PhenoFinLait (LactoScan)

French national program for high scale phenotyping and genotyping to detect QTL linked with fine composition of ruminant milk

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PhénoFinlait

Summary

1. **Context and motivations**
2. Background and objectives
3. Organization and 1st works
4. Financial support
5. Conclusions

International context

- Consumers are aware of the food impact on their health
- Better knowledge on genomes and milk synthesis and secretion by mammary gland
- Appearance and use of bulls from genomic selection (New Zealand, USA, France)

French context

- In Europe: end of quota by 2015 → need to find new added value for milk
- June 2009: 1st publication of genomic bulls on quantitative and functional criteria
- Consumers want milk and milk products **naturally** good for their health

Scientific context

- Numerous articles on impact of milk components on human health (FA, proteins, carbohydrates…)
- Increase knowledge on milk synthesis and secretion and on genes participating to these mechanisms
- New technologies (high density), everything is going fast

Phénofinlait: why ?

- **For milk producers:** need to develop tools (management of herds and feeding strategies) for a better control of milk components and for a production of naturally healthy milk and milk products
- **For dairy industries:** need to bring to consumers milk and milk products **naturally** healthy
- **For breeding companies:** need to produce genomic evaluation on fine milk composition

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Phénofinlait: background

- Advanced technology: advance in discoveries of fine milk components with interest for farmers, industries and consumers
  - **Proteins**:
    - SAA3 as a precocious tracer for mastitis (Eckersall *et al.*, 2001),
    - B β-lg variant increases strength of gels (Meza-Nieto et al., 2007),
    - A2 β-casein variant decreases incidence of cardiovascular disease and type 1 diabetes (Bell *et al.*, 2006)

Phénofinlait: background

- Advanced technology: advance in discoveries of fine milk components with interest for farmers, industries and consumers
  - **Lipids**:
    - trans 10 C18:1/trans 11 C18:1 as a marker of rumen acidosis (when it increases) (Enjalbert *et al.*, 2008),
    - CLA-enriched milk decreases butter and cheese firmness (Jones *et al.*, 2005),
    - myristic acid (C14:0) participates to protein acylation and cell membrane properties (Rioux *et al.*, 2002)

Phénofinlait: background

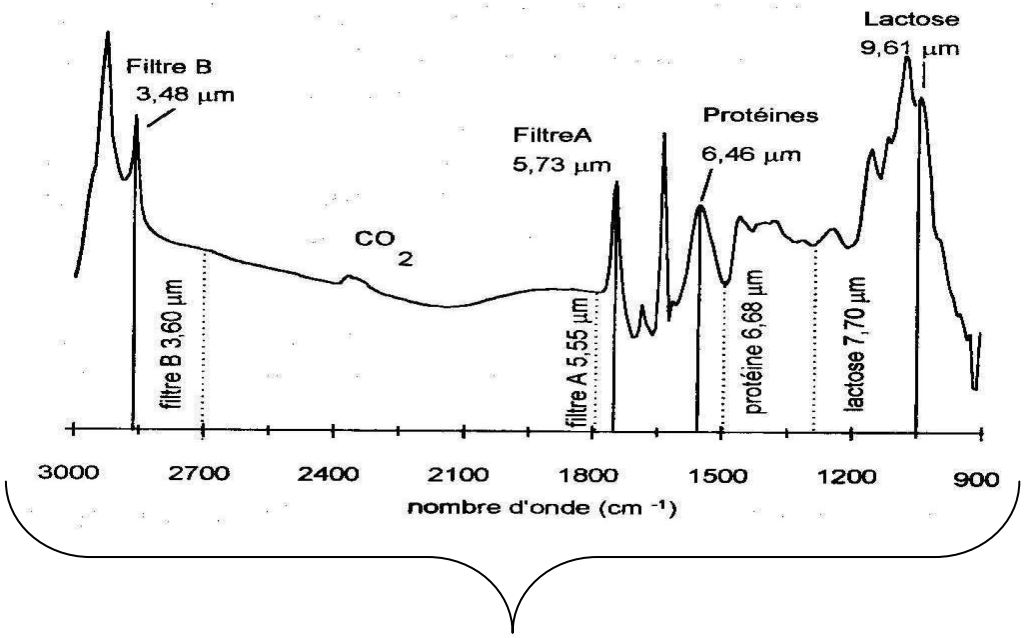
- Advanced technology: advance in discoveries of fine milk components with interest for farmers, industries and consumers
  - **Carbohydrates:**
    - Sialic Acid participates to infant cognitive development, learning and memory (Wang, 2009)
  - **Minerals:**
    - calcium increases bones density (Haug *et al.*, 2007)

