

Towards a genomic evaluation of cheese-making traits including candidate SNP in Montbéliarde cows

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FRANCE



Background

In the world: 1/3 bovine milk produced transformed into cheese

In France: 1.7 million tons produced in 2017

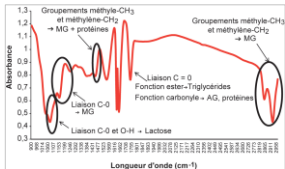
The Comté cheese (Montbéliarde cows in Franche-Comté) = 1st PDO cheese in France



Milk cheese-making properties (**CMP**), strongly related to milk composition, are thus economically important BUT difficult and costly to measure

Objectives of the From'MIR project

- Equations of prediction of CMP from mid-infrared (**MIR**) spectra
- Genetic analysis of CMP and milk composition traits (proteins, fatty acids and minerals) predicted from 6 million MIR spectra from 400,000 Montbéliarde cows

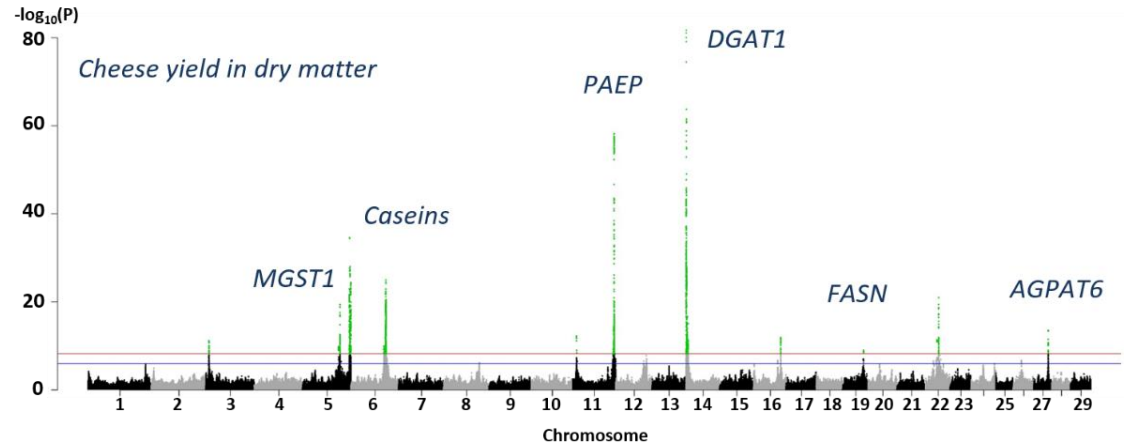


+ equations →



Previous results of the From'MIR project

- 8 CMP traits predicted from MIR spectra with moderate to high **accuracies** ($0.54 \leq R^2 \leq 0.89$)
 Cheese yields and coagulation traits *El Jabri et al. J Dairy Sci 2019, 102:6943-6958*
- Medium **heritabilities** of CMP traits ($0.37 \leq h^2 \leq 0.48$)
Sanchez et al. J Dairy Sci 2018, 101:10048-10061
- **GWAS** on imputed whole-genome sequences
 ➔ Candidate variants with highly significant effects on CMP traits
- **Network genes analysis**
 ➔ Candidate variants located in genes functionally related to milk composition (custom part of the EuroG10K chip) *Sanchez et al. Genet Sel Evol 2019, 51:34*



Objectives of the present study

➤ Objectives

- Estimate the **reliability** of single step GBLUP breeding values (**ssEBV**) by testing different models and different SNP sets (including candidate variants detected by GWAS) in a validation population
- Estimate the **genetic trends** of CMP traits
- Simulate different **breeding objectives** including CMP traits

➤ 10 traits related to milk cheese-making:

