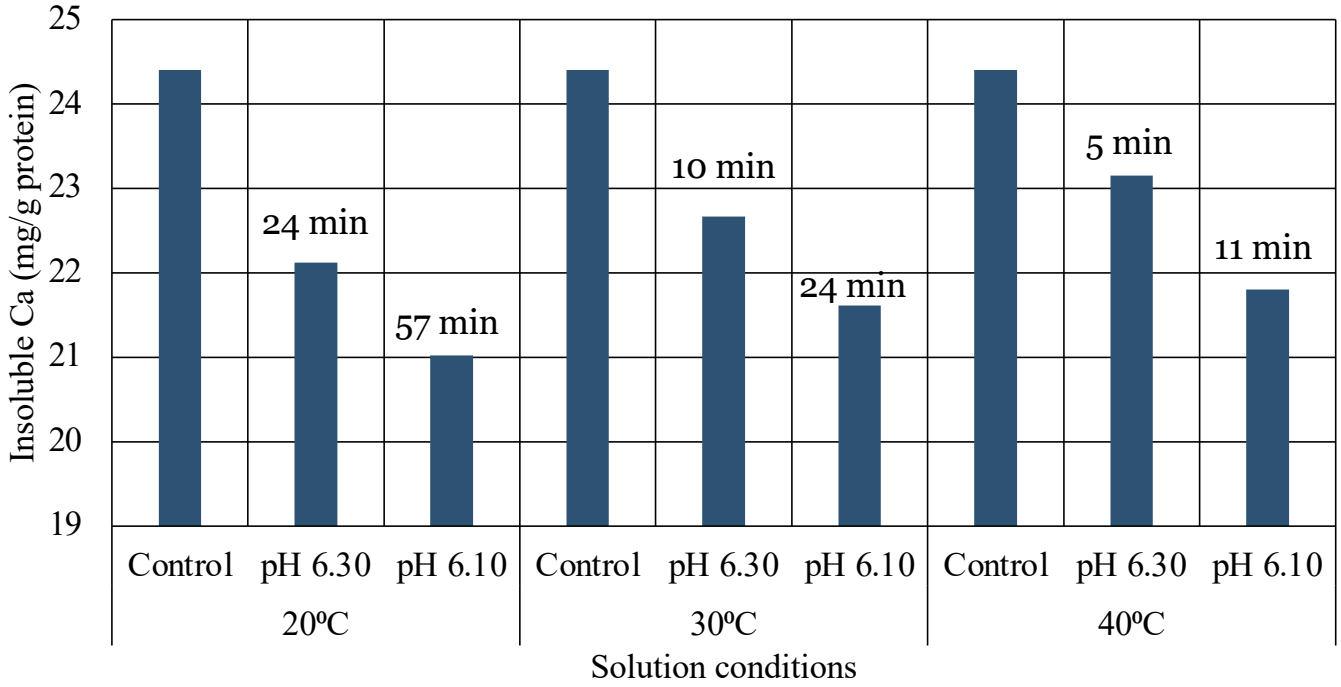
Temperature vs Rate of acidification



Samples were drawn when pH reached 6.30 and 6.10, respectively at each temperatures and the insoluble calcium was measured