Phénofinlait: background

- Advanced knowledge in factors impacting fine milk composition
  - **Genetic:** bovine DGAT1 polymorphism and milk FA composition (Schennink *et al.*, 2007) ;

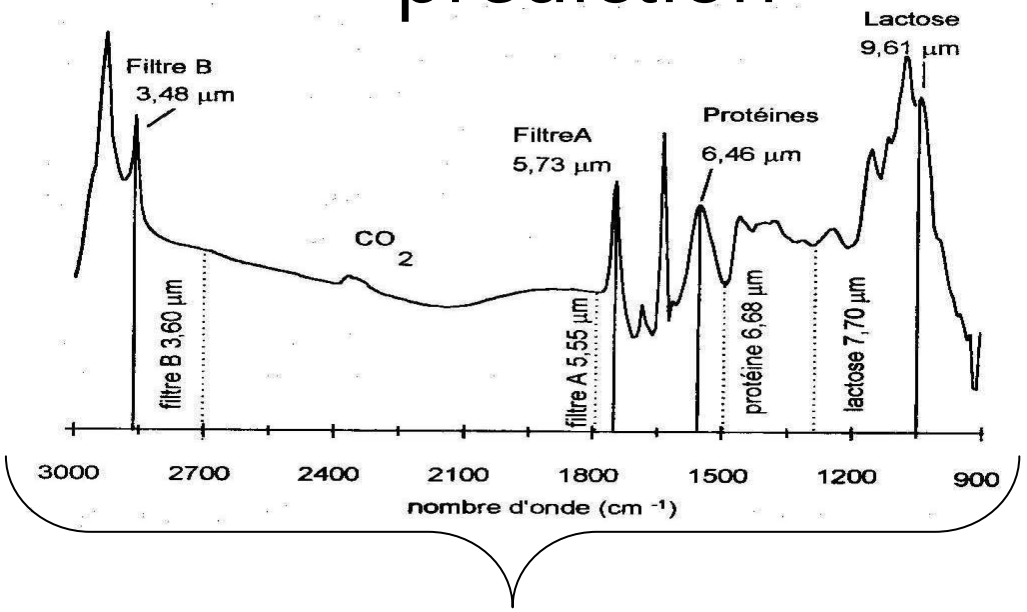
    goat CSN1S1 polymorphism and milk protein content (Grosclaude *et al.*, 1994)
  - **Feeding:** in comparison to maize silage diet, pasture, grass forages or some supplemented diets increase milk mono- and poly-unsaturated FA content

Phénofinlait : MIR spectra and milk FA profile prediction



Usually used by laboratories to predict lipid, protein and lactose content and percentage

Phénofinlait: MIR spectra and milk FA profile prediction



Can also help to estimate FA, lactoferrin and some minerals (Ca, P) content

(Soyeurt *et al.*, 2006 ; Soyeurt *et al.*, 2007 ; Soyeurt *et al.*, 2009)

A French dairy industry R&D program on thin milk composition

PhénoFinlait

Phénofinlait: objectives

- **Develop and control methods to analyze fine milk composition**
- **High scale analysis of milk composition and development of a huge data base**
    - Fine composition (FA and proteins)
    - Feeding strategies and management of herd
    - Biological samples (blood for genotyping and milk)
- **Understand how genetic and feeding strategies impact fine milk composition**
- **Create tools** (genetics + feeding strategies) to adapt variation of consumers demand and health

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Phénofinlait: How ?

