Modulation of the redox state in pigs differing in feed efficiency as revealed by a proteomic analysis

F. Gondret[1], S. Tacher[1] & H. Gilbert[2]

[1]UMR Pegase, 35590 Saint Gilles, France

[2]UMR GenPhySe, 31326 Castanet-Tolosan, France

Florence.gondret@rennes.inra.fr

EAAP 2014: Appetite control – mechanisms and comparative aspects

Animal feed efficiency (FE): a trait with a large economic impact for producers

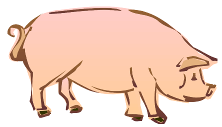
Typical calculation of FE: **feed intake**/average daily gain

Feed composition

Feed availability

Feed palatability

Physiology & genetics



Management factors

Disease

Environment

Residual feed intake (RFI) :

observed feed intake – expected feed intake

$BW^{0.60}$; ADG ; Backfat

maintenance ***production***

RFI: ~ one third to half of the total variation in feed intake in growing pigs

(*Knapp, 2009;* Young & Dekkers, 2012)

- Context

Variations in residual feed intake (RFI):

Feed consumption & behavior (number of visits, duration of meal intake, time spent eating, etc…)

Young et al., 2011 *Meunier-Salaün et al., 2012*

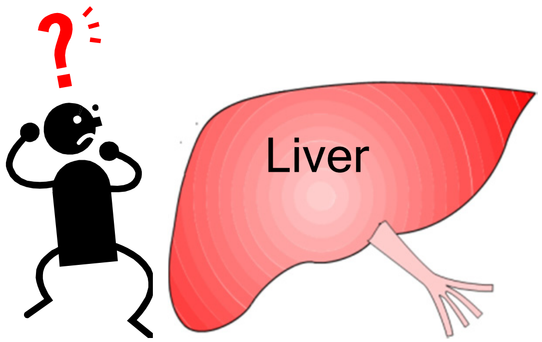
Digestion and utilization of nutrients

Barea et al., 2010

Organ physiology : thermoregulation
basal metabolic rate
energy efficiency of mitochondria
protein turnover rate
immunity, etc.

Skeletal muscle

Le Naou et al., 2012; Gabler et al., 2013; Grubbs et al., 2013

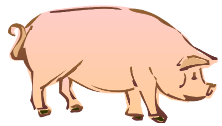


The liver is a complex and unique organ responsible for a breadth of functions that are crucial for sustaining life

We propose to use a proteomic differential approach to identify the modulation of **hepatic** metabolic processes participating **to feed efficiency**

- Objectives

6th generation of a **divergent selection for RFI** in pigs



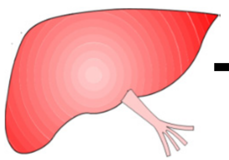
Large White pure genotype 10 wks of age
(30 kg BW)

RFI-
(low feed intake, high FE)

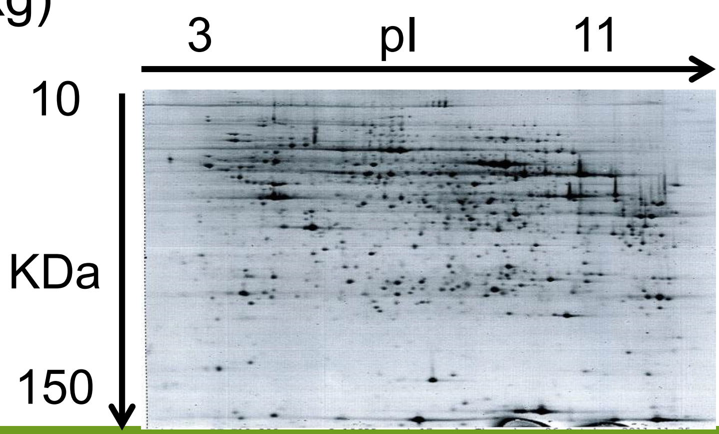
RFI^{+}_R
(pair-fed to RFI- pigs)

RFI+
(high feed intake, low FE)

