Impact of Handling and Thawing on Cheesemaking Properties of Frozen Sheep Milk

Bill Wendorff
Dept. of Food science
Univ. of Wisconsin-Madison
Initial Frozen Storage -1996
Early Problems with Freezing

- Milk Separation
- Poor knit of curd
- Poor cheese yield
- Oxidized flavor
Storage Stability of Frozen Raw Sheep Milk

- Frozen at -15°C and -27°C.
- Sampled at 0, 1, 2, 3, 6, 9, and 12 months.
- Analyzed for:
  - SPC
  - Coliforms
  - ADV
  - Intact protein
ADV of Frozen Raw Milk

ml of 1N KOH/100 g of fat

Mo of storage

-15 C

-27 C
Intact Protein in Frozen Milk

Mo of storage

% Protein

-15 C
-27 C
Recommended Storage Conditions for Frozen Raw Sheep Milk

- Fast freezing and storage at -27°C (-10°F) or lower for 6-12 months.
- If freezing in home freezer at -12°C (10°F), limit storage to 3 months maximum.
Abusive handling of frozen sheep milk during transport and impact on cheese-making properties

Thawing procedure and impact on cheese-making potential of frozen milk
Composition of frozen sheep milk used in cheesemaking trials

<table>
<thead>
<tr>
<th>Total solids, %</th>
<th>17.04</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk fat, %</td>
<td>6.65</td>
</tr>
<tr>
<td>True protein, %</td>
<td>4.73</td>
</tr>
<tr>
<td>Casein, %</td>
<td>3.89</td>
</tr>
<tr>
<td>Casein/true protein, %</td>
<td>82.23</td>
</tr>
<tr>
<td>Casein:fat ratio</td>
<td>.58</td>
</tr>
</tbody>
</table>

(Raw milk was frozen at -29°C)
### Abusive handling of frozen sheep milk during transport

#### Treatments
- Control, no abuse
- 4°C for 24 h – potential loss of freezing temp in refrigerated trailer
- 24.4°C for 4 h – placed on loading dock during transit

#### Procedure
- Bags of raw milk were quick frozen at -29°C for 6 wk.
- Abusive treatments were applied and milk was refrozen for additional 2 mo.
- After 3.5 mo of storage, milks were thawed and analyzed
Cheese from Abusive Handled Milk

- Abusive treatments did not result in precipitated casein
  - Initial pHs of milk
  - Coagulation times
  - Cut times
  - Whey pHs
  were similar for all treatments
Influence of abusive storage treatments on semi-soft sheep cheese

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>24 h @ 4°C</th>
<th>4 h @ 24.4°C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cheese yield, %</strong></td>
<td>20.62^a</td>
<td>20.48^a,b</td>
<td>20.19^b</td>
</tr>
<tr>
<td><strong>Cheese moisture, %</strong></td>
<td>43.98^a</td>
<td>42.29^a,b</td>
<td>40.94^b</td>
</tr>
</tbody>
</table>
Recommendations on use of transported frozen sheep milk

- For transport in warm weather, use frozen milk within 2-3 months of receipt
- In warm weather, use temperature loggers to ensure proper frozen transport
- If milk received any potential abusive handling, assume “slow-frozen” milk and limit storage to less than 2 months
Transport Temperature Loggers

- Temperature loggers may be single service or reusable
- Loggers may be recordable and provide alarms in transit
Frozen Sheep Milk

- Milk frozen at -27°C has over 96% of the water in frozen state and has over 75% solids in the unfrozen portion.
- Proteins are partially dehydrated and soluble calcium is decreased (reversible reaction).
- Upon thawing, protein will be rehydrated and calcium will be resolubilized.
Impact of thawing procedure on cheesemaking potential

- **Treatments**
  - 24 h @ 3.8°C (38°F)
  - 32°C water bath
    - Equals set temperature for cheese (90°F)
  - 54.5°C water bath
    - Assuming thawing in vat pasteurizer (130°F)
  - Microwave defrost
Soluble calcium and coagulation time of thawed sheep milk

<table>
<thead>
<tr>
<th>Thawing procedure</th>
<th>Soluble calcium (mg/100 ml of milk)</th>
<th>Coagulation time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 h @ 3.8°C</td>
<td>32.50(^a)</td>
<td>9(^c)</td>
</tr>
<tr>
<td>32°C water bath</td>
<td>29.55(^b)</td>
<td>10(^b)</td>
</tr>
<tr>
<td>54.5°C water bath</td>
<td>31.95(^a,b)</td>
<td>10(^b)</td>
</tr>
<tr>
<td>Microwave defrost</td>
<td>27.11(^b)</td>
<td>12(^a)</td>
</tr>
</tbody>
</table>
Rennet Coagulation
(thin network = soft clot, small pores)