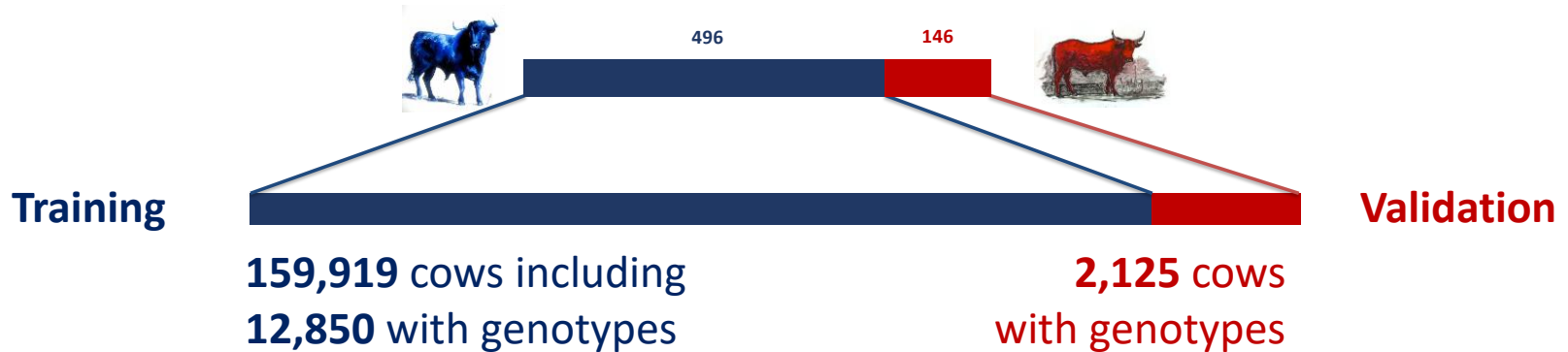
- 3 cheese yields (fresh, in dry matter & in protein and fat) and 5 coagulation traits (curd firmness & curd organization speed)
- % caseins and calcium (Ca) in milk

Training and validation sets

1) Removal of all performances > August 2016

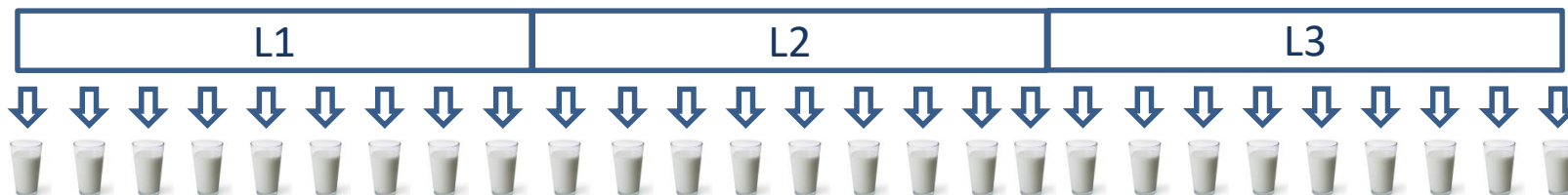


2) Complete and distinct sire families / population (removal of half-sib cows performances)