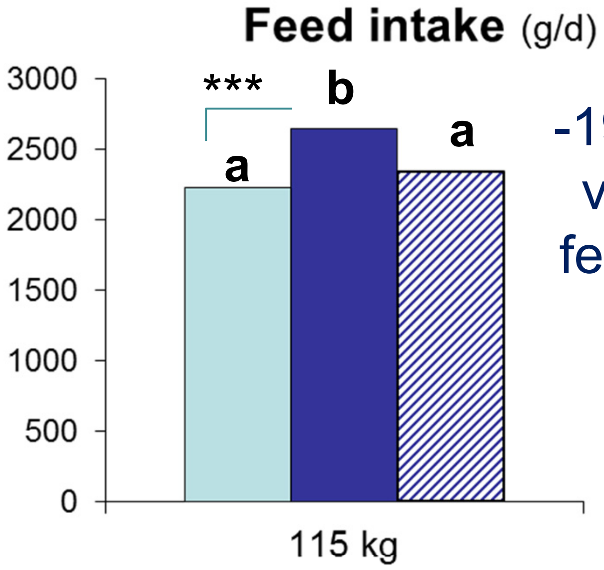
Slaughtered
at the same BW (115 kg)
(n = 8 / group)



2D-electrophoresis of soluble proteins
+ MS/MS identification of differentially-abundant spots

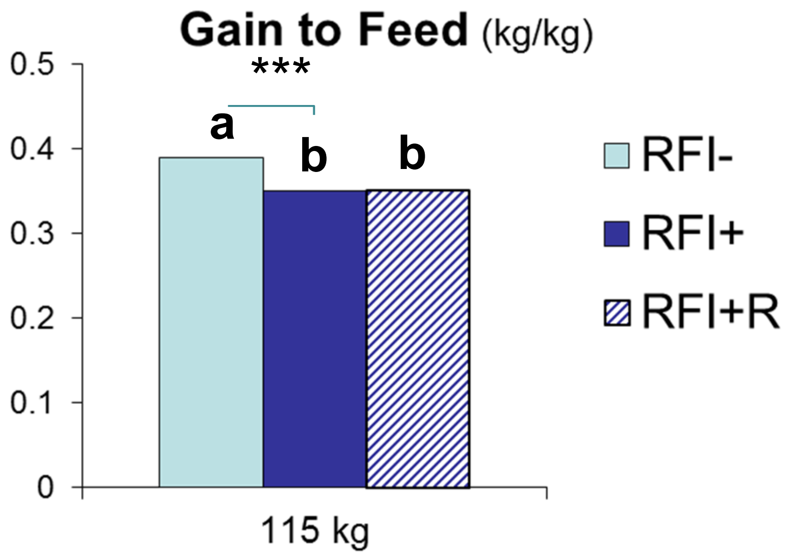


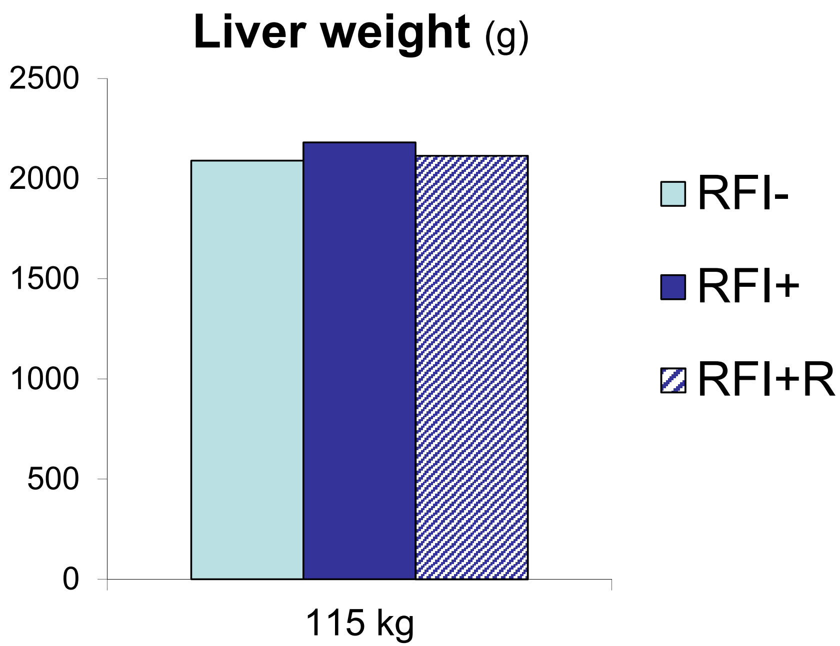
- Experimental design



-19% of the voluntary feed intake

RFI corresponded to a biologically imposed feed restriction





- Results: Animal performance

A total of 50 protein spots in the liver had a differential abundance between pigs

Proteins were included in pathways related to AA metabolism, glycolysis/gluconeogenesis, ion binding, purine binding, and **oxido-reduction**

