Milk protein profile: measure from mid infrared spectra and identification of influence factors

Session 71 « Milk and meat quality – highlighting knowledge gaps in the supply chain »

M. Gelé (marine.gele@idele.fr)

M. Ferrand-Calmels, G. Miranda, N. Ballot, L. Bianchi, M. Brochard, P. Martin

Milk protein profile: a strategic issue for the dairy sector

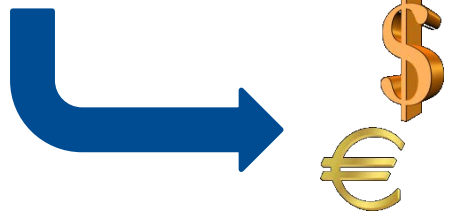
Fat content

Protein content

Lactose

Minerals

Vitamines



high market value

sulfur amino acids, tryptophan, lysine

β-casein

κ-casein

α-lactalbumin

1. How to measure concentrations of major milk proteins in routine?
2. What are the nutrition and physiology-related factors that influence their concentration?

The methodology at a glance

MIR spectroscopy

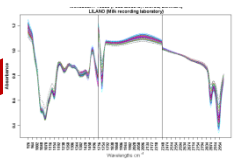
Calibration set

LC-MS

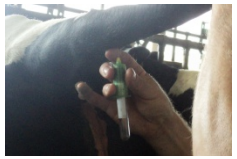
PREDICTION EQUATIONS

Estimated protein profile

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms



MIR analysis → Spectral data



DNA samples → Genotypes

Field surveys → Management

Genetic determinism / QTL

Non-genetic influence factors

MIR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry ~ QTL : quantitative trait locus