Partners from every rings of dairy industry

CNIEL (Dairy industries and farmers)

France Génétique Elevage :
(France Livestock Genetics)

UNCEIA, ANIO and CapGène
(about 10 breeding companies)

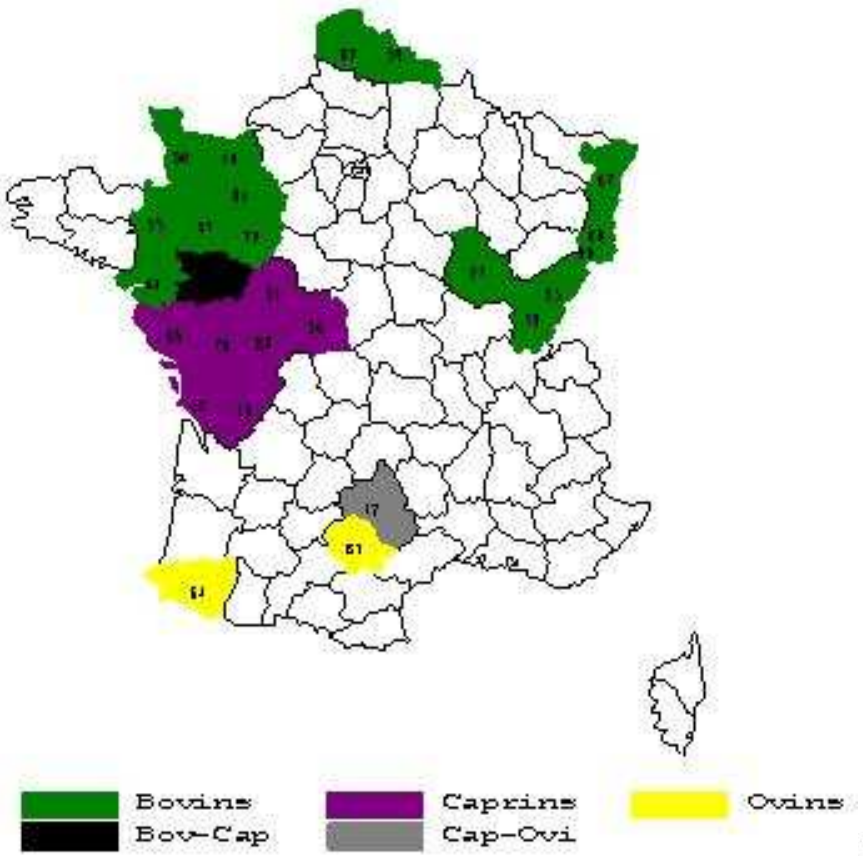
FCL and CNBL
(Milk recording organizations)

Actilait and regional laboratories

INRA
(French National Institute for Agricultural Research)
(4 labo, 4 exp. units, 2 dép.)

Institut de l'Elevage
(French Livestock Institute)
(4 teams, 3 dép.)

And about 1500 farms !



26 departments
3 species, 7 breeds

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A French dairy industry R&D program on thin milk composition

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Phénofinlait: How ?
Organizing committee

- **Phénofinlait consortium**: Actilait (1), CNIEL (2), FCL (3), CNBL-ANIO (4), Institut de l'Elevage (5), INRA (6), Lilano (7) and UNCEIA (8)
- **Steering committee**: D. Boichard (6), M. Brochard (5) and K. Duhem (2)
- **Scientific committee**: F. Barillet (6), P. Brunschwig (5), S. Fritz (8), P. Martin (6), S. Mattalia (5), J.L. Peyraud (6)

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A French dairy industry R&D program on thin milk composition

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Phénofinlait: How ?
3 steps, 6 work packages

