Transforming routine MIR milk data into actionable tools for Dairy Herd Improvement and cheese production

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Avec la contribution financière du compte d'affectation spéciale développement agricole et rural CASDAR
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IN FRANCE, CHEESE IS SERIOUS BUSINESS!

Some key figures

- 3rd largest cheese producer in the world
- 46 PDO cheeses (Protected Designation of Origin)
- 16% of cheeses are made from raw milk
- The world's biggest cheese consumers, with more than 26 kg per person per year

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→ 35% of cow's milk production is transformed into cheese by:

- more than 2,000 farm producers
- more than 500 industrial facilities

→ €8 billion in annual revenue

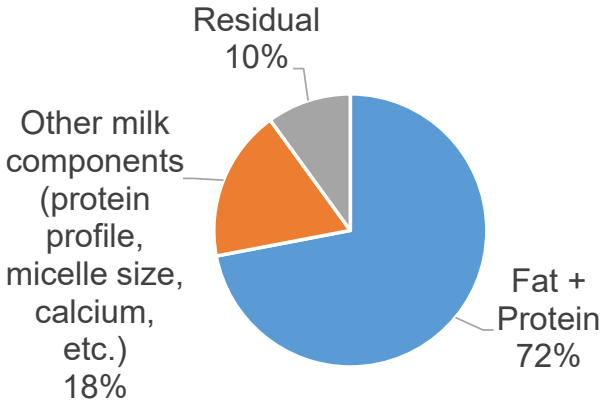
WHY MEASURE MILK CHEESE-MAKING PROPERTIES USING MIR?

What is cheese-making ability? It's milk's ability to be transformed into cheese

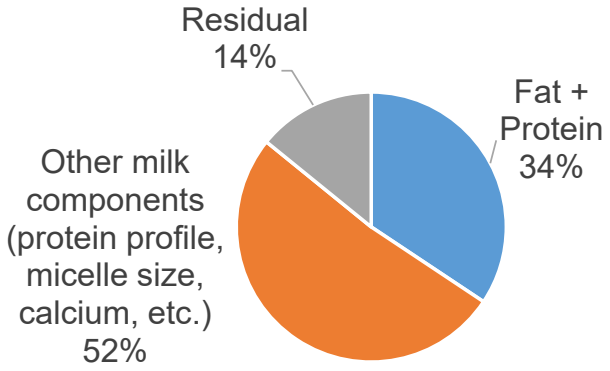
Why manage cheese-making ability? To produce milk suited to its intended use, anticipate and adjust technological parameters during processing, and generate added value (yield, sensory quality, etc.).

Is looking only at fat and protein content enough? No

Explanation of variability in curd yield in dry matter
(individual milk samples)



Explanation of variability in curd firmness for pressed cooked cheeses
(individual milk samples)



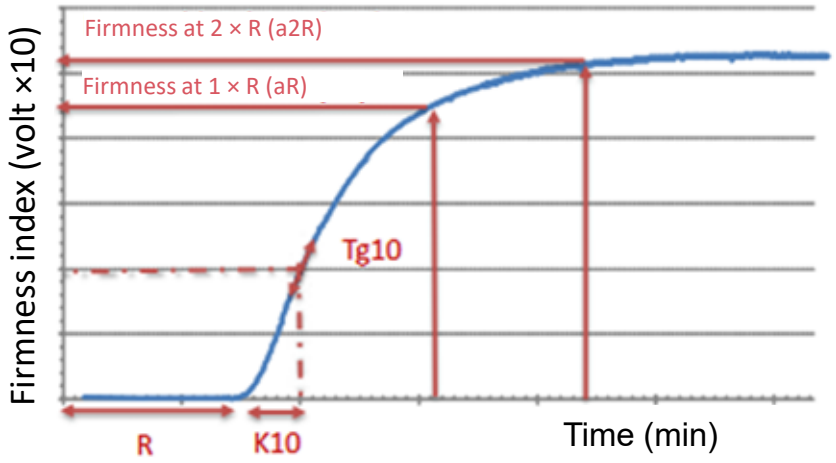
FROM'MIR

→ MIR offers the opportunity to characterize milk cheese-making properties quickly and at low cost.

