Investigating Performance Shelf-life of High Pressure treated, Reduced Sodium, Low Moisture Part Skim Mozzarella cheese

Mustafa Ozturk, Rani Govindasamy-Lucey*, John Jaeggi, Mark Johnson and John Lucey
Senior Scientist,
Wisconsin Center for Dairy Research

Center for Dairy Research “Solution Based Research Backed by Experience, Passion and Tradition”
Introduction

- LMPS Mozzarella has 2-6wk performance shelf-life at refrigerated temperatures
- Reduced Na cheeses are an export opportunity as well as for school lunch program
- Problems associated with long term refrigerated storage of LMPS Mozzarella
  - Unmelted: Soft body, poor shreddability (clumping)
  - Melted: Loss of consistency (poor stretch), high blister quantity
Solution?

High Pressure Processing
What is High Hydrostatic Pressure (HPP)?

- 110MPa at deepest point in world’s oceans
- 600MPa for 3 min treatment reported to be similar to thermal pasteurization
- Mostly used for food safety purposes
What Does HPP Affect in Cheese?

- Decreases microbial activity and viability
- Increases/decreases enzymatic activity (depending on the magnitude)
- Modifies the structure (affecting texture and rheology)


Hypothesis

Pressure treatment of 600 MPa (87 kpsi) will;

- Increase refrigerated storage of reduced Na, LMPS Mozzarella cheese by decreasing microbial and enzymatic (esp. proteolytic) activity.
- Alter the texture and functionality by modifying the calcium equilibrium
Objectives

➢ To investigate the impact of using HPP treatment of 600 MPa on the functional and textural properties of reduced Na, LMPS Mozzarella cheeses for 20 wk in refrigerated storage

➢ Determined the following properties:
  ✓ Composition
  ✓ pH
  ✓ Calcium Equilibrium
  ✓ Textural and Functional properties
  ✓ Sensory attributes
All cheeses were manufactured with Chymax M

Control

HPP treatment at 2 wk

600 MPa (87 kpsi), 3 min

2 wk after manufacture HPP applied
Processing

American Pasteurization Company (Milwaukee, WI)
## Mozzarella Composition

<table>
<thead>
<tr>
<th></th>
<th>N=5</th>
<th>Control Cheese</th>
<th>600 MPa treated Cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>48.9 ± 0.9</td>
<td>48.2 ± 0.4</td>
<td></td>
</tr>
<tr>
<td>Fat (%)</td>
<td>22.4 ± 0.6</td>
<td>22.7 ± 0.3</td>
<td></td>
</tr>
<tr>
<td>Salt (%)</td>
<td>1.06 ± 0.08</td>
<td>1.05 ± 0.12</td>
<td></td>
</tr>
<tr>
<td>Protein (%)</td>
<td>24.4 ± 0.9</td>
<td>24.7 ± 0.4</td>
<td></td>
</tr>
<tr>
<td>Fat in Dry Matter (%)</td>
<td>43.9 ± 0.6</td>
<td>43.7 ± 0.4</td>
<td></td>
</tr>
<tr>
<td>Salt in Moisture (%)</td>
<td>2.17 ± 0.18</td>
<td>2.17 ± 0.26</td>
<td></td>
</tr>
</tbody>
</table>
Changes in pH and Starter Bacteria Numbers with Ripening Time

- HPP treated cheeses had higher pH values and lower starter numbers at 2 wk of ripening.
- No difference in lactic acid or galactose levels between the cheeses.

<table>
<thead>
<tr>
<th>Ripening time</th>
<th>Control Cheese (no HPP)</th>
<th>600 MPa treated Cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactic acid (%)</td>
<td>2 wk 0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>2 wk 0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Galactose (%)</td>
<td>2 wk 0.6</td>
<td>0.6</td>
</tr>
</tbody>
</table>
HPP treatment decreased the level of insoluble (INSOL) Ca at 2 wk of storage

No difference after 6 wk
Changes in Proteolysis of Cheeses with ripening time

HPP treatment decreased proteolysis after 8 wk
HPP treatment decreased breakdown of $\alpha_{s1}$-casein

