Performance Shelf-Life Extension of Cheese Using High Pressure Processing and Superchilling

Luis A. Jiménez-Maroto, Rani Govindasamy-Lucey, John Jaeggi, Mark Johnson, John Lucey

Center for Dairy Research “Solution Based Research Backed by Experience, Passion and Tradition”
NDC Funded Projects

1. Increasing the shelf-life of export cheese by prolonged low-temperature storage.

2. Investigating the textural changes when cream cheese and mascarpone are super chilled.
Export Cheese

Shelf life
Market Expectations

• LMPS mozzarella for pizza
  – Mild flavor
  – Light color
    • Few dark blisters
  – Long stretch
    • Very long
Performance Shelf Life

• Proteolytic activity
  – Rennet
  – Microbial enzymes

• Proteolysis over time
  – Soften the cheese (weak)

➢ What can be done?
Coagulant

• Use a less proteolytic coagulant

– Reduced proteolysis and bitterness
– Maintained firmer texture over time
High Pressure Processing (HPP)

- Hydrostatic pressures 300 – 600 MPa (43,500 – 87,000 psi).
- Effect:
  - Alteration of ionic and hydrogen bonds
  - Affects proteins
- Consequences:
  - Inactivation of microorganisms (5 log)
  - Reduction of enzymatic activity
  - Modification of food matrix
High Pressure Processing (HPP)
High Pressure Processing (HPP)

- Previous research (9 mo):
  - Reduced microbial activity.
    - Decreased starter numbers.
  - Decreased enzymatic activity.
    - Reduced proteolysis.
  - Disrupted protein structure.
    - Affected textural & rheological properties.


Ozturk et al. 2015. Low-sodium Cheddar cheese: Effect of fortification of cheese milk with ultrafiltration retentate and high-hydrostatic pressure treatment of cheese. J. Dairy Sci. 98. 6713-6726
Storage Temperature

- Freezing cheese - Good!
  - Slows enzymatic activity to a crawl

- But not perfect:
  - Convert first (shred, slice)
  - Freeze & maintain frozen
  - Thaw
  - Possible structural damage – ice crystals
Low Temperature Storage: Superchilling

• Lowering temperature to just above freezing point.

• Benefits:
  – No need to label as ‘frozen’
  – No thawing
  – Low functional damage
  – Extended performance shelf life
Performance Shelf Life Extension

• Extend performance shelf life by combining:
  – Use of less proteolytic rennet
  – High pressure processing (HPP)
  – Low temperature storage
PROJECT 1

INCREASING SHELF LIFE OF EXPORT CHEESES BY PROLONGED LOW TEMPERATURE STORAGE: LMPS MOZZARELLA
LMPS Mozzarella Manufacture

- 1% Na
- Five make dates

Less Proteolytic Coagulant

Ripen at 5° C (42° F), for 2 weeks

1. High Pressure Treatment (600MPa, 3min)
2. Control Group without HPP treatment

- -20° C (-4° F)
- 0° C (32° F)
- 4° C (40° F)

Storage for 12 months
Evaluation Time Points

- Temperature storage effects
  - 3 months
  - 5 months
  - 7 months
  - 9 months
  - 12 months
  Frozen samples are thawed at 4°C (40°F) for 7 days
Superchilling at 0° C (32° F)

• Why choose 0° C?

• Literature reports:
  – Initial freezing point of cheese
    -1.2° to -4.4°C
    (30 – 24° F)
DSC Cooling Curve

Peak = -18.13 °C

-16° to -19° C
(+3.2° to -2.2° F)
Methods

• pH

• Starter & non-starter bacteria

• Quantitative Descriptive Analysis
  – Cheese
  – Pizza
Methods

• Texture Profile Analysis – TA/TX
  – Hardness

• Small amplitude oscillatory rheometry
  – Crossover point (melt point)
  – Max loss tangent (indicator of meltability)
EFFECT OF HPP
(2 WEEK TIME POINT)
Effect of HPP @ 2w

- Increase in pH

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.21</td>
<td>5.32</td>
</tr>
</tbody>
</table>

- ~5 log reduction in starter bacteria

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter</td>
<td>1.6 x 10⁹</td>
<td>4.9 x 10⁴</td>
</tr>
</tbody>
</table>
Effect of HPP @ 2w

Control

HPP
Effect of HPP @ 2w

- LT max (meltability) increase

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LT max</td>
<td>3.09</td>
<td>3.63</td>
</tr>
</tbody>
</table>

- Lower melting point

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melt Point (° C)</td>
<td>46.1</td>
<td>40.6</td>
</tr>
</tbody>
</table>
Effect of HPP @ 2w

- Softens the cheese. Texture Analyzer:

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPA Hardness (N)</td>
<td>15.8</td>
<td>12.9</td>
</tr>
</tbody>
</table>

- Sensory

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>HPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Firmness</td>
<td>7.5</td>
<td>6.4</td>
</tr>
</tbody>
</table>
EFFECTS OVER TIME
3 TO 12 MONTHS STORAGE
CDR UW Proteolysis Control, 4 °C
Control, 0 °C
Control, -20 °C
HPP, 4 °C
HPP, 0 °C
HPP, -20 °C

pH 4.6 Soluble Nitrogen (% of total N)

Storage Time (d)
14 90 150 210 365
Softening Over Time

- TPA Hardness

![Graph showing TPA Hardness over storage time for different conditions: Control, 4 °C; Control, 0 °C; Control, -20 °C; HPP, 4 °C; HPP, 0 °C; HPP, -20 °C.](image)
Temperature at Crossover Point
(Melt point)
Maximum Loss Tangent

![Graph showing LTmax vs Storage Time (d)]
Blister Quantity

After 1 year

Control, Refrig

HPP, Superchilled

Frozen

14 days
Strand Thickness

14 days

After 1 year

Control, Refrig  HPP, Superchilled  Frozen
Flavor Impact

- No significant flavor differences between treatments
  - Panelists noted a sulfur note on refrigerated samples after 9 month time point.
  - Note not perceived on baked cheese (pizza)
Future

• Currently testing: gouda
  – Milled curd
  – Stirred curd

• Up next:
  – Cheddar
PROJECT 2.

INVESTIGATING THE TEXTURAL CHANGES WHEN CREAM CHEESE AND MASCARPONE ARE SUPER CHILLED INSTEAD OF FREEZING
Performance Shelf Life

- Mascarpone and cream cheese have:
  - High pH
  - High moisture
  - High fat
  - Low protein
  - Freezing highly detrimental!
Cream Cheese
Cream Cheese
Mascarpone
Shelf Life Extension

• Combine:
  – HPP
  – Low temperature storage
Future

• Continuing with trials for both:
  – Cream cheese
  – Mascarpone
Acknowledgements

• American Pasteurization Company and our industry partners.

• Wisconsin Center for Dairy Research Analytical, Cheese Research, Applications, and Sensory staff.

• Program funding provided by Wisconsin Milk Marketing Board and National Dairy Council.
Questions?