Thesis PhD

May 2015 - May 2018

Prediction of milk fat composition from diets: focus on the duodenal flows of fatty acids.

Lucas de Ofeu AGUIAR PRADO

Supervisors :
Anne FERLAY
Philipe SCHMIDELY

Co-supervisors :
Pierre NOZIERE

Systali project : renovation of ruminant feed systems

Plan

1. Context and objectives of thesis

2. Scientific content

3. Materials and methods

4. Results

5. Conclusions and perspectives

- **Evolution of animal science knowledge :**
  - ↑ number of data with fine milk profiles of FA
  - Quantitative laws of response with empirical modelling (meta-analysis).

- **Advantages and limits of existing models on the secretion of milk fatty acids :**
  - Level : animal and mammary gland
  - Prediction of the major milk components and two FA groups (short- and long-chain)
  - Standard diets ?
  - No prediction of all milk fatty acid

(Whagorn and Baldwin, 1984, Hannigan and Baldwin, 1994, Shorten and al., 2004, Moate and al. 2008)

- **Previous studies have also demonstrated the role of digestive and mammary factors on the production and composition of milk fat.**

1. At Digestive level :
   - Ruminal biohydrogenation of PUFA
   - Interaction with other Nutrient flows

2. At Mammary gland level:
   - Interaction between *de novo* synthesis and uptake of long FA
   - Saturation and esterification

(Glasser and al., 2008, Schmidely and al., 2008)

Thesis objective : Predict the yield and composition of milk fat from the diet via the absorbed nutrient flows by modelling approach

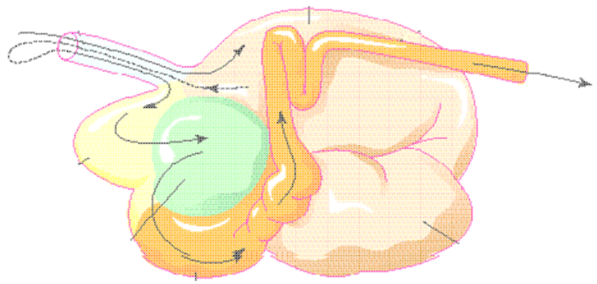
from

challenge

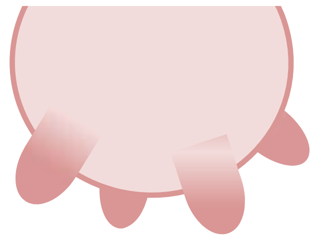
complexity of lipid metabolism

Diet

Rumen



Predicting the milk fatty acid profile



An essential step is to quantify the duodenal flows of fatty acids.

Duodenal flows of C18:1 isomers

The duodenal C18:1 isomers studied (fatty acids selected with over 50 observations from database).

Total C18:1
Total cis C18:1
Total trans C18:1

cis-n C18:1
n = 9, 11, 12, 13, 15

trans-n C18:1
n = 4 to 15

Statical analysis

- Model

- **GLM** ➔ the response of duodenal C18:1-isomers to a variation of factors :
  - ✓ Isomer precursors intake (main covariates)
  - ✓ Dietary and digestive factors (interfering factors)
- Including the experiment effect **(fixed effect)**
- A reliable **within-experiment variation** of these factors

- Selected data for the analysis

- AGRum database

- Literature data
- 2008 Treatments
- Ruminant species

Experiments with duodenal C18:1-isomers flows

- Excluded data :

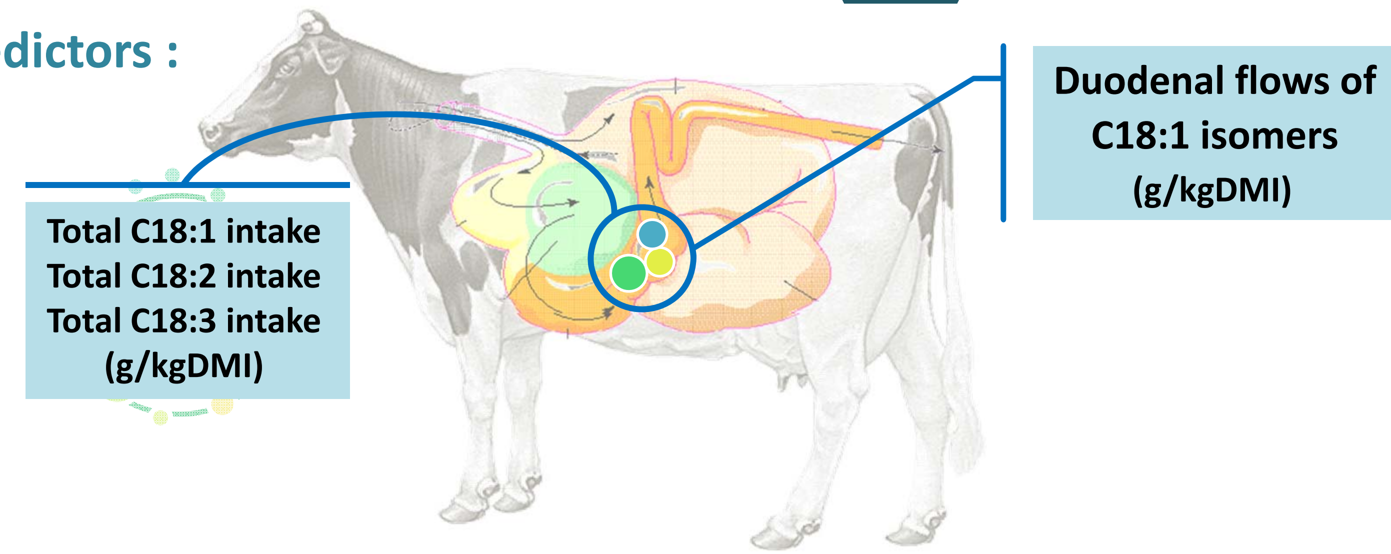
- Fish by-products
- Ruminal infusion
- 1 experiment with 1 treatment