The methodology at a glance

MIR spectroscopy

Calibration set

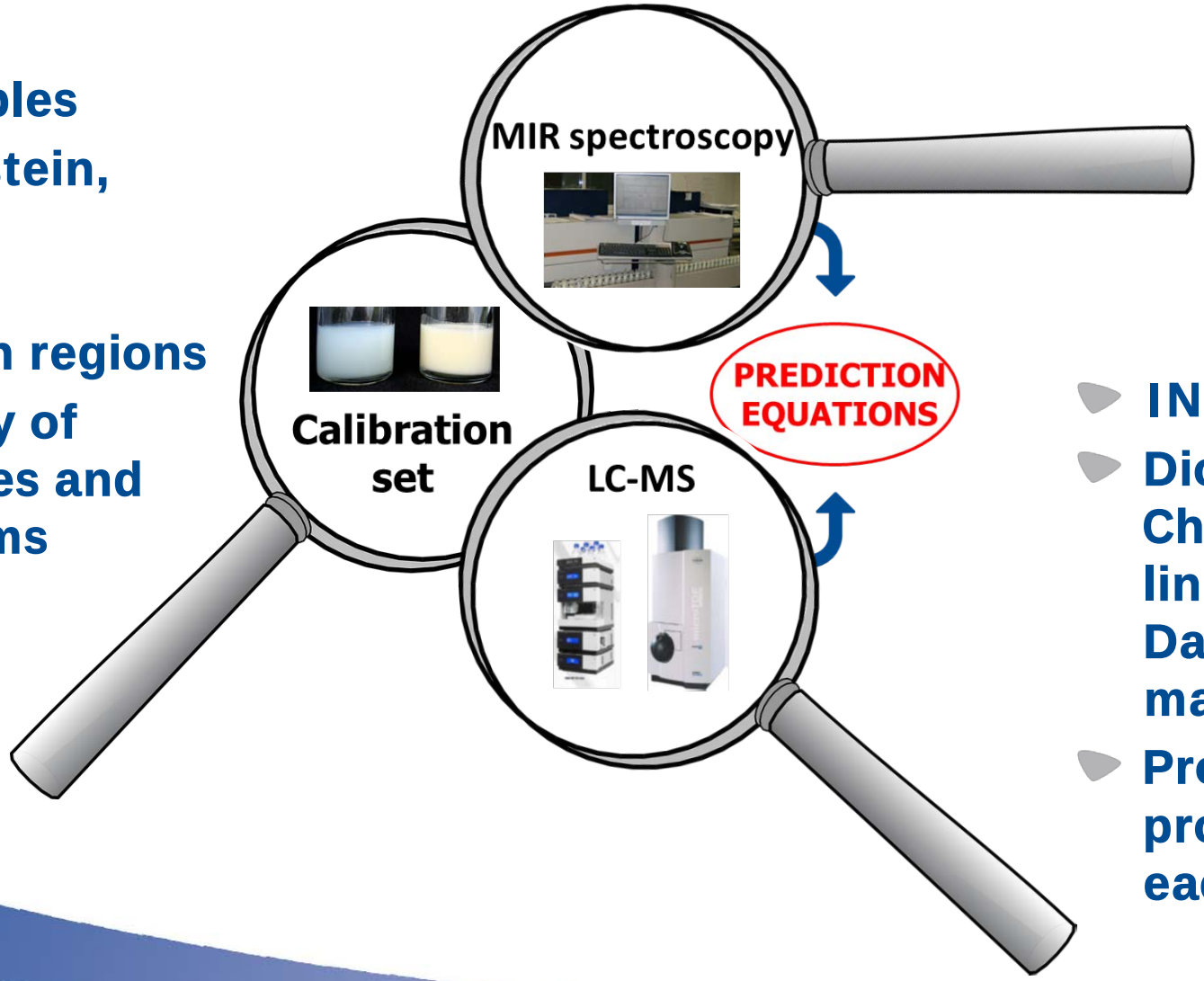
PREDICTION EQUATIONS

LC-MS

MIR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry ~ QTL : quantitative trait locus

1st step: quantifying protein profile

- 280 milk samples
- 3 breeds: Holstein, Normande & Montbeliarde
- Several French regions
- Large diversity of lactation stages and feeding systems

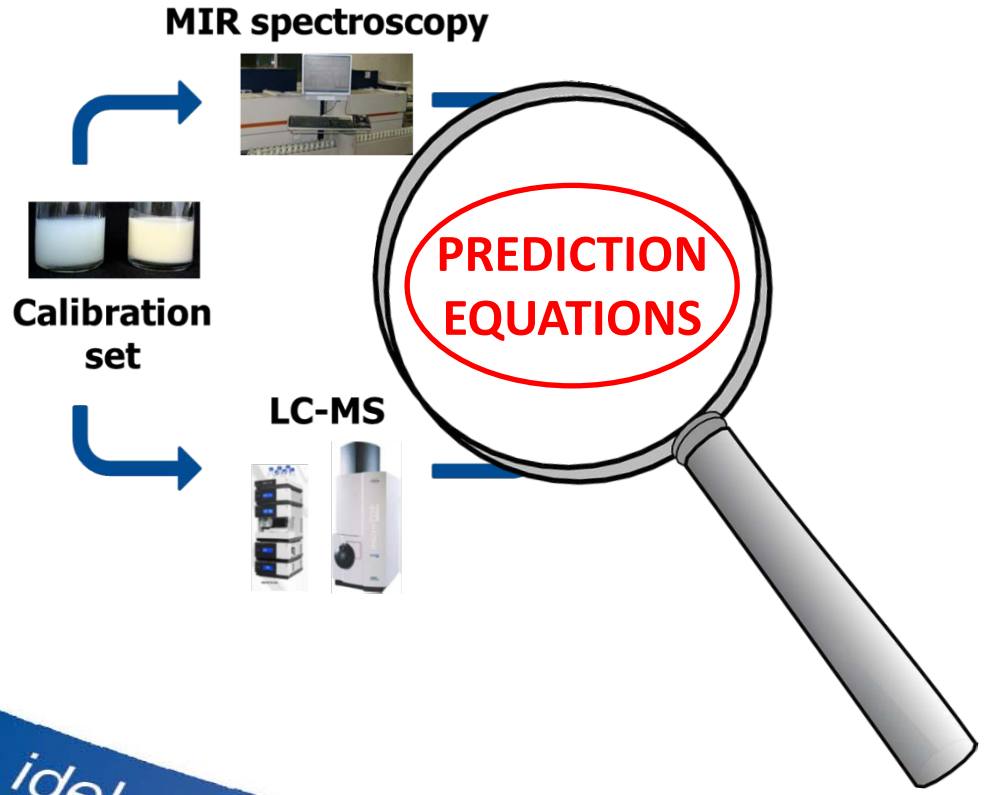


- Milk analysis labs (Foss machines only)