4 models tested

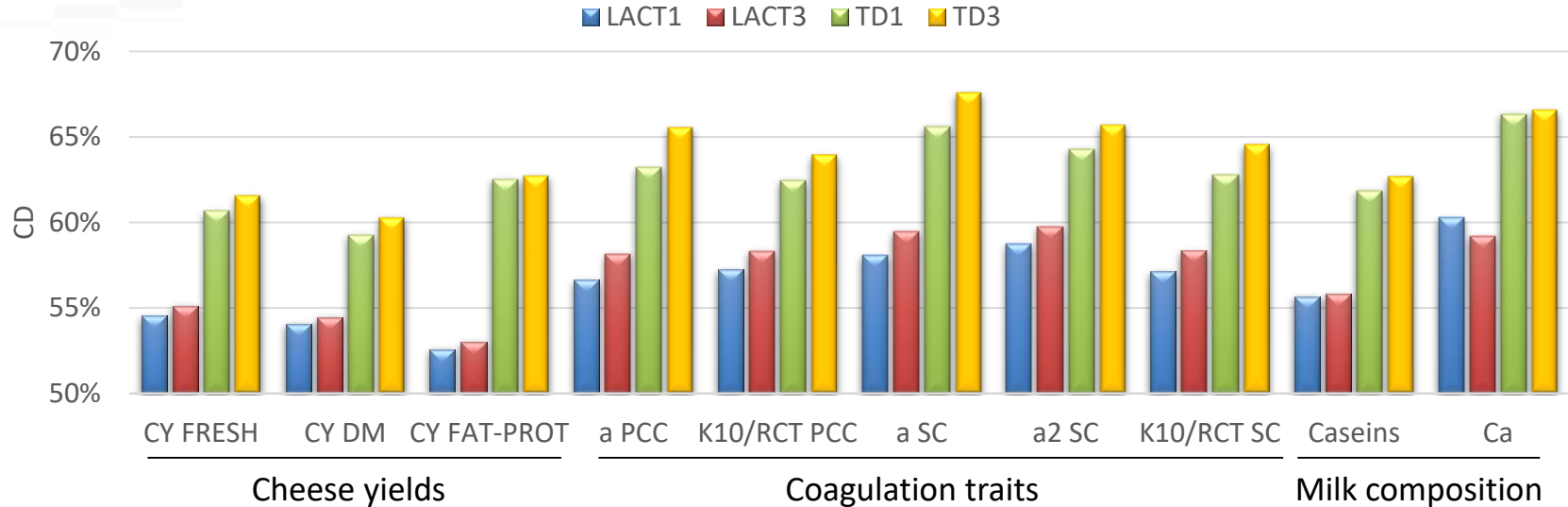
Test-day records



	L1	L1 – L3
Mean per lactation	LACT1 191,532 obs.	LACT3 327,255 obs.
Test-day records	TD1 1,422,782 obs.	TD3 2,659,054 obs.

Comparison of 4 models: reliability of ssEBV

CD validation = correlation² (ssEBV, adjusted phenotype) / h²



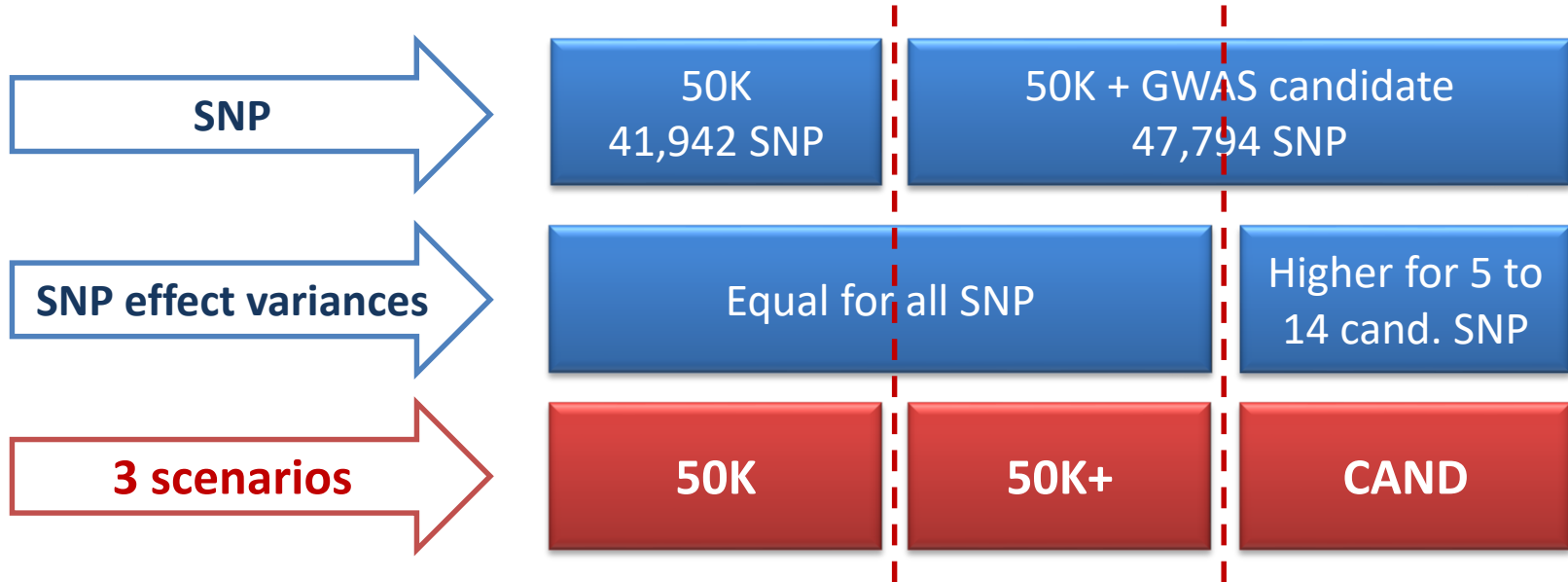
Reliabilities > 50% for all models and all traits