FROM'MIR INDICATORS TO BE PREDICTED BY MIR

Enzymatic coagulation properties

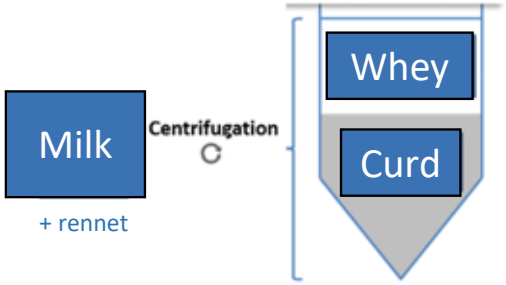
(monitored using Formoptic) in models for
Soft Cheese (SC) and Pressed Cooked Cheese (PCC)



- Coagulation time **(R)**
- Gel structuring speed **(Tg10, K10/R)**
- Gel firmness **(aR, a2R)**

Theoretical laboratory cheese yield

(method of Hurtaud et al., 1995)
with a single renneting condition



- Fresh curd yield $\mathbf{CY_{fresh}}$ (%)
  (curd weight / milk weight) × 100
- Curd yield in dry matter $\mathbf{CY_{DM}}$ (%)

$$1 - \left(\frac{\text{whey dry matter} \times \text{whey weight}}{\text{milk dry matter} \times \text{milk weight}} \right) \times 100$$

MILK SAMPLES USED TO DEVELOP PREDICTION EQUATIONS

1 set of equations / scale that applies only in **Montbeliarde** breed in **Franche-Comté** context

N samples *with spectra & ref. data*	
	250
	100
	70

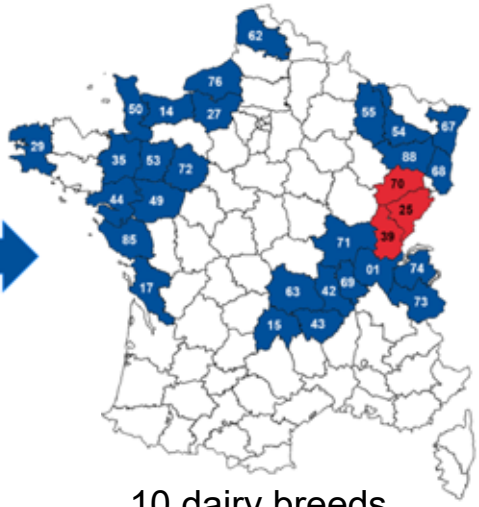
N samples *with spectra & ref. data*	
	724
	423
	185

A single set of equations that applies **across scales**, to **multiple breeds** and in **various production contexts**

FROM'MIR

Montbeliarde breed only

FROM'MIR + + + Overallmilkqual



10 dairy breeds

Performances on validation set

	N	R^2	RPD
CY_{fresh}	351	0.82	2.37
CY_{DM}	353	0.88	2.88
aR_{PCC}	120	0.73	1.92
aR_{SC}	311	0.71	1.86
$a2R_{SC}$	308	0.68	1.78
$K10/R_{SC}$	363	0.63	1.63

R^2: Proportion of total variability explained by the equation

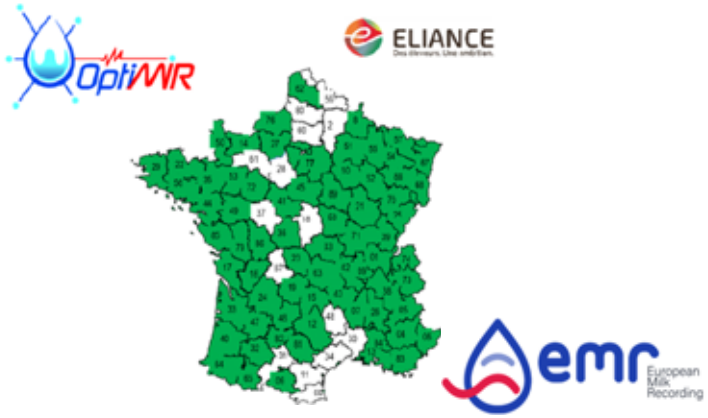
Performance deviation ratio ($RPD = sd/\sigma_e$): Dispersion of reference data /prediction error

Excellent
Good
Fair
Bad

PREDICTION EQUATIONS, MIR SPECTRA – WHICH APPLICATIONS?

