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Using mid-infrared spectroscopy to assess udder health in dairy cows

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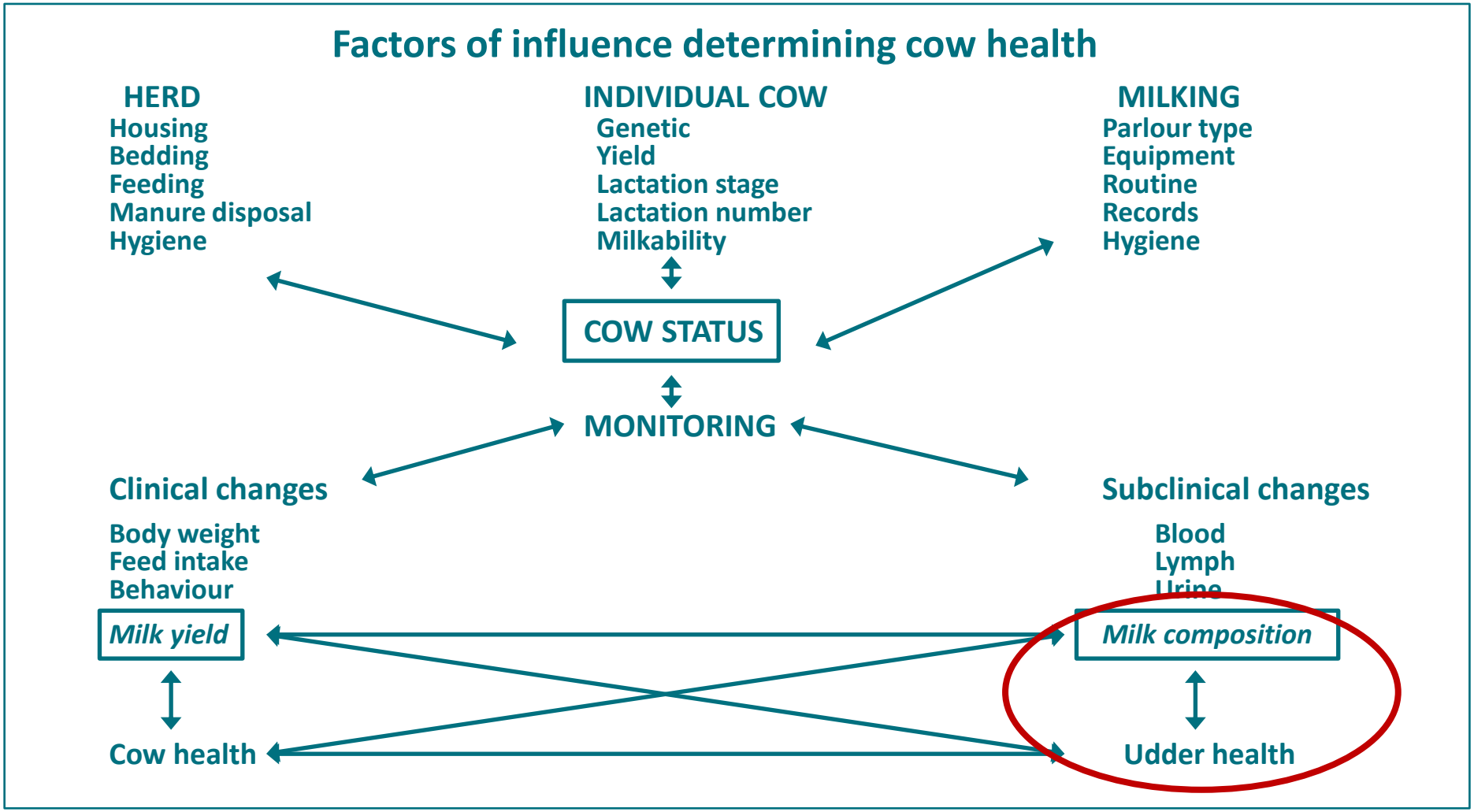
Usefulness of Milk Composition



Hamann & Krömker 1997. Livest. Prod. Sci. 48: 201-208.

Milk Composition

- Until recently 5 major constituents
  - Milk fat, protein, urea nitrogen, lactose and somatic cell count (SCC)

    SCC ➔ traditional udder health indicator
- However
  - Milk is a very complex substance with large number of constituents
  - Some major constituents themselves complex groupings of minor constituents

⇨ many potential Biomarkers for Udder Health

Fine Milk Composition

- Milk fat
  - Fatty acids mostly as triglycerides
  - Non-esterified fatty acids (NEFAs)
- Milk protein
  - Caseins
  - a-lactalbumins
  - b-lactoglobulins
  - Other minor proteins (e.g., lactoferrin)
- Other minor constituents
  - β-hydroxybutyrate (BHB or 3-hydroxybutyrate)
  - Acetone and acetoacetate
  - Minerals
  - Vitamins
  - ….