11 unique proteins belong to a top cluster related to cell oxido-reduction processes (enrichment score = 2.92)	
Response to oxidative stress	PRDX2, PRDX4, PRDX5, PRDX6, SOD1
Cell redox homeostasis	PRDX2, PRDX4, PRDX5, PRDX6, PDIA3, PDIA6, GSTO1
Oxidation reduction	PRDX2, PRDX4, PRDX5, PRDX6, SOD1, HAAO, DMGDH, ETFA

- Results: differential proteins in liver

Liver mitochondria and Reactive Oxygen Species (ROS) production

Tricarboxylic acids (TCA) cycle ↘   ↙ Fatty acid oxidation

Oxidation of reducing equivalents

Transfer of electrons along the respiratory chain

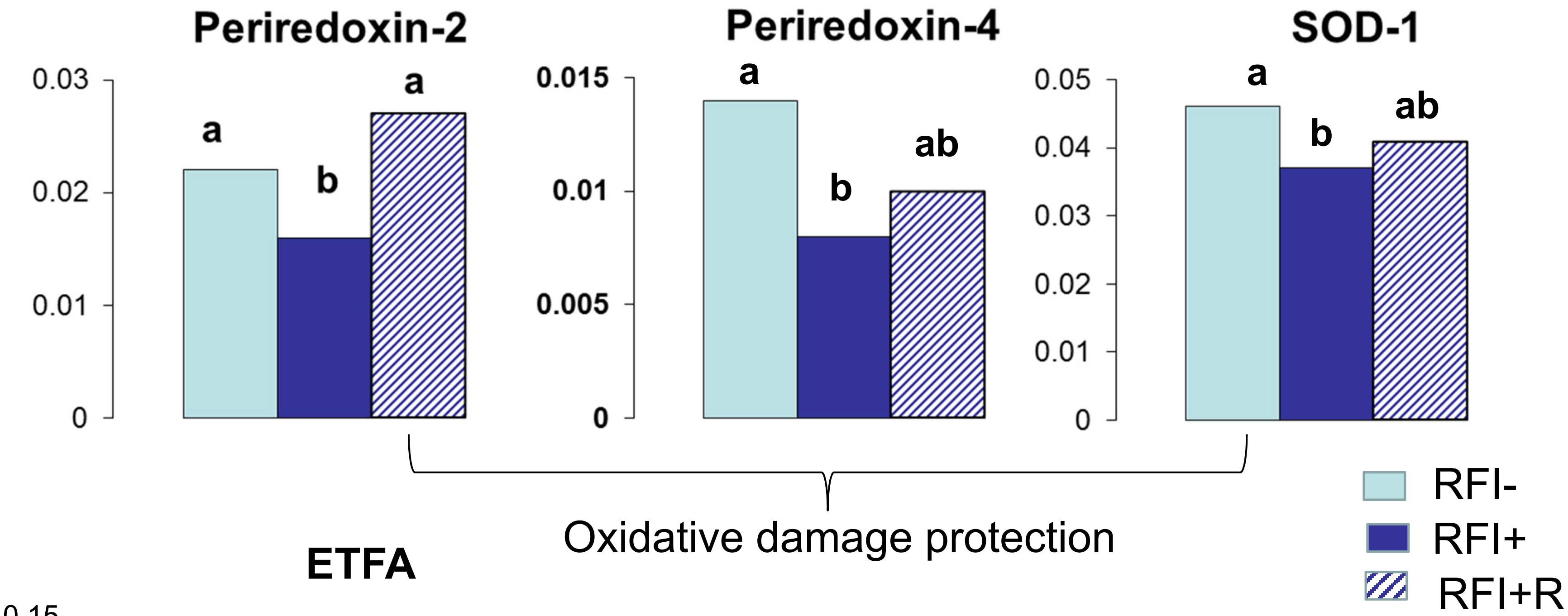
↓

oxidation to H_2O

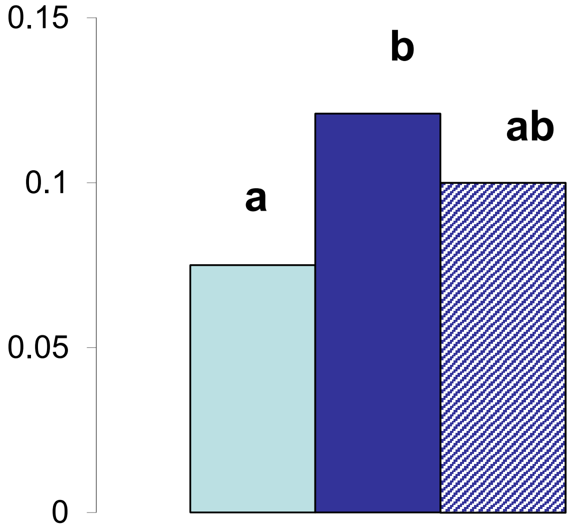
ATP ↘

ROS ↗

- Liver mitochondria are a main site of ROS production