FROM'MIR equations available on a large scale

Implemented in the French OptiMIR MROs Information System since 2019



Member of the GIEE European Milk Recording

Millions of spectra collected in routine every year

Milk Recording:
~ 13 M spectra (1.5 M dairy cows in 20,000 farms)

Quality-based milk payment:
~ 8 M spectra (44,000 farms collected every 48 hours)

Daily analyses in cheese production plants

A great opportunity to:

Better characterise the cheese-making potential of milk

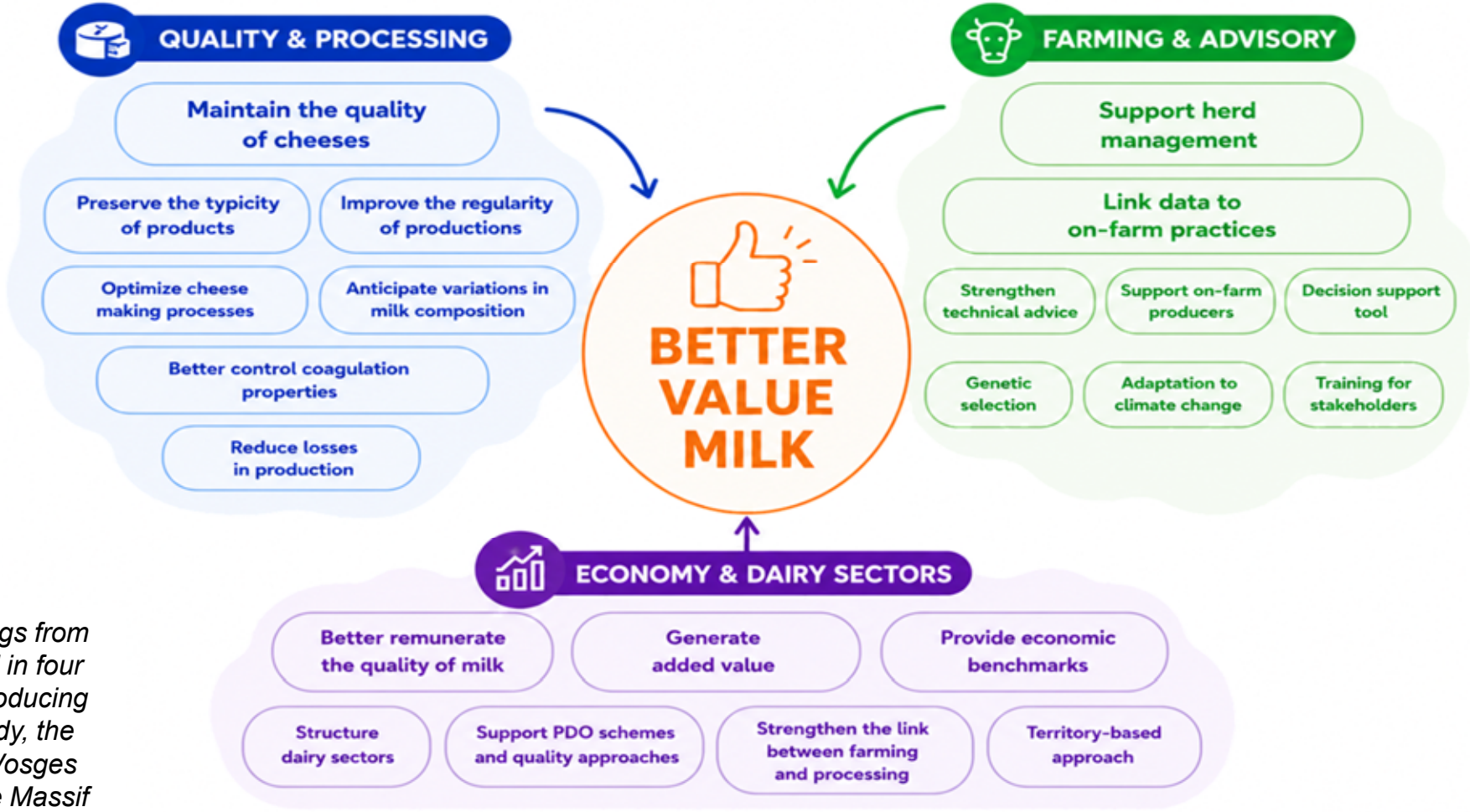
Guide animal selection

Develop new indicators for advising dairy farmers

Optimise cheese-making processes

Improve the efficiency of the cheese industry

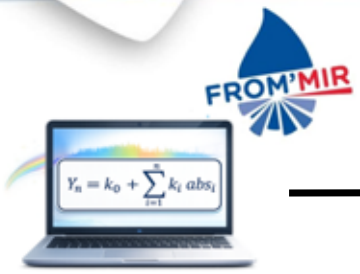
WHAT DO STAKEHOLDERS IN THE SECTOR EXPECT?



APIS-GENE

Summary of findings from focus groups held in four French cheese-producing regions: Normandy, the Savoy Alps, the Vosges Mountains and the Massif Central in 2024-2025 (FROM4ALL project)