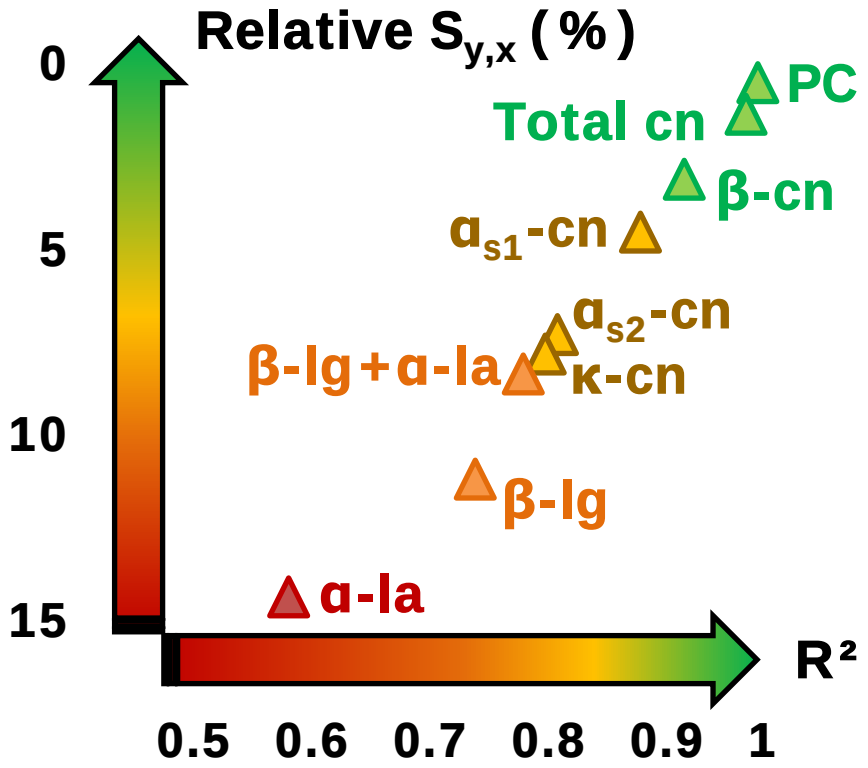
- INRA Jouy-en-Josas
- Dionex «Ultimate 3000» Chromatography column linked with a Brucker Daltonics «micrOTOF II» mass spectrometer
- Proteolysis kinetics → proteolysis attributed to each protein

MIR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry

1st step: quantifying protein profile



- Partial Least Square regression
- Cross-validation (LOO)



Possible use

- ☺ Routine, any application
- ☺ Analytic use, quantitative information
- 😐 Screening, high or low levels
- ☹ Not recommended

LOO: leave one out ~ PC: protein content ~ cn: casein ~ la: lactalbumin ~ lg: lactoglobulin

The methodology at a glance

MIR spectroscopy

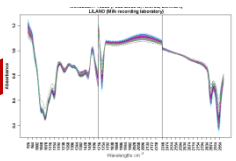
Calibration set

LC-MS

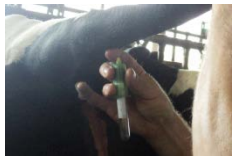
PREDICTION EQUATIONS

Estimated protein profile

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms



MIR analysis → Spectral data



DNA samples → Genotypes

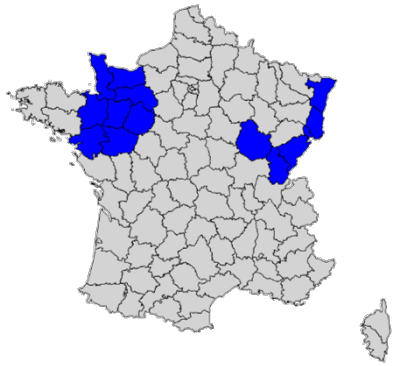
Field surveys → Management

Genetic determinism / QTL

Non-genetic influence factors

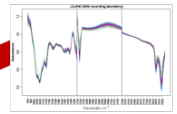
idele.fr

MIR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry ~ QTL : quantitative trait locus