Fine Milk Composition ➔ Udder Health

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- Other mi… …nts
  - β-H… …r 3-hydroxybutyrate)
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  - Vitamins
  - ….

Two major biomarker in next slides

Conductivity

However Fundamental Problem

- How to get (fine) milk composition:
  - Fast and reliable
  - At reasonable costs

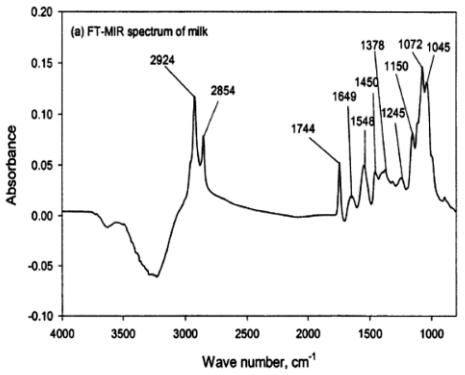
- Idea: following the example of major milk components
  - Using infrared (IR), in particular mid-infrared (MIR) as technology already widespread

Major Milk Components (except SCC)

Milk samples

(milk payment, milk recording)

MIR analysis



Raw data = MIR spectra

Calibration equations

Quantification:

fat

protein

urea

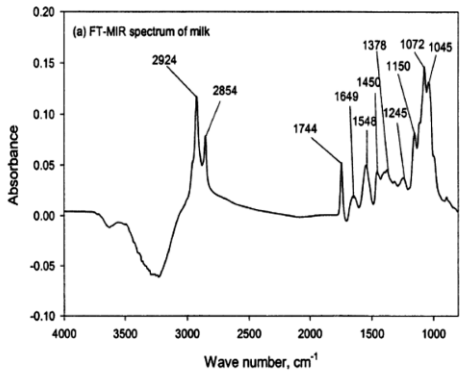
lactose

Novel Traits

Milk samples

(milk payment, milk recording)

MIR analysis



Raw data = MIR spectra

Novel Calibration equations

Quantification:

Novel traits

Lactoferrin

- Glycoprotein present naturally in milk
- Involved in the immune system
- Soyeurt et al. (2012) showed potential indicator of mastitis

Animal (2012), 6:11, pp 1830–1838 © The Animal Consortium 2012
doi:10.1017/S1751731112000791

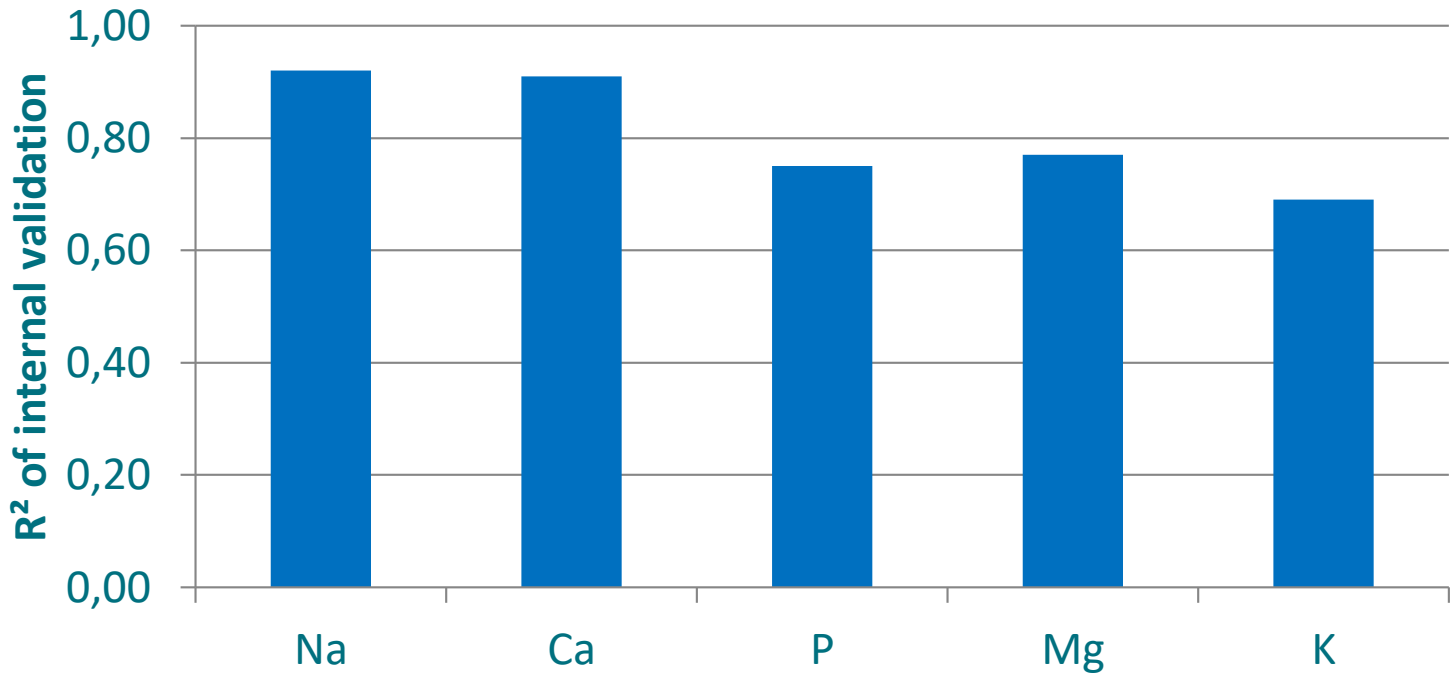
Mid-infrared prediction of lactoferrin content in bovine milk: potential indicator of mastitis