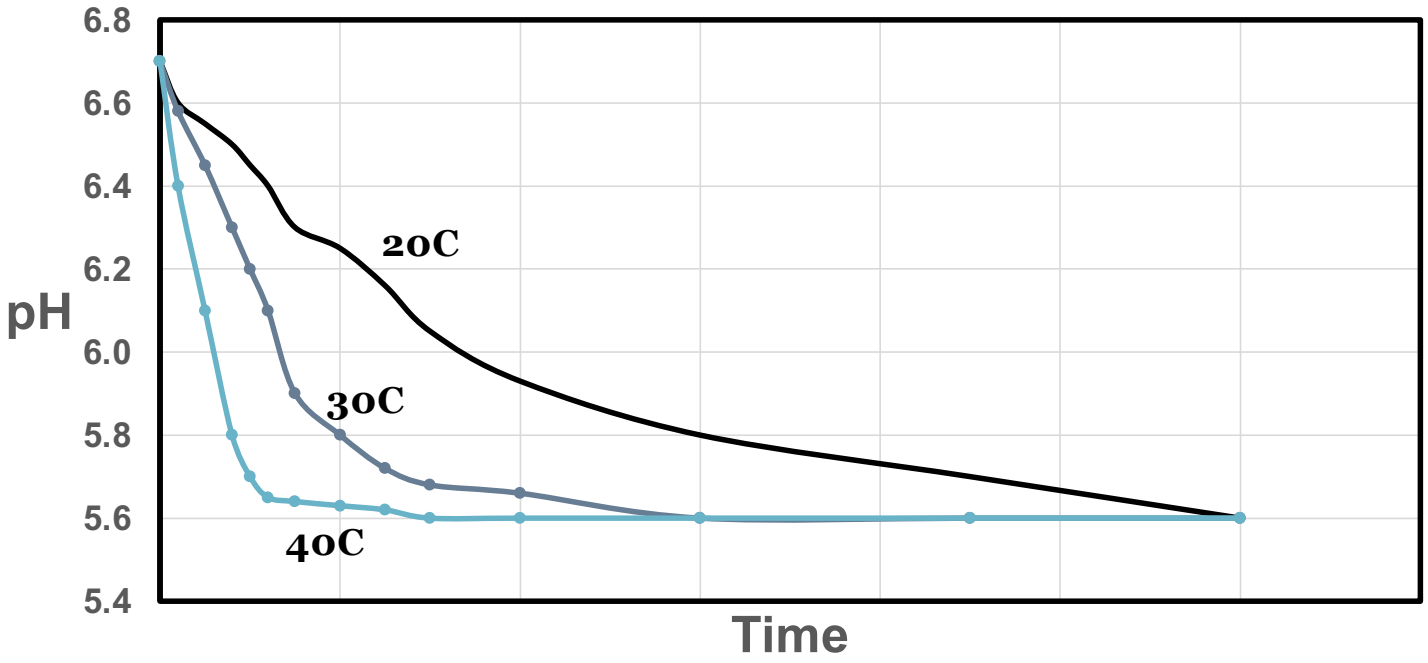
Looked at Impact of Rate of Acidification on Insoluble Ca in Milk

Slower Rate of Acidification Resulted in Greater Ca Solubilization



3.5% total protein
0.05% GDL

Altering temperature, but using same GDL concentration, allows us to vary time to reach the same target pH