2nd step: screening a population

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

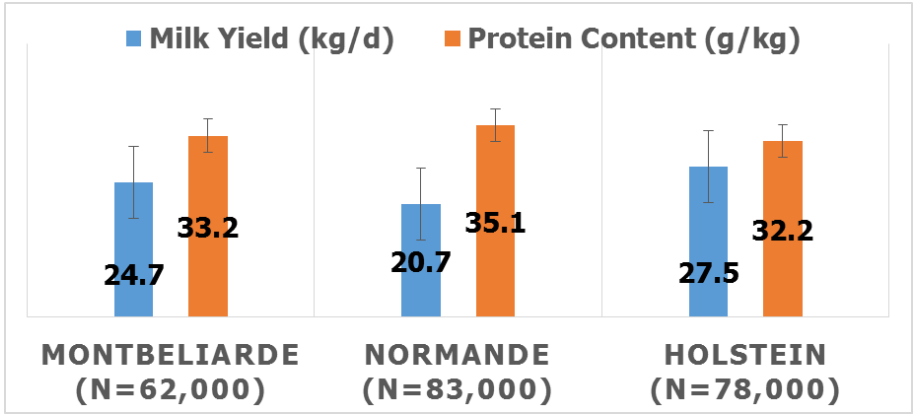


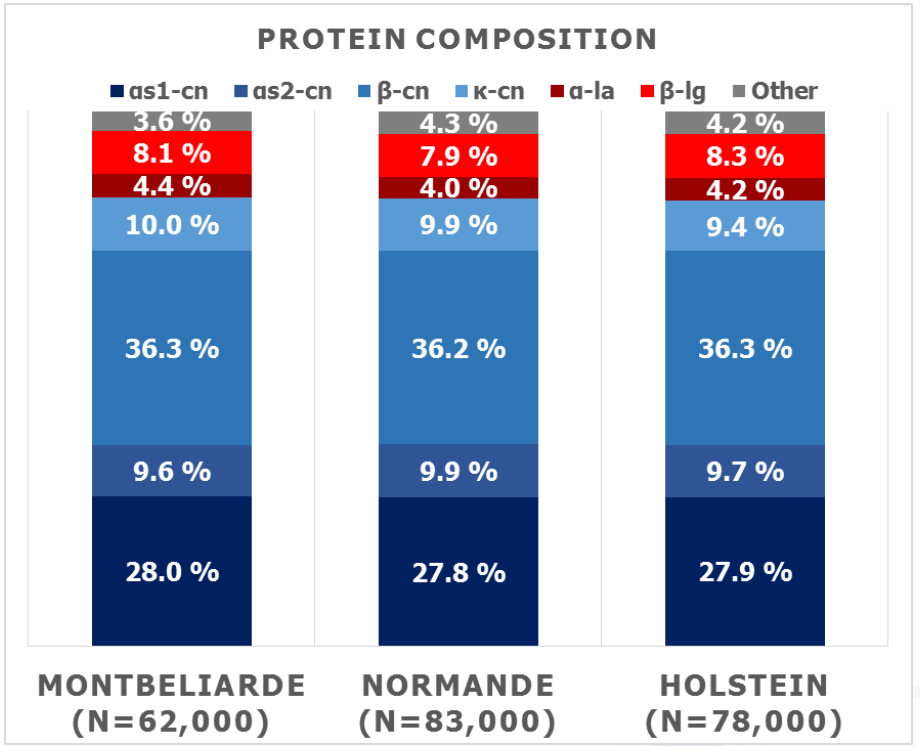
MIR analysis
→ Spectral data
220,000 data

PREDICTION EQUATIONS

Estimated protein profile

- **Very similar protein profile between breeds**
- **Very low variability of protein contents (Std <1.2 point)**





MIR: mid infrared spectrometry ~ cn: casein ~ la: lactalbumin ~ lg: lactoglobulin

The methodology at a glance

MIR spectroscopy

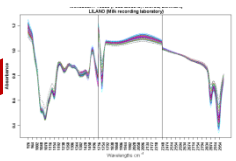
Calibration set

LC-MS

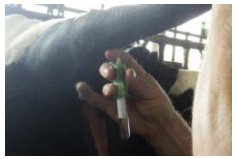
PREDICTION EQUATIONS

Estimated protein profile

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms



MIR analysis → Spectral data



DNA samples → Genotypes

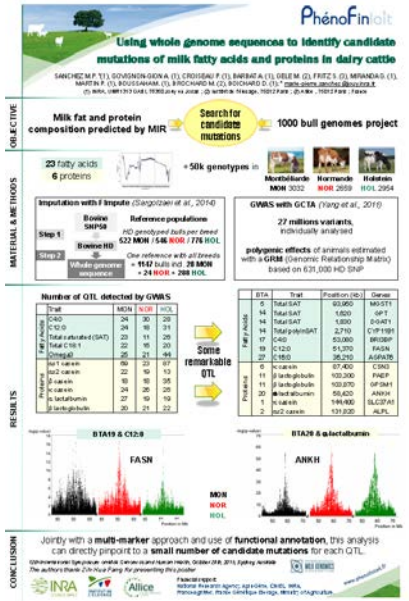
Field surveys → Management

Genetic determinism / QTL

Non-genetic influence factors

MIR: mid infrared ~ LC-MS: liquid chromatography – mass spectrometry ~ QTL : quantitative trait locus