Reliabilities L1-L3 > L1

Reliabilities TD >> LACT

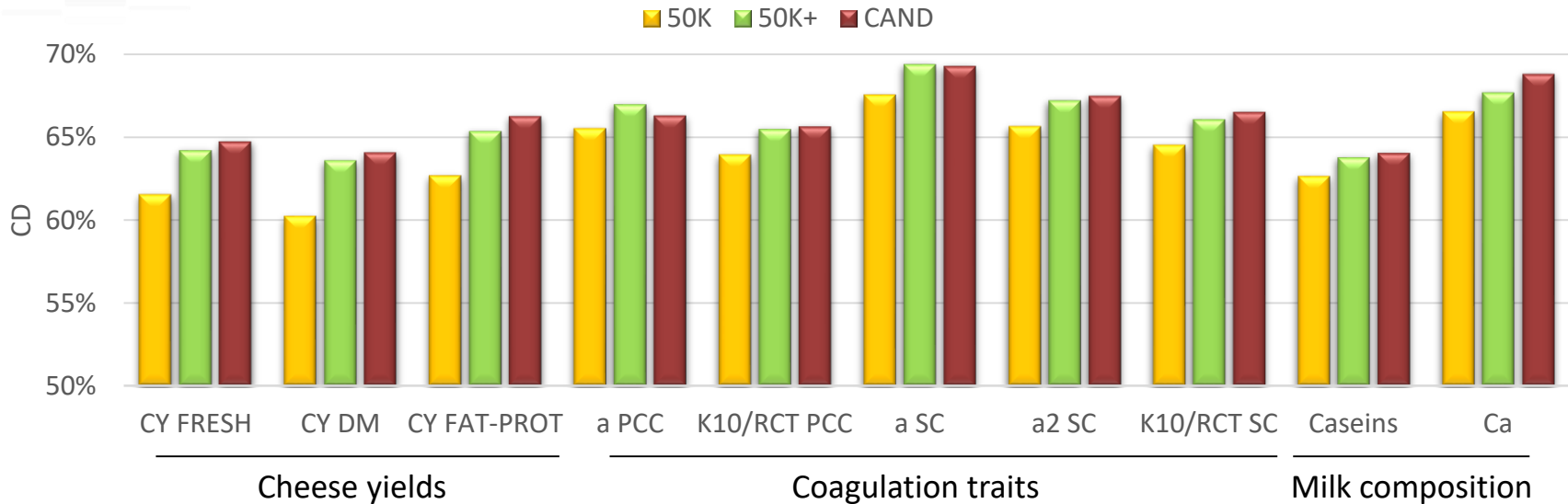
3 scenarios tested

Application of 3 scenarios with the best model (TD3)