- **Step 1: test, development and validation of methods for fine milk composition analysis**
  - WP1: fix terms to use routinely MIR spectra
  - WP2: development of phenotyping method for FA
  - WP3: development of phenotyping method for proteins
- **Step 2: collect of phenotypes, blood (DNA) and milk samples (WP4)**
- **Step 3: valorization and results**
  - WP5 : genotyping and analysis of genetic and environmental factors
  - WP6 : valorization and enhance of herd management advices

A French dairy industry R&D program on thin milk composition

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Phénofinlait: 1st works
WP2: routine phenotyping of FA composition

- Based on **MIR spectra**
- Development of predictive equations with PLS regressions method (PLS1 or PLS2)
- Good prediction for **17 FA and some ratios** (cross-validation coefficient of determination (R2CV) >80%)
- Correct prediction for 15 FA (70<R2CV<80%)
- **Better results for ewe and cow milks** than goat milk

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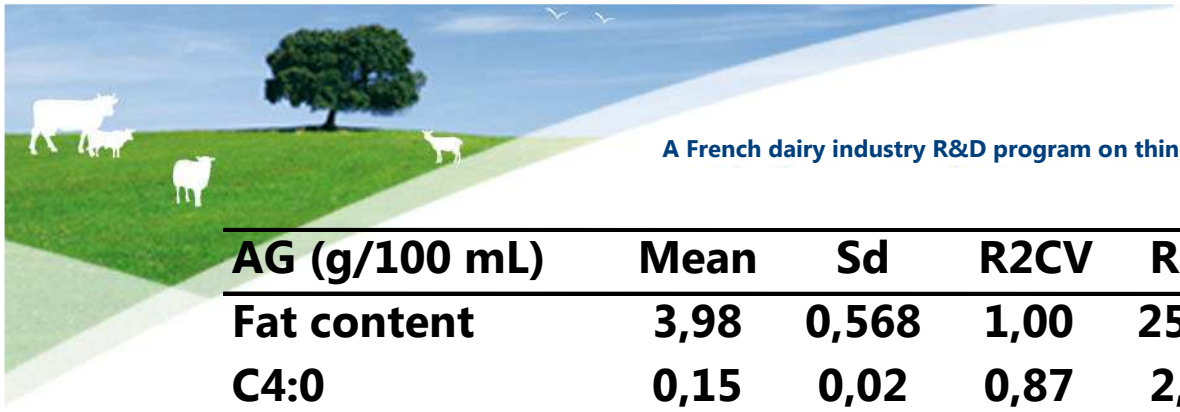


AG (g/100 mL)	Mean	Sd	R2CV	RPD
Fat content	3,98	0,568	1,00	25,96
C4:0	0,15	0,02	0,87	2,58
C6:0	0,09	0,02	0,94	3,94
C8:0	0,05	0,01	0,96	4,91
C10:0	0,13	0,03	0,93	3,61
C12:0	0,15	0,05	0,93	3,52
C13:0	0,01	0,00	0,76	1,97
C14:0	0,46	0,09	0,81	2,20
C16:0	1,31	0,29	0,90	3,03
C17:1 10c	0,01	0,00	0,87	3,14
C18:1 9c	0,71	0,22	0,95	4,67
C18:1 12c	0,01	0,00	0,78	2,02
Total 18:1cis	0,74	0,23	0,95	4,70
Total 18:1	0,82	0,24	0,96	5,23
C18:3n-3	0,02	0,01	0,80	2,13
Total C18:3	0,02	0,01	0,80	2,10
Saturated FA	2,91	0,49	0,99	10,47
Monounsat. FA	0,93	0,26	0,97	5,80

FA with good prediction (cow)