- **138 experimentations**
- **422 Treatments**

Cattle
N_{exp} = 114
N_{trt} = 348

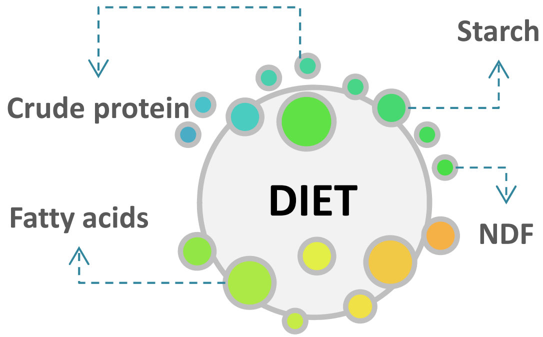
Sheep
N_{exp} = 24
N_{trt} = 74

The potential predictors :



The interfering factors :

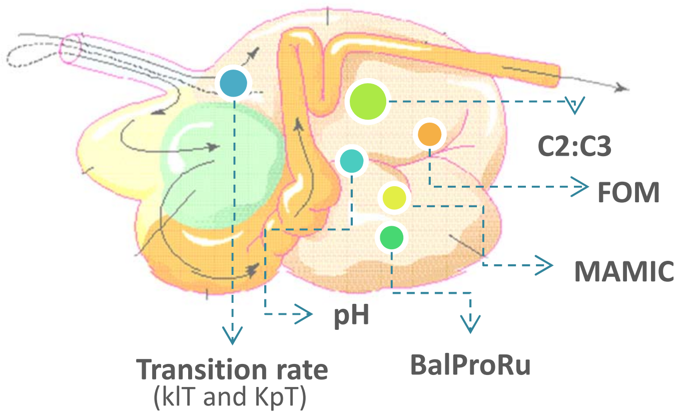
- **Dietary** (controled factors)



- Concentrate:Forage

- Level of intake

- **Ruminal fermentation** (not controled factors)



BalProRu = Protein Balance in the rumen ; FOM = Fermentable Organic Matter in the rumen ; MAMIC = Microbial Nitrogenous Matters coming out of the rumen; Klt and Kpt = exit rate from the rumen of the liquid/particules phase

The analysis approaches *(example : duodenal cis-9 C18:1 flow)*

duodenal cis-9 C18:1 flow = *f*(Total C18:1 + Total C18:2 + Total C18:3 intake)

Significant

Not significant

cis-9 C18:1 = *f*(Total C18:3)
within-experiment variation of C18:3 intake

Not significant

REJECTED

Effect of
The interfering factors
Dietary and Ruminal fermentation
on residual values of the model

cis-9 C18:1 = *f*(Total C18:1 + Total C18:2)

pure effet of predictors

Significant

Significant

cis-9 C18:1 = *f*(Total C18:1)
within-experiment variation of C18:1 intake
(Slope variation ?)

cis-9 C18:1 = *f*(Total C18:2)
within-experiment variation of C18:2 intake
(Slope variation ?)

Significant

ACCEPTED

Prediction of duodenal Total C18:1 and C18:1-isomers flows (g/kgDMI)

Dependent variables (Y)		Coefficient (B) of independent variables (X)						
Duodenal C18:1 isomers	Intercept	Total C18:1 intake	Total C18:2 intake	Total C18:3 Intake	N_{exp}	N_{trt}	RMSE	R^2
Total C18:1	-0,755^{NS}	0,310*	0,266*	0,251*	117	295	2,387	83,47
Total cis C18:1	0,070^{NS}	0,256*	0,079*	-	75	202	1,12	89,88
cis-9 C18:1	-0,188^{NS}	0,265*	0,074**	-	44	124	1,10	92,30
cis-12 C18:1	-0,066*	-	0,018*	0,004*	27	73	0,04	93,20
Total trans C18:1	-1,201***	0,065**	0,252*	0,194*	49	141	1,54	83,27
trans-10 C18:1	-	-	-	-	-	-	-	-
trans-11 C18:1	0,287^{NS}	0,036***	0,069**	0,082*	27	82	0,82	83,8

DMI = dry matter intake; Nexp = number of trials included; Ntrt = number of treatments; RMSE = root mean square error of the model; NS : not significant ; * p-value<0,001 ; ** p-value<0,005 ; *** p-value<0,05.

- **cis9-C18:1 = + C18:1** (*P*<0,001) and **C18:2** (*P*<0,005)
- **trans11-C18:1 = + C18:1** (P<0,05)**, C18:2** (P<0,005) **and C18:3** (P<0,001)
- **trans10-C18:1 =** not affected by **FA intake**

No interfering factors selected had a signicant effect on any of these relationships

Conclusions and Perspectives

- **Prediction of duodenal flows of new C18-isomers**

- **The different parameters (dietary and digestive) chosen don't affect significantly these predictive relations**

- **Improve the prediction of a wide range of FA flows at duodenum or/and absorbed :**
  - ✓ C18:1, C18:2 and C18:3 isomers
  - ✓ Odd and branched fatty acids were not predicted previously

A better prediction of duodenal FA flows necessary to improve the prediction of milk FA profile

Thank you for your attention !

“all models are wrong, but some are useful.”

George Box