Comparison of 3 scenarios: reliability of ssEBV

CD validation = correlation² (ssEBV, adjusted phenotype) / h²

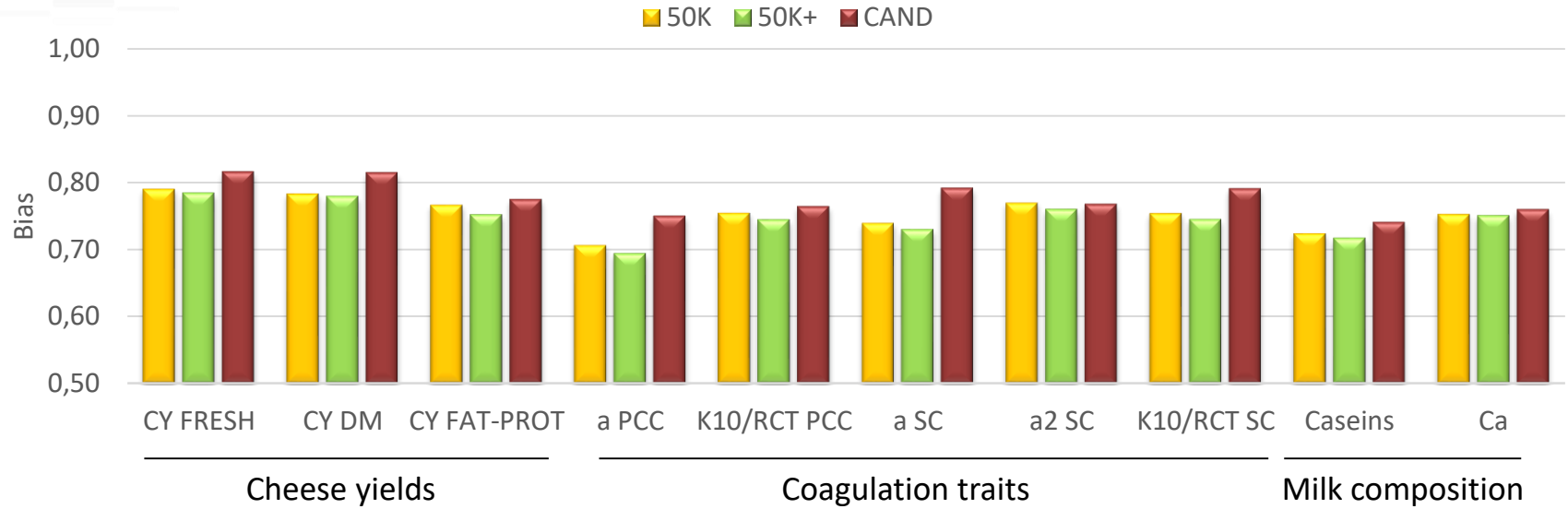


Reliabilities **50K+** > Reliabilities **50K** for all traits (+1.9 on average)

Reliabilities **CAND** ≈ Reliabilities **50K+** (+0.34 on average)

Comparison of 3 scenarios: bias of ssEBV

Bias = deviation from the slope b of adjusted phenotype to ssEBV => $E(\hat{b}) = 1$

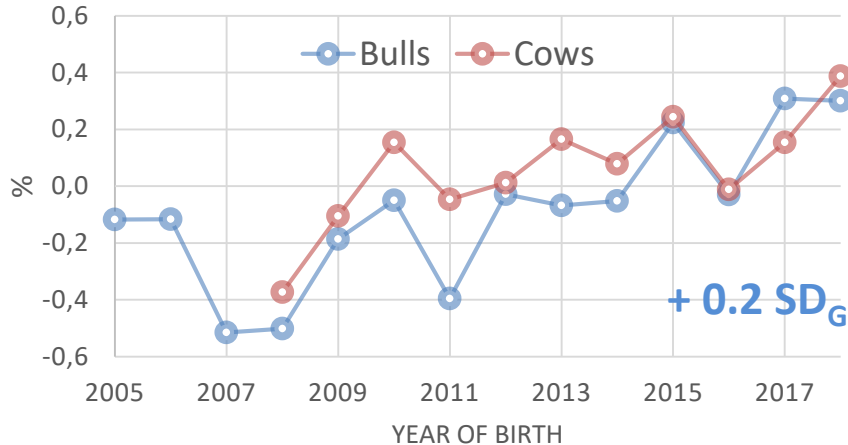


Bias **CAND** < Bias **50K** < Bias **50K+**

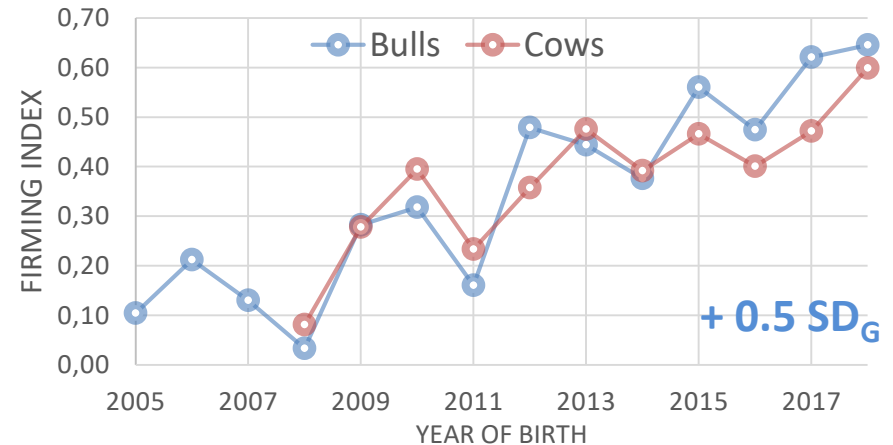
Genetic trends of CMP: evolution of ssEBV

Application of genomic prediction equations on Montbéliarde cows (311,761) and bulls (21,171) born between 2005 and 2018 and with genotypes

Cheese yield in dry matter



Firmness curd a_{PCC}



Favourable evolution for all CMP traits probably due to selection on protein content

