Responses of adipose tissue to feed efficiency: effects of genetics, dietary restriction and diet composition

F. Gondret[1], I. Louveau[1], A. Vincent[1], T. Le Naou[1], M. Jegou[1], J. van Milgen[1] & H. Gilbert[2]

[1]UMR Pegase, 35590 Saint Gilles, France