Future Experiments

Study the effects of rate of acidification on calcium balances

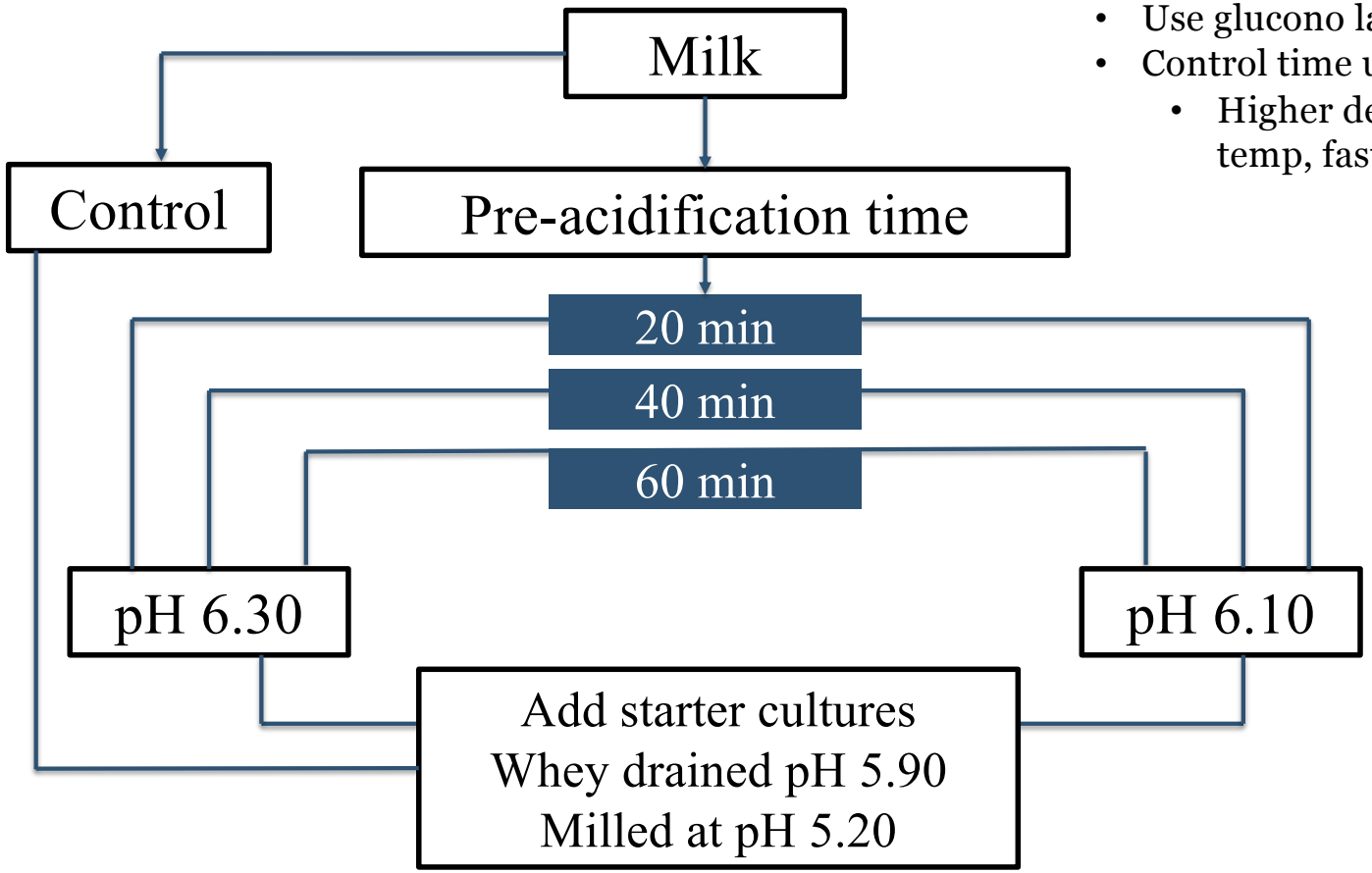
- Constant GDL conc. (chosen from previous experiment)
- Various temperatures (20, 30, 40ºC)
- Measure the insoluble calcium once the rate of acidification has reached a plateau (similar pH values reached at different temp since constant GDL conc.)
- Is there a difference in calcium balances with different rates of acidification?
- How does that impact cheese functionality?