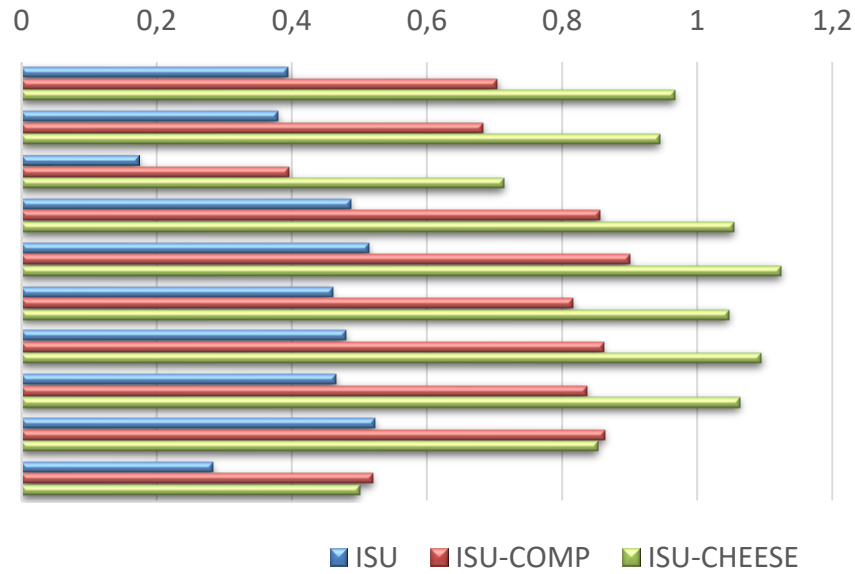
Alternative breeding scenarios: responses for CMP traits

Current total merit index: **ISU** (milk production and composition, mammary health, reproduction, longevity and conformation)

Alternative breeding objectives:

ISU-COMP = 0.7 ISU + 0.3 Caseins

ISU-CHEESE = 0.7 ISU + 0.1 (CY_{DM} + a_{PCC} + (- K10/RCT_{PCC}))



With alternative scenarios:
higher responses for all CMP traits

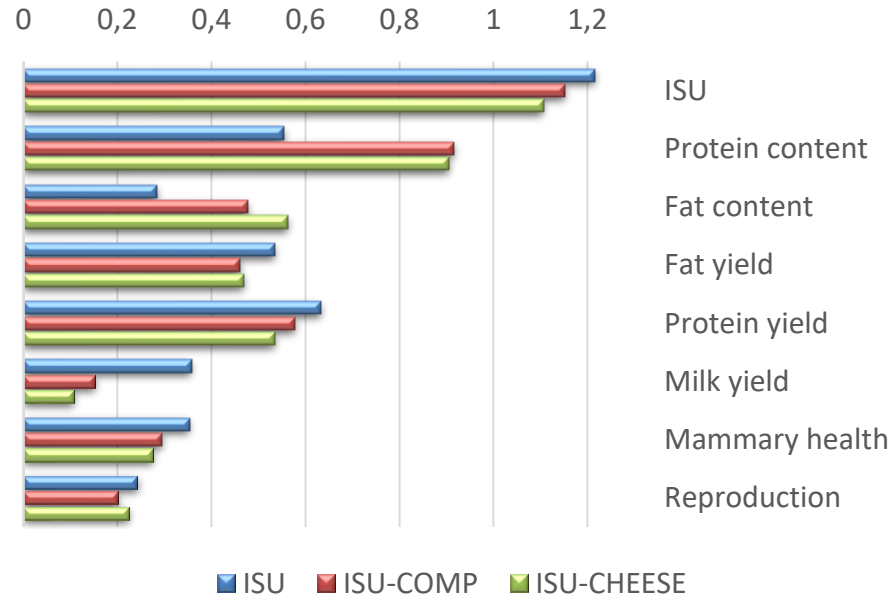
Alternative breeding scenarios: responses for other traits

Current total merit index: **ISU** (milk production and composition, mammary health, reproduction, longevity and conformation)

Alternative breeding objectives:

ISU-COMP = 0.7 ISU + 0.3 Caseins

ISU-CHEESE = 0.7 ISU + 0.1 (CY_{DM} + a_{PCC} + (- K10/RCT_{PCC}))



With alternative scenarios:
limited impact for other traits

Conclusions & perspectives

Reliable cheese-making genomic indexes

The most reliable and less biased obtained with:

1. A test-day model applied to the first 3 lactations
2. 50K SNP + candidate variants detected by GWAS
3. Higher weightings for candidate variants

CMP traits indirectly selected with the current breeding objective but possible to increase responses by directly including CMP traits in the breeding objective with a limited impact on other traits

In progress: implementation of a genomic evaluation of CMP predicted from MIR spectra in Montbéliarde cows

Acknowledgements