Calcium ion “free calcium”
(ionic calcium from the milk, or addition of calcium chloride)

Loss of protruding k casein

Addition of coagulant
pH 6.4 - 6.6

Casein micelles

Fat and serum are trapped
### Soluble calcium and coagulation time of thawed sheep milk

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<tr>
<td>24 h @ 3.8°C</td>
<td>32.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>32°C water bath</td>
<td>29.55&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>54.5°C water bath</td>
<td>31.95&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Microwave defrost</td>
<td>27.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12&lt;sup&gt;a&lt;/sup&gt;</td>
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</table>
Van Slyke Cheese Yield Formula

\[
\text{% yield} = \left[ \text{RF} \times \text{% fat in milk} + \text{RC} \times \text{% casein in milk} \right] \times \text{RS}
\]

\[
\text{% solids/100}
\]

RF = Fat recovered in cheese.
RC = Casein recovered in cheese.
RS = This number reflects the contribution of other solids not casein or fat that are part of the cheese solids ie. salt, minerals, lactic acid. This number increases as the serum solids increase.
### Recommended Retention Factors for Van Slyke Cheese Yield Formula for Sheep Milk

<table>
<thead>
<tr>
<th></th>
<th>Soft cheese</th>
<th>Hard cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF value</td>
<td>.82</td>
<td>.84</td>
</tr>
<tr>
<td>RC value</td>
<td>.96</td>
<td>.96</td>
</tr>
<tr>
<td>RS value</td>
<td>1.01</td>
<td>1.08</td>
</tr>
</tbody>
</table>
Theoretical cheese yield

- Theoretical yield from milk in Table 1 = 17.39 %
## Yield of cheese from thawed sheep milk

<table>
<thead>
<tr>
<th>Thawing procedure</th>
<th>Yield of curd, % (1 h)</th>
<th>Yield of cheese, % (24 h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 h @ 3.8°C</td>
<td>20.50&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.85</td>
</tr>
<tr>
<td>32°C water bath</td>
<td>20.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.75</td>
</tr>
<tr>
<td>54.5°C water bath</td>
<td>21.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.70</td>
</tr>
<tr>
<td>Microwave defrost</td>
<td>20.59&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16.67</td>
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Moisture of cheese from thawed sheep milk

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<th>Cheese moisture, %</th>
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<tr>
<td>24 h @ 3.8°C</td>
<td>42.21&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>32°C water bath</td>
<td>43.61&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>54.5°C water bath</td>
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Slow vs. rapid thawing of milk
(as reported in literature)

- **Slow thaw**
  - Higher protein values (Timms, 1988)
  - Destruction of microbial cells was greater (Gebre-Egziabher et al., 1982)
  - Higher levels of soluble calcium and increased expulsion of whey from milk gels (Lin et al., 1994)

- **Rapid thaw**
  - Reduced fat separation in buffalo milk (Addeo et al., 1992)
  - No significant differences in cream volume or viscosity; however, rapid thawing had least harmful effect on colloidal properties of whole milk (Baudart and Coppens, 1962)
Conclusions from current study

- Slow thawing at 4°C provided the greatest concentration of soluble calcium, most efficient coagulation, and most effective syneresis of whey.
- No significant differences in cheese yield between thawing procedures.
- The 54.5°C thawing procedure resulted in a higher moisture cheese.
Rapid thawing of frozen sheep milk

- Using 32°C is an ideal compromise since rehydration of milk proteins is optimum and equilibration of soluble calcium is sufficient.
- Temperature is very close to set temperature.
Quality Milk for Quality Sheep Milk Cheeses
Acknowledgements

This research was supported in part by:

College of Agricultural & Life Sciences, Univ. of Wisconsin-Madison
Wis. Center for Dairy Research
Univ. of Wis. Agric. Research Station, Spooner, WI
Out with the Old
In with the New

Franco Milani
- Sustainable Food System Specialist
- Ph: (608) 890-2640
- Fx: (608) 262-6872
- milani@wisc.edu


An Outreach Program of the Dept. of Food Science & Wis. Center for Dairy Research
College of Agricultural and Life Sciences
University of Wisconsin-Madison

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