ETFA



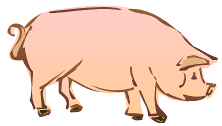
A lower abundance in the **electron transfer flavoprotein** (**ETFA**) is considered as leading to ROS elevation

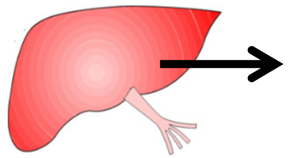
Levels in feed-restricted high RFI pigs were similar or intermediary to levels observed in low RFI pigs

- Results: greater anti-oxidant enzymes in low RFI pigs

A low abundance of ETFA signs a low activity of the respiratory chain

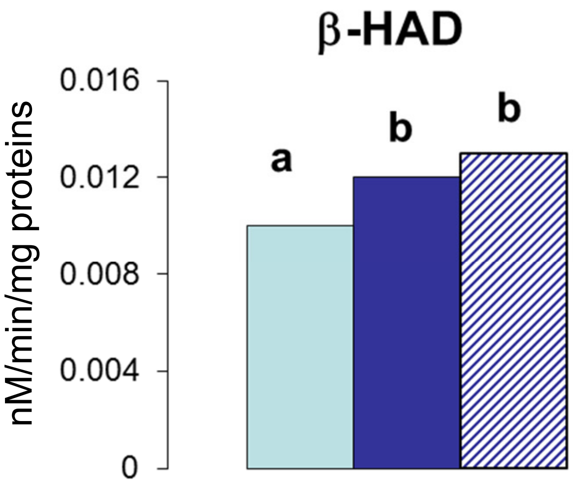
A severe inhibition of the respiratory chain is considered as inhibiting lipid oxidation process in rats *(Pande, 1971)*





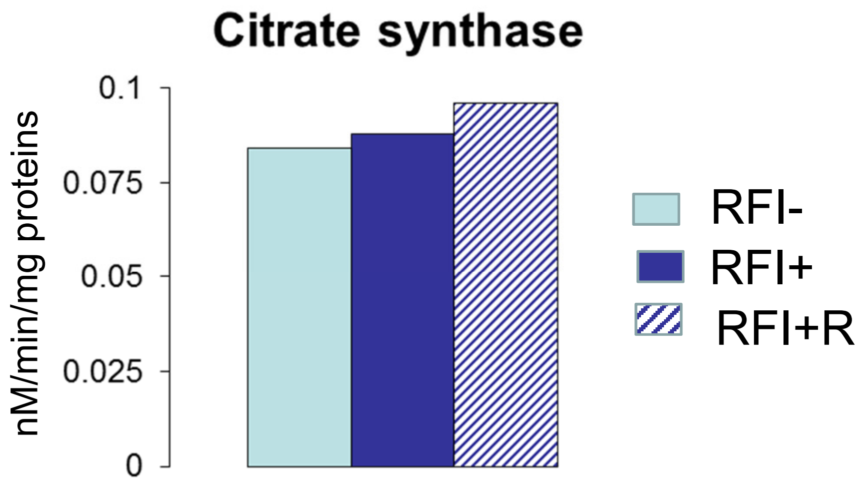
Monitoring oxidative enzyme activities in the 3 groups