3rd step: identifying influence factors



- **Sanchez et al publications from 2013**

Proceedings, 10th World Congress of Genetics Applied to Livestock Production

Identification of QTL and candidate mutations affecting major milk proteins in three French dairy cattle breeds

M.P. Sanchez[*], A. Govignon-Gion[*], M. Ferrand[†], M. Gele[†], D. Pourchet[‡], M.N. Rossignol[§], S. Fritz[*#], M. Boussaha[*], A. Capitan[*#], D. Rocha[*], G. Miranda[*], P. Martin[*], M. Brochard[†], D. Boichard[*]
[*]INRA, UMR1313 GABI, 78350 Jouy en Josas, France ; [†]IDELE, 75012 Paris, France ; [‡]ECEL Doubs - Territoire de Belfort, 25640 Roulans, France ; [§]Labogena, 78350 Jouy en Josas, France ; [#]UNCEIA, 75012 Paris, France

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

DNA samples → Genotypes

Field surveys → Management

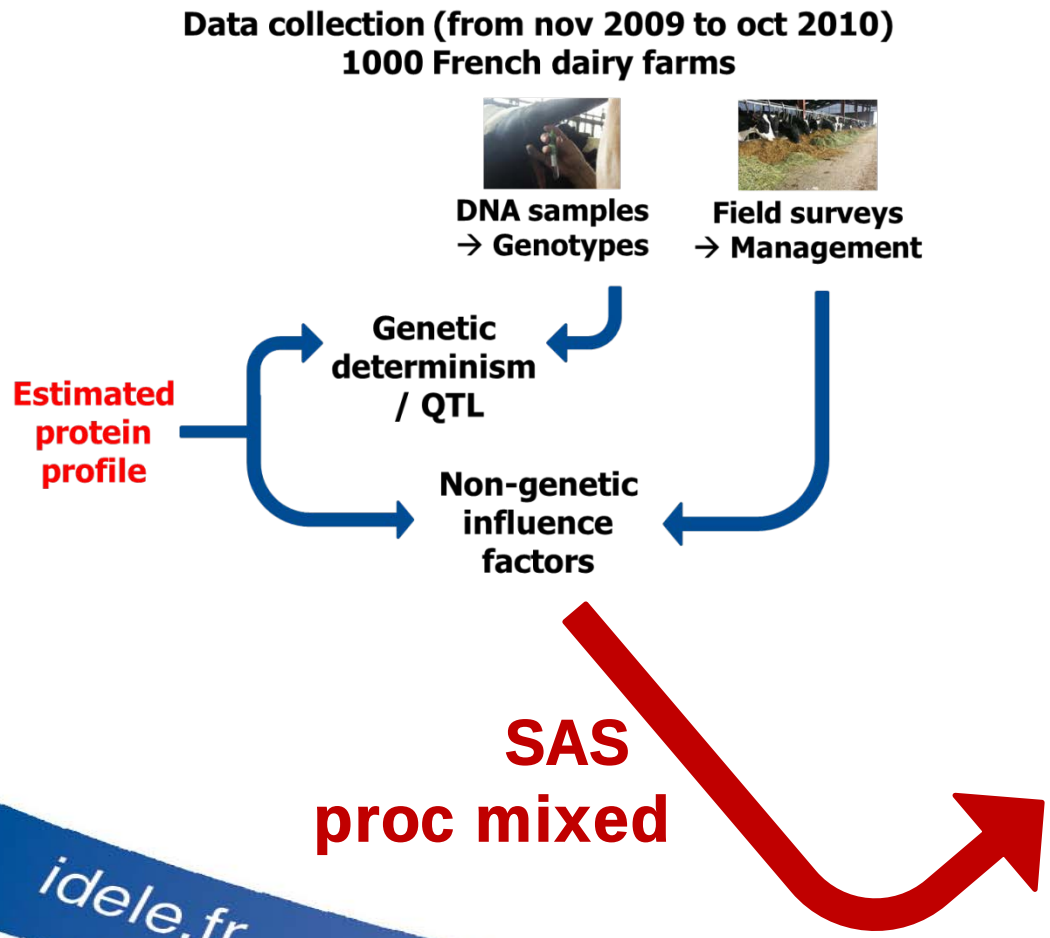
Genetic determinism / QTL

Estimated protein profile

Non-genetic influence factors

QTL : quantitative trait locus

3rd step: identifying influence factors



Nutrition-related factors

FOOD TYPE	αs1-cn	αs2-cn	β-cn	κ-cn	β-lg
Hay	+	=	=/+	+	-
Grass silage	+	=	=	=	-
Mais silage & Grass silage	=	=	=	=	=
Mais silage	Baseline				
Mais silage & Pasture	=	=	=	=	=
Pasture	+	+	=	+	-

- More caseins with hay and pasture
