Milk as new phenotypes

Bart Buitenhuis
DK-SE Milk Genomics Initiative

- Fatty Acid profile
- Protein profile
- Coagulation properties
- Micro- Macro elements
- Vitamins
- Metabolite profile

Image Credit: violetkaipa / Shutterstock
Breed differences

Poulsen et al. 2012. JDS 95: 6362-6371

Metabolite profile


Co-agulation properties

Poulsen et al. 2013. JDS 69:4830-4842
Genetics or Environment?

$h^2$ for the Metabolites

- **< 0.15**
  - Metabolites
    - Lactic acid
    - Acetic acid
    - Fumaric acid
    - Galactose

- **0.15 - 0.40**
  - Metabolites
    - Alanine
    - Butyrate
    - Lactate
    - Valine
    - Ornithine
    - Isoleucine
    - Fucose

- **> 0.40**
  - Metabolites
    - Creatinine
    - Choline
    - Citric Acid
    - Glucose
    - Orotic acid
    - BHBA
## Genetics or Environment?

### $h^2$ for Fat and Protein

<table>
<thead>
<tr>
<th>$&lt; 0.15$</th>
<th>$0.15 - 0.40$</th>
<th>$&gt; 0.40$</th>
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</thead>
<tbody>
<tr>
<td>• Fatty acids</td>
<td>• Fatty acids</td>
<td>• Proteins</td>
</tr>
<tr>
<td>• C15:0</td>
<td>• C6:0 to C12:0</td>
<td>• Caseine</td>
</tr>
<tr>
<td>• C16:0</td>
<td>• C13:0</td>
<td>• K-CN</td>
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<tr>
<td>• C17:0</td>
<td>• C14:0/C14:1</td>
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<tr>
<td>• C18:1c9</td>
<td>• C18:0</td>
<td></td>
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<tr>
<td>• C18:1t11</td>
<td>• C16:1</td>
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<tr>
<td>• Proteins</td>
<td>• C18:2n6</td>
<td></td>
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<tr>
<td>• A-s1-CN</td>
<td>• C18:3n3</td>
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<tr>
<td>• A-s2-CN</td>
<td>• CLA</td>
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</tbody>
</table>
Association study

Metabolites: 8 QTL (Bonferoni P<0.05)
Association study

Fatty acid profile:

- Holstein vs Jersey: phenotypic level → different
Association study

- QTLs found are already known from the literature.
- Significant overlap of SNP markers between HOL and JER for:
  - Fat%
  - C16 index
  - C14 index
  - C16:1
  - C14:1
What did we learn from the MG project?

• Broad overview of:
  • Phenotypic differences between breeds
  • Which traits are heritable
  • Genetic and phenotypic correlations among traits measured in the project
  • QTLs within/across different breeds

Spinn-off projects:

• Metagenome project (Dansk Kvæg)
• Coagene (HTF)
Can we get more out of milk?

Milk control system: Data

Breeds

Individual level

Herd level

Once or twice a month
Can we get more out of milk?

Product quality

Fertility

Health

Emission
How to measure this in the milk?

Technology is already implemented at RYK:

**FT-IR**

Lactose  Fat  Protein  Urea

Saving full spectra is necessary!
Examples

Product quality

Fertility/ Energy balance

Health

Emission
FTIR spectra and Genetics I

- PC analysis
- 8 traits 99.18% of variation
- 3 regions of interest
  - 926-1,612 cm\(^{-1}\)
  - 1,682-3,064 cm\(^{-1}\)
  - 3,672-5,010 cm\(^{-1}\)

Figure 2. Repeatability estimated from the ratio of the sum of the genetic and permanent environmental variances to the total variance and heritability calculated for 1,000 spectral data points expressed in wavenumber (cm\(^{-1}\)) and illustration of mid-infrared milk spectrum.
FTIR spectra and Genetics II

- 1,056 analyses (Animal Model)
- 5 regions of interest
  - SWIR 5,000-3,673 cm\(^{-1}\)
  - SWIR-MWIR 3,669-3,052 cm\(^{-1}\)
  - MWIR-1 3,048-1,701 cm\(^{-1}\)
  - MWIR-2 1,698-1,586 cm\(^{-1}\)
  - MWIR-LWIR 1,582-930 cm\(^{-1}\)
- Wave lengths close to each other are more correlated than WL far apart
What do we need?

- Contract herds (pilot herds)
- Platform to save the full FT-IR spectra
- Data 1: full FT-IR spectra
- Data 2: ‘new’ phenotypes to be predicted from FT-IR