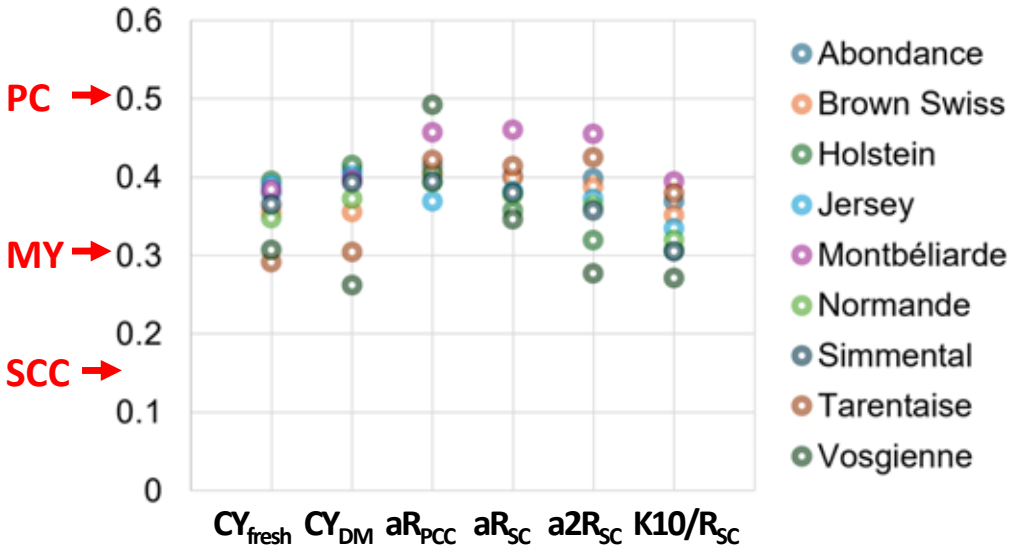
FROM'MIR EQUATIONS AS BASIS FOR DAIRY HERD IMPROVEMENT



- CY_{fresh}
- CY_{DM}
- aR_{PCC}
- aR_{SC}
- $a2R_{SC}$
- $K10/R_{SC}$

ESTIMATION OF GENETIC PARAMETERS

Heritabilities

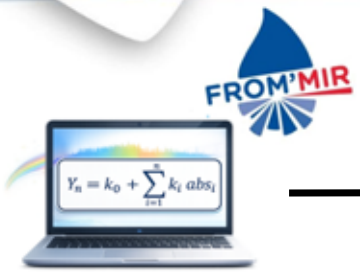


- ✓ **Moderate heritability estimates** that are consistent across breeds and accurate
- ✓ **Genetic correlations:**
  - High between FROM'MIR traits (0.62 to 1)
  - High between FROM'MIR traits and fat and protein content (0.36 to 1)
  - Moderate between FROM'MIR traits and milk yield (-0.25 to -0.65)
  - None between FROM'MIR traits and SCC (-0.04)

N cows = 1,699 to 1,141,657 depending on the breed
N samples = 13,020 to 9,068,638 depending on the breed

FROM4ALL project funded by APIS-GENE

FROM'MIR EQUATIONS AS BASIS FOR DAIRY HERD IMPROVEMENT



- CY_{fresh}
- CY_{DM}
- aR_{PCC}
- aR_{SC}
- $a2R_{SC}$
- $K10/R_{SC}$

IMPLEMENTATION SINGLE-STEP GENOMIC EVALUATIONS

A **synthetic genomic index** has been available for the **Montbéliarde** breed since 2022

Pilot evaluation carried out for the other 8 breeds
(N cows = 2,234 to 2,568,184 depending on the breed)

Deployment of routine evaluation
Scheduled for 2027

FROM4ALL project funded by
APIS-GENE

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THE DEPLOYMENT OF FROM'MIR INDICATORS CONTINUES

- Need for « real-world » references to support adoption
- Moving from pilot studies to sector-wide deployment

→ **2 ONGOING R&D PROJECTS**

FromACT
Scaling Up to National Deployment

Collaborative regional approach involving four demonstration areas and strong engagement from cheese sector stakeholders