Fatty acid oxidation



P = 0.01

TCA cycle

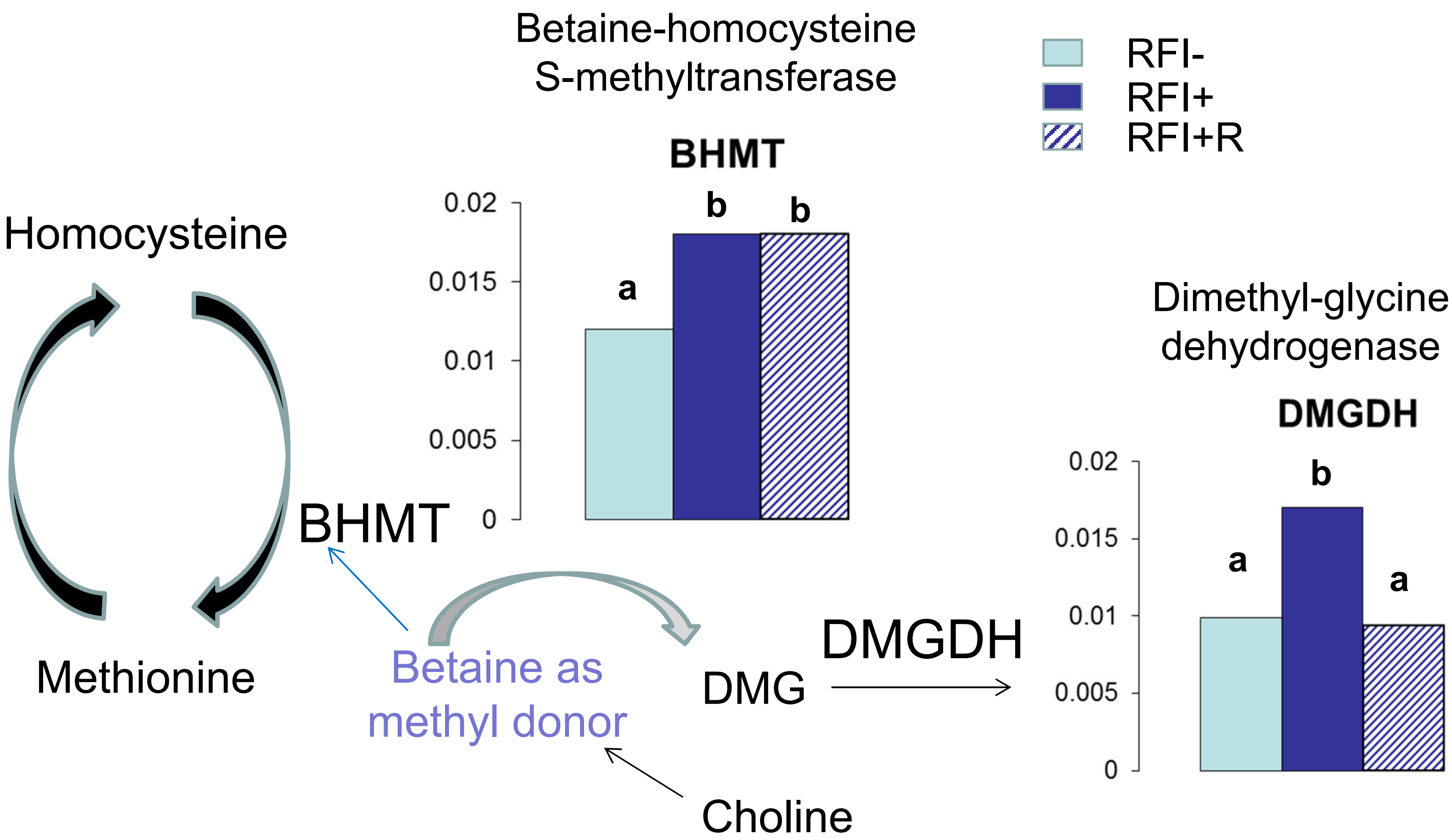


P = 0.11

Lower fatty acid oxidation in the low RFI pigs, independently of feed intake

- Results: lower lipid oxidation pathway in low RFI pigs

Balance in labile methyl groups (methionine, betaine, choline) is involved in maintaining normal lipid functions and health (*Mato et al., 2008)*



- Results: homocysteine/methionine/betaine equilibrium ?

- Pigs selected for a low residual feed intake had eaten less during the growing period

- Higher anti-oxidant capacities in the liver of the most efficient pigs, due to (?) greater ROS generation

Consequences on the redox state of the animals remains to be determined (other tissues)

- Levels of anti-oxidants were lower with feed restriction.

Relationships between feed intake and oxidative stress/redox metabolism in pigs deserve further studies

caloric restriction in aging mice decreased hydrogen peroxide production from the mitochondria.

Conclusions

Special thanks to:

The staffs of:
- UMR GenEsi (Poitou-Charente, France) for the divergent selection experiment
- UMR Pegase for the feeding trials, animal slaughtering and lab analyses

The financial support of:
- Program PigFeed (ANR-08-GANI-038)

High-proteomic core facilities (Rennes, France)

Acknowledgements