H. Soyeurt[1,2†], C. Bastin[1], F. G. Colinet[1], V. M.-R. Arnould[1,3], D. P. Berry[4], E. Wall[5], F. Dehareng[6], H. N. Nguyen[6], P. Dardenne[6], J. Schefers[7], J. Vandenplas[1,2], K. Weigel[7], M. Coffey[5], L. Théron[8], J. Detilleux[8], E. Reding[9], N. Gengler[1,2] and S. McParland[4]

⇨ MIR predictor of lactoferrin

- Calibration:
  - $R^2cv = 0.71$; $R^2v = 0.60$

Milk Minerals



$R^2 \geq 0.80$ for Na and Ca

⇨ MIR indicators but with potential use for udder health

NB: Unpublished results equations were developed from at least 465 milk samples

Early Indicators in Milk?

- Comparisons of milk composition data from a test-day occurring before (from 10 to 45d.) a mastitis event (clinical and sub-clinical cases) and milk composition data from healthy lactations

	Healthy			Before a mastitis event			
Trait	N	Mean	Std	N	Mean	Std	p-value
Na (mg/kg)	1,834	347.0	49.4	1,148	359.8	57.3	<0.001
Lactoferrin (mg/l)	1,589	159.5	74.0	988	170.0	73.5	<0.001

NB: Collaborative Model for Calibrations

- Developing calibrations through concerted actions

  ⇨ lactoferrin and minerals opportunities

  - New partners join with data (reference ⇔ spectra) and help improve equations
  - Get in exchange access to equation + updates
- Collaborative approach until recently unknown in MIR
  - More usual in NIR ← feed composition
  - In collaboration with Walloon Agricultural Research Center (CRA-W)
  - Consortia were initiated for many novel traits

More Biomarkers Under Development

- But problem of lower validation R2 biomarkers
  ➔ single biomarkers often very “unprecise”
- At the ICAR meeting presentation on the grouping of EBV for several biomarkers*: IGF1, glucose, urea, cholesterol, fructosamine, BHB and NEFA

*These are biomarkers in blood but milk MIR predicted

  - @16:30 Targeted combination of estimated breeding values for lower accuracy mid-infrared biomarkers increases their usefulness in genetic evaluation of dairy cattle
  - Allowed to achieve better correlations to udder health
- Growing interest in direct use of MIR spectra to predict udder health ➔ catching global “foot print” in milk

Conclusions

- Clear potential for lactoferrin and minerals (Na)
- Possible added value by combining different information ← even biomarkers with poor R^2
- Direct use of whole MIR spectra (global "foot print")
  - Predicting udder health directly
  - Multi-trait genetic evaluations
    → massive multivariate models
- But further studies needed on MIR but also NIRs (already on-line on-farm) and udder health

Some Elements for UDH Recommendations

- Routine
  1. Keep in routine MIR data ➔ raw MIR data database
  2. Identify spectral variability of each spectrometer by running regularly test samples with "known" MIR profiles ➔ validation and standardization of MIR data
  3. Develop procedures for routine MIR predictions using standardized MIR data (for udder health and beyond….)

➔ These points were already developed in the OptiMIR project. Technical advise available from EMR (http://www.milkrecording.eu).

- Research
  1. Keep direct udder health data
     but generate also potential biomarker data as lactoferrin and minerals
  2. Link this data to MIR spectral data
  3. Consider joining forces to assemble your reference data and related MIR data with that from others (e.g. existing CRA-W and ULg-GxABT consortia) ➔ getting access to better MIR prediction equations!

Interpretation of Generated Information

- Most MIR based udder health biomarkers are indicators
  ➔ they do not replace reference values
- Interpretation
  - On a herd level ➔ often OK (average of a group)
  - Individual level ➔ careful
    not one biomarkers but several, many (clustering)
- More research needed to separate
  - Milk composition changes ➔ then animal gets mastitis
    - Indicators of future udder health status
  - Animal has mastitis ➔ we see it in the milk:
    - indicators of current udder health status
- Careful !
  - Genetic correlation of biomarkers to other traits in breeding goal !