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MICROBIOLAIT
Next steps in the Franche-Comté pilot area

Disseminate the FROM'MIR indicators at herd and cheese vat level to develop tools to support production plants in improving cheese quality

WHAT RESULTS CAN WE EXPECT?

Using existing knowledge

Building on the experience acquired in Franche-Comté

Monitoring of industrial and farm-based pilot plants

Guidance on interpreting these new indicators

Demonstration of the added value provided

Testimonials on their use

- ❑ **Guidelines**
- ❑ **Support and advisory services**
- ❑ **Training materials**

- **Dairy farmers**
- **Cheese makers**
- **Advisors**
- **Labs**
- **Trainers**

RESULTS EXPECTED IN 2029

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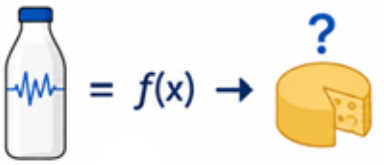
TAKE HOME MESSAGES

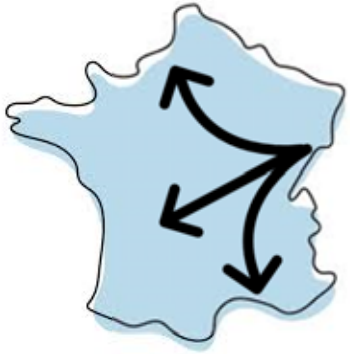


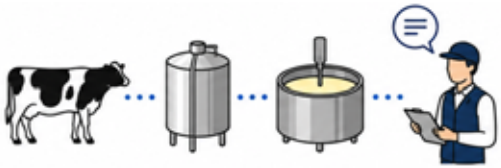
✓ **MIR spectroscopy, a rapid and routinely implemented technology, can now be used to predict milk cheesemaking properties**

- *Across different breeds and production systems*
- *At multiple scales, from individual cows to bulk milk and cheese vats*

✓ **Large-scale deployment is already underway through collaborative projects involving stakeholders across the entire dairy chain**

- *From on-farm milk production to cheese manufacturing*





✓ **Next challenge = assess the added value of FROM'MIR indicators for dairy and cheese sectors**

Thank you for your attention!

Questions ?

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