Lower levels of key bitter peptide, $\beta$-casein (f1-189) in HPP treated cheeses
Methods-Texture Profile Analysis

– 2 step compression
– 80% of its original height
– Test temperature: 4°C
– Defined Hardness: Peak force at first compression
Changes in Hardness of Cheeses with Ripening time

- HPP treated cheeses were softer than control cheese until 8 wk of ripening.
- HPP treated cheese was firmer than control cheese at 20 wk of ripening.
Rheological Analysis

- Dynamic small amplitude oscillatory rheometer

- Method:
  - Heat from 5 to 85°C over 80 min
  - Strain: 0.5%

- Measured Parameters:
  - Storage modulus ($G'$): elastic-like behavior
  - Loss modulus ($G''$): viscous-like behavior
  - Loss tangent (LT) = $G''/G'$
    - LT = 1 (cross-over point; the melting point)
    - Maximum Loss Tangent (Max LT; indicates how meltable cheese is)
Changes in Crossover Temperature (or Melting Temperature) of the Cheeses with Ripening Time

- HPP treatment decreased the melting temperature of cheeses
# Sensory Evaluation of Unmelted Cheese

- Quantitative Descriptive Analysis with trained panelists
- 15 point scale

<table>
<thead>
<tr>
<th>Unmelted Cheese</th>
<th>Ripening Time (wk)</th>
<th>Control 600 MPa (87 kpsi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand firmness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 wk</td>
<td>7.2a</td>
<td>7.6a</td>
</tr>
<tr>
<td>16 wk</td>
<td>6.9a</td>
<td>7.9b</td>
</tr>
<tr>
<td>20 wk</td>
<td>7.4a</td>
<td>8.1b</td>
</tr>
</tbody>
</table>

- No significant differences in sensory flavor attributes (sweet, salt acidity).
- No difference in texture before 12 wk of storage
Strand Thickness = The thickness of the melted cheese strand

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<th>Control</th>
<th>600 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 wk</td>
<td>3.7a</td>
<td>6.3b</td>
</tr>
<tr>
<td>16 wk</td>
<td>3.6a</td>
<td>5.2b</td>
</tr>
<tr>
<td>20 wk</td>
<td>1.3a</td>
<td>5.0b</td>
</tr>
</tbody>
</table>

Stretch Length = 6 inches

Stretch Length = 16 inches
**Blister Quantity** = The amount of blisters on the melted surface of the pizza pie

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<th>Control</th>
<th>600 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 wk</td>
<td>9.4a$b$</td>
<td>6.3b</td>
</tr>
<tr>
<td>16 wk</td>
<td>9.6a$b$</td>
<td>5.2b</td>
</tr>
<tr>
<td>20 wk</td>
<td>8.9a$b$</td>
<td>5.0b</td>
</tr>
</tbody>
</table>
28-week (7-month) old LMPS Mozzarella cheese stored at 38ºF – HPP treated, 600MPa (87 kpsi)

Temperature of cheese at shredding = 35ºF
28-week (7 month) old LMPS Mozzarella cheese stored at 38ºF – HPP treated, 600MPa (87 kpsi)
600 MPa HPP treated cheese at 9 mo

Cheese shreds

Cheese shreds baked on a pizza
Impact of HPP in Mozzarella

- Decreased Starter numbers
- Disrupted proteins \(\rightarrow\) Softer matrix
- Inactivated enzymes \(\rightarrow\) Reduced proteolysis
- pH increased \(\rightarrow\) solubilization of CCP

Extend the Performance shelf life
## Summary

<table>
<thead>
<tr>
<th>Problem</th>
<th>Did HPP processing help?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Softness</td>
<td>✓</td>
</tr>
<tr>
<td>Shreddability</td>
<td>✓</td>
</tr>
<tr>
<td>Blister quantity</td>
<td>✓</td>
</tr>
<tr>
<td>Strand thickness/length</td>
<td>✓</td>
</tr>
<tr>
<td>Increased performance shelf-life</td>
<td>✓</td>
</tr>
</tbody>
</table>
Acknowledgements

- Graduate Student: Mustafa Ozturk
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- Wisconsin Center for Dairy Research Analytical, Cheese Research and Applications and Sensory staff
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Thank you!