Dairy plant Cheesemake Experiments

Cheese making in dairy plant

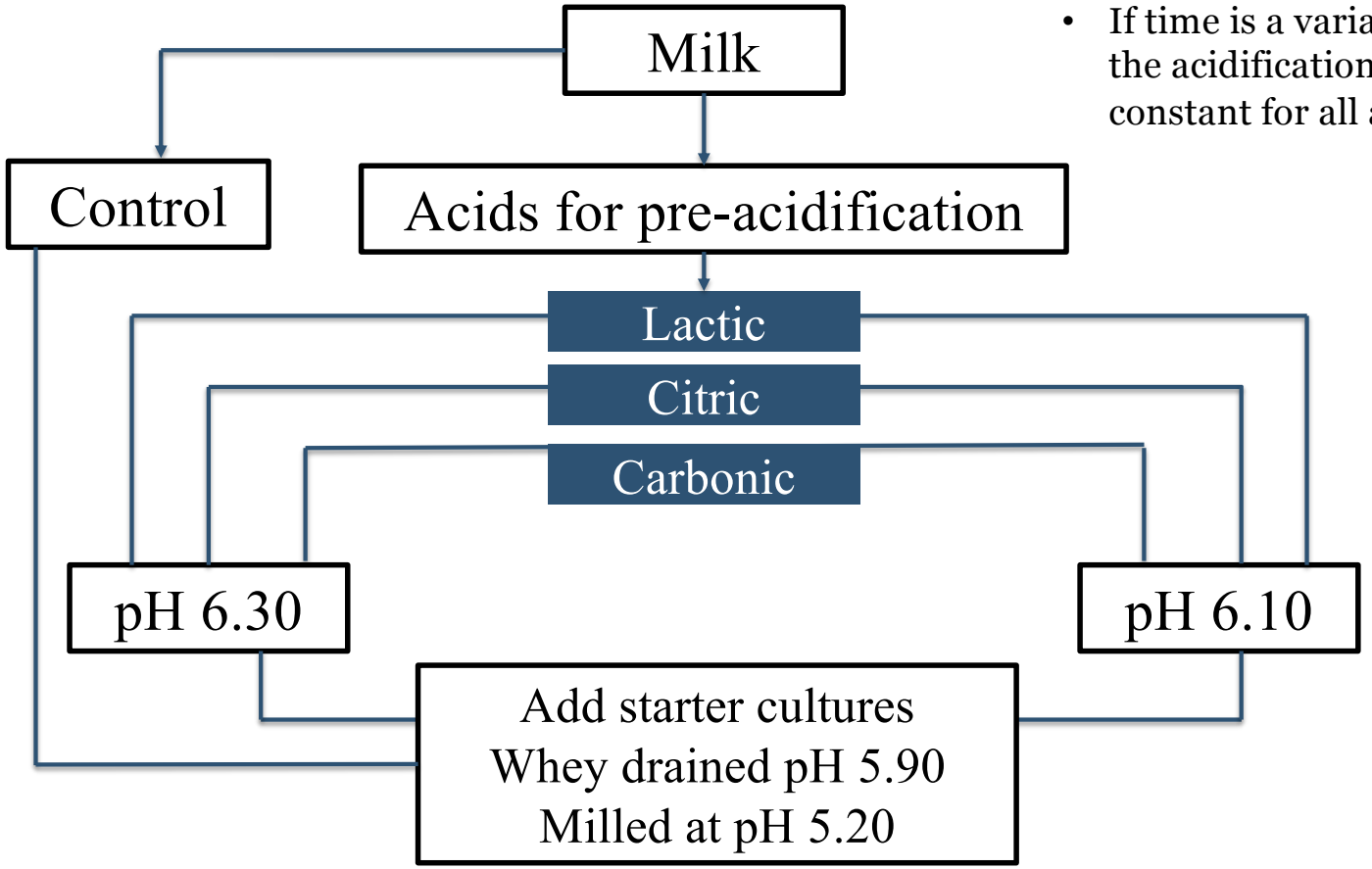
- Experimental design
  - Rate of acidification vs pH
  - Different acids vs pre-acidification pH
  - Different casein conc. vs acids/ pre-acidification pH