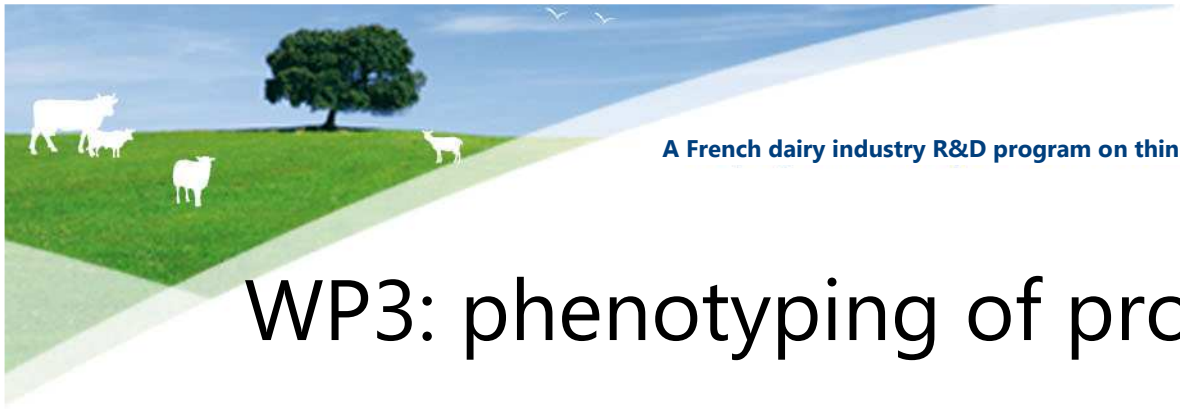
Sd: standard deviation

R2CV: cross-validation coefficient of determination

RPD= Standard error of cross-validation/Sd

Ratios with techno functional or nutritional interests

PLS 1	Mean	Sd	R2CV	RPD
LA/ALA (C18:2 9c12c/c18:3 n-3)	3,52	1,79	0,85	2,51
omega 6/omega 3	3,61	1,47	0,83	2,30
C18:1/C16:0	0,66	0,27	0,88	2,77
C16:1 9c /C16:0	0,05	0,01	0,87	2,63
C16 index	4,29	1,34	0,86	2,62
Atherogenicity index	3,39	1,09	0,87	2,69



WP3: phenotyping of protein composition

- Choose and establish a reference method for protein analysis: HPLC associated with MASS spectrometry
- Create equations to evaluate milk content of some proteins from MIR spectra (in process)
- Fine protein content analysis of referenced milk (genotype and management of herd) to determine QTL or feeding strategy affecting protein composition (in 2010-2012)

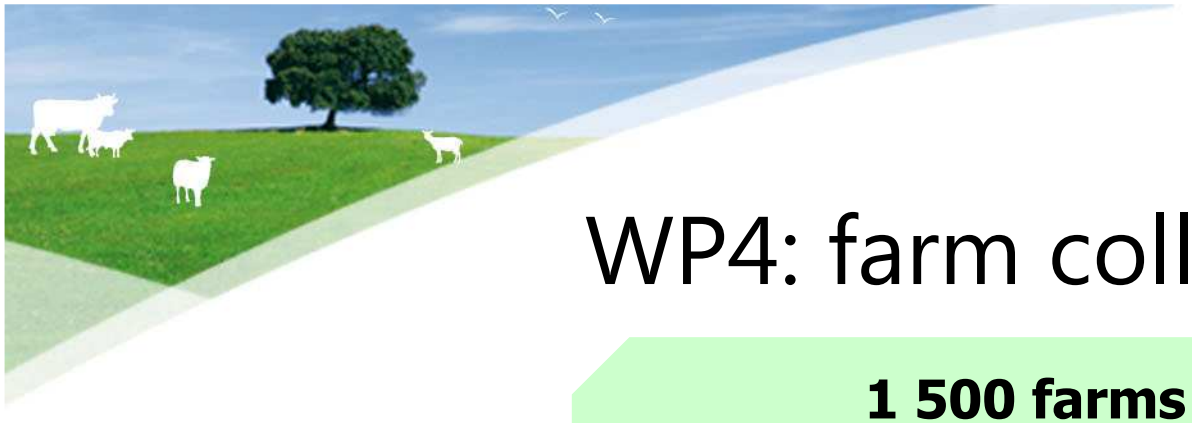
WP4: farm collecting

1 500 farms

- **12 000 cows**: 3 breeds (Prim'Holstein, Normande, Montbéliarde) with at least 15 bulls for each breed, 150 daughters for each bull, 10 « Phénofinlait » females in each farm