- Very limited impact of food type on protein profile (<1 point)

cn: casein ~ lg: lactoglobulin

3rd step: identifying influence factors

Data collection (from nov 2009 to oct 2010)
1000 French dairy farms

DNA samples → Genotypes

Field surveys → Management

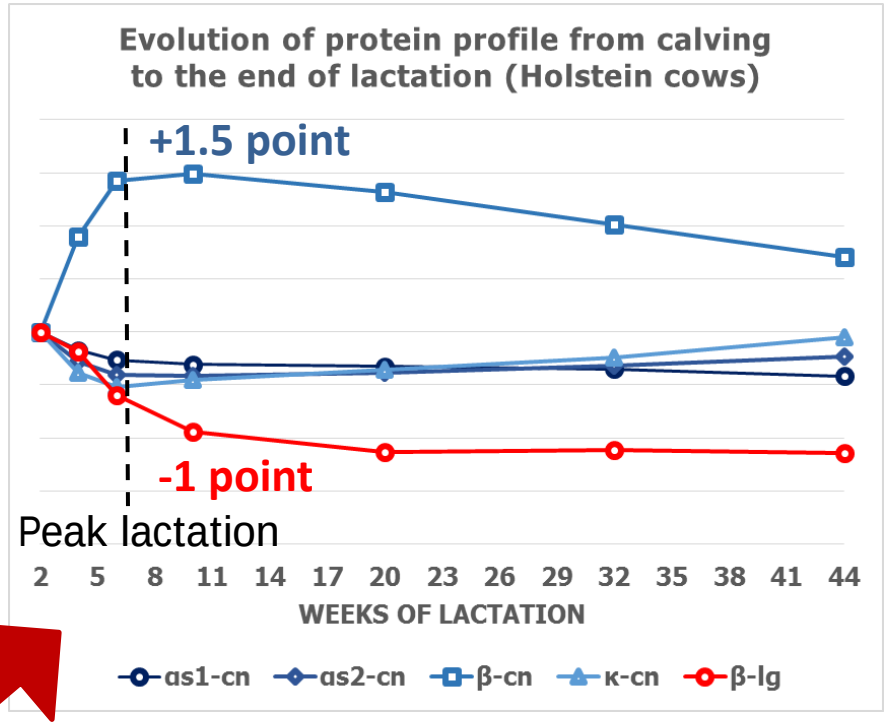
Estimated protein profile

Genetic determinism / QTL

Non-genetic influence factors

SAS proc mixed

Physiology-related factors



- **No significant impact of the number of lactation**
- **Impact of udder health**
- **Impact of lactation stage during the first 2 months on β-cn and β-lg**

cn: casein ~ lg: lactoglobulin

Some conclusions

- Quantifying protein profile in routine IS possible
- Protein profile is not (a lot) dependent on breed or food type
- Lactation stage is the most impactful non-genetic factor
- β-cn and β-lg are responsible for the change in protein profile

What about future prospects?

- Improving LC-MS method → Improving the equations
  - Using the equations to phenotype new traits such as cheese-making properties of milk

TO BE CONTINUED…

LC-MS: liquid chromatography – mass spectrometry ~ cn: casein ~ lg: lactoglobulin

PhénoFinlait
Un programme R&D pour les filières laitières de demain

MANY THANKS TO…

- Farmers
- Financial partners
- Technical partners
- You!