Use of mid-infrared spectroscopy to predict coagulation properties of buffalo milk

S.Currò*, C.L. Manuelian, M. Penasa, M. Cassandro, M. De Marchi

*sarah.curro@phd.unipd.it
University of Padova
Department of Agronomy, Food, Natural resources, Animals and Environment (DAFNAE)

Heilbrunn (Austria)
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Introduction

World Milk Production

- Cow: 83%
- Buffalo: 14%
- Sheep: 1%
- Other: 0%
- Goat: 2%

ANASB, 2017

Italian Buffalo Census

- Buffalo heads x 1,000

FAOSTAT, 2017

**Buffalo Milk**

### Milk yield and composition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield (kg/d)</td>
<td>7.11</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>7.70</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>4.76</td>
</tr>
<tr>
<td>Casein (%)</td>
<td>3.65</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>4.60</td>
</tr>
</tbody>
</table>

Manuelian et al., 2017
Mozzarella cheese making process

- Packaging
- Milk preparation
- Brining vats
- Curd Molding
- Curd Stretching
- Curd Maturation
- Curd
- Coagulation Process
Milk Coagulation Properties (MCP)

- **RCT** = rennet coagulation time, min
- **k_{20}** = curd-firming time, min
- **a_{30}** = curd firmness after 30 min from rennet addition, mm
Mid-infrared spectroscopy (MIRS) analysis

- Cheap
- Chemical-free
- No time-consuming
- 500 samples/hour
- Routine determination of milk composition traits

Milkoscan FT6000, FOSS Electric A/S

MIRS spectra
Introduction

AIM

To investigate the feasibility of MIRS to predict MCP of buffalo milk
Material and Methods

116 samples (50 ml)
Bronopol (preservative)
Collected in March 2017 from 2 farms of North Italy (Veneto)

Buffalo milk

Formagraph, Foss
MilkoScan FT 6000, Foss

Match of reference data and spectra

MCP prediction equations
Mid-infrared spectroscopy (MIRS) analysis

- Software: WinISI III v 1.60
- Spectra region from 5,000 to 900 cm\(^{-1}\)
- Removal of water noise regions (3,690 to 2,990 cm\(^{-1}\) and 1,710 to 1,580 cm\(^{-1}\))
- Modified partial least squares regression analysis
- Several math treatments (25 combinations)

Prediction procedures
- Cross-validation (116 samples)
- External-validation (75% of samples for calibration set and 25% for validation set)
**Results**

<table>
<thead>
<tr>
<th>Trait</th>
<th>N</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT, min</td>
<td>116</td>
<td>13.07</td>
<td>4.00</td>
<td>26.3</td>
<td>3.86</td>
</tr>
<tr>
<td>$k_{20}$, min</td>
<td>114</td>
<td>3.19</td>
<td>1.45</td>
<td>8.15</td>
<td>0.99</td>
</tr>
<tr>
<td>$a_{30}$, mm</td>
<td>116</td>
<td>43.88</td>
<td>12.88</td>
<td>56.24</td>
<td>8.32</td>
</tr>
</tbody>
</table>

RCT = rennet coagulation time; $k_{20}$ = curd-firming time; $a_{30}$ = curd firmness 30 min after rennet addition to milk
## Fitting statistics of prediction models

### Cross-validation

<table>
<thead>
<tr>
<th>Trait</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>SE₂</th>
<th>R²c</th>
<th>SECV</th>
<th>R²CV</th>
<th>RPDCV</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT, min</td>
<td>110</td>
<td>12.99</td>
<td>3.56</td>
<td>1.55</td>
<td>0.81</td>
<td>1.89</td>
<td>0.72</td>
<td>1.88</td>
</tr>
<tr>
<td>k₂₀, min</td>
<td>103</td>
<td>3.02</td>
<td>0.63</td>
<td>0.46</td>
<td>0.47</td>
<td>0.47</td>
<td>0.44</td>
<td>1.34</td>
</tr>
<tr>
<td>a₃₀, mm</td>
<td>113</td>
<td>44.53</td>
<td>7.25</td>
<td>3.84</td>
<td>0.72</td>
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<td>1.47</td>
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### External-validation

<table>
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<th>Validation set (n=29)</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>RCT, min</td>
<td>13.06</td>
<td>3.77</td>
</tr>
<tr>
<td>k₂₀, min</td>
<td>2.97</td>
<td>0.64</td>
</tr>
<tr>
<td>a₃₀, mm</td>
<td>45.20</td>
<td>7.04</td>
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RCT = rennet coagulation time; k₂₀ = curd-firming time; a₃₀ = curd firmness 30 min after rennet addition to milk
R²c = coefficient of determination of calibration; SECV = standard error in cross-validation; R²CV = coefficient of determination of cross-validation; RPDCV = residual predictive deviation of cross-validation calculated as the ratio of SD to the SECV.
## Fitting statistics of prediction models

### Cross-validation

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<th>R&lt;sup&gt;2&lt;/sup&gt;&lt;sub&gt;C&lt;/sub&gt;</th>
<th>SE&lt;sub&gt;CV&lt;/sub&gt;</th>
<th>R&lt;sup&gt;2&lt;/sup&gt;&lt;sub&gt;CV&lt;/sub&gt;</th>
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Conclusions

• Prediction models not enough accurate to be implemented in milk payment systems.
• Prediction models allow milk segregation.
• Future studies will investigate the feasibility of using MIRS predictions as indicator traits in breeding programs for the enhancement of coagulation properties of buffalo milk.
Thank you for your attention