- **4 000 ewes**: 2 breeds (Lacaune – Manech Tête Rousse) 36 rams, about 130 daughters for each ram

- **4 000 goats**: 2 breeds (Alpine – Saanen) 20 billy goats, about 200 daughters for each billy goat



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WP4: farm collecting

1 500 farms
20 000 “Phenofinlait” females

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WP4: farm collecting

1 500 farms
20 000 "Phenofinlait" females

Milk recording organization

Milk

Feeding and management recording

Milk recording laboratories

FA
Proteins ?

Phenotyping

WP4: farm collecting

1 500 farms
20 000 "Phenofinlait" females

Milk recording organization

Breeding companies

Milk

Blood

Feeding and management recording

Milk recording laboratories

Labogena

FA
Proteins ?

Genotype

Phenotyping

Genotyping

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WP5: results valorization (by 2012)

Routine methods to evaluate fine milk composition

Better knowledge of factors impacting fine milk composition

Feeding and management recording

FA
Proteins ?

Genotype

Enrichment of breeding and herd management advice

References for genomic selection on fine milk composition criteria

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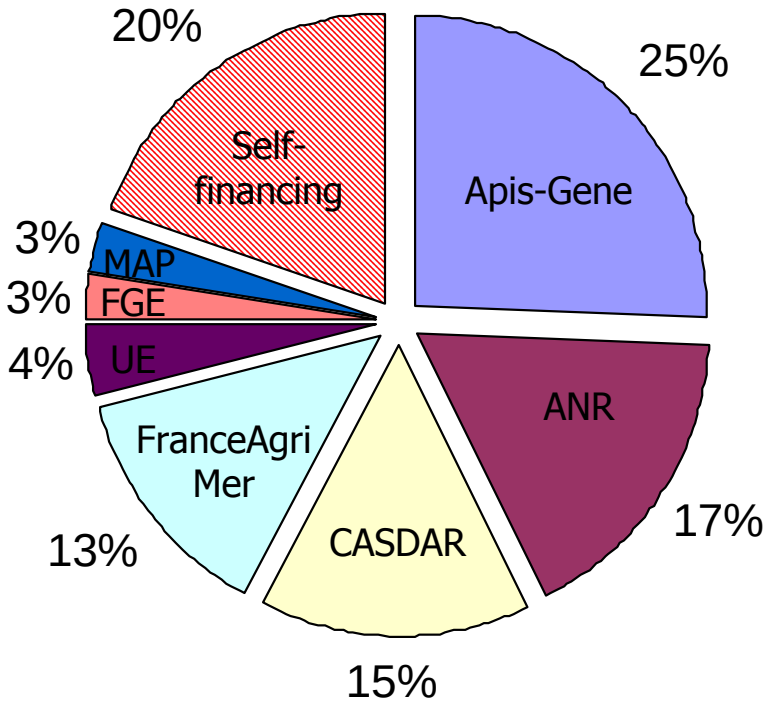
Financial support

- Apis-Gene
- ANR *(French National Research Agency)*
- CASDAR *(Agricultural Development Fund)*
- France Agri Mer
- European Union (EU)
- France Génétique Elevage (FGE)
- Ministry of Agriculture (MAP)
- Self-financing



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Conclusions

- Ambitious program
- All French dairy industry partners are implicated and concerned
- Diversity of stakes:
  - For the future: create knowledge basis for fine and ultra-fine milk composition, its control and its improvement
  - At medium-term: enrichment of selection program and farmer feeding and herd management advice
  - At short-term: analysis methods for milk composition validated and usable. Capacity to improve these methods. Experience to manage and treat this new kind of data.

Thanks to every partners of this project

Thank you for your attention !

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