Exp 1: Rate of acidification vs pre-acidification pH



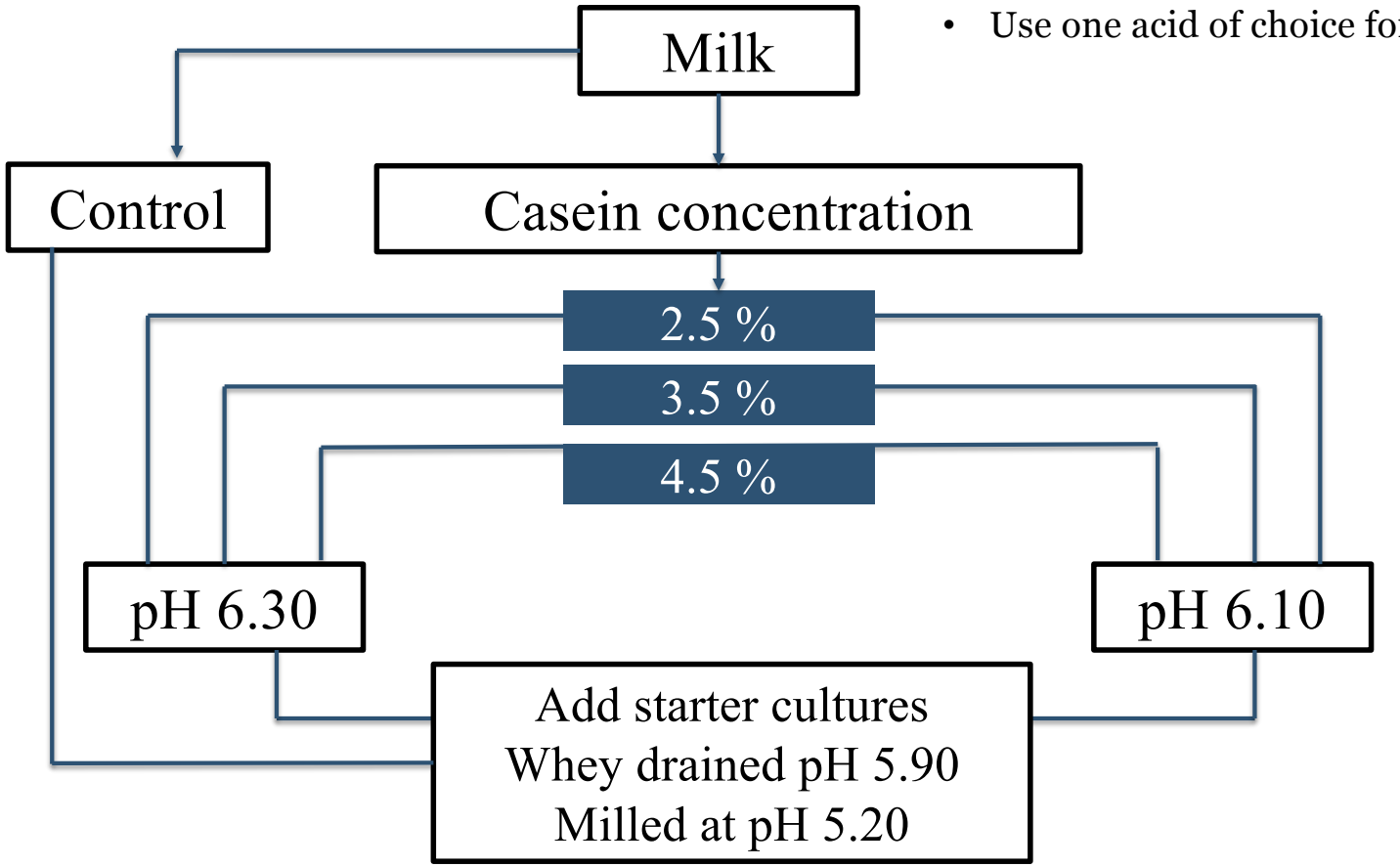
- Use glucono lactone for pre-acidification
- Control time using temperature
  - Higher degree of hydrolysis at high temp, faster acidification

Exp 2: Effect of different acids vs pre-acidification pH



- If time is a variable from previous exp, the acidification time should be kept constant for all acids

Exp 3: Effect of casein concentration vs pre-acidification pH



- Use one acid of choice for pre-acidification

Analyses

- Calcium balances during cheese make
  - Milk samples (Initial milk, pre-acidified milk)
  - Curds (At whey drain, milled curd, cheese after brining)

- Analyses during storage (@ 2w and 1m)
  - Functionality tests (Rheology, Sensory)
  - pH, Calcium balances during storage (Also @ 1w)
  - Proteolysis
  - Confocal microscopy (Fiber structure)
  - Texture Profile Analysis (TPA)

Ultimate Goals

- To develop predictive models for how rate of acidification during cheesemaking impacts insoluble calcium levels in cheese (both at end of manufacture and during ripening)
  - Relate these models to cheese functionality
  - Allow cheesemakers to select make conditions needed to achieve specific functionality (an app or spreadsheet)

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Acknowledgements

- Dr. John Lucey
- Arla Foods- Funding
  - Søren Kristian Lillevang
- CDR Cheese Research Staff
- CDR Analytical Lab
- Yanjie Lu
- Lucey Lab mates

Thank You to Our Supporters

Wisconsin and US Dairy Farm Families | Dairy Farmers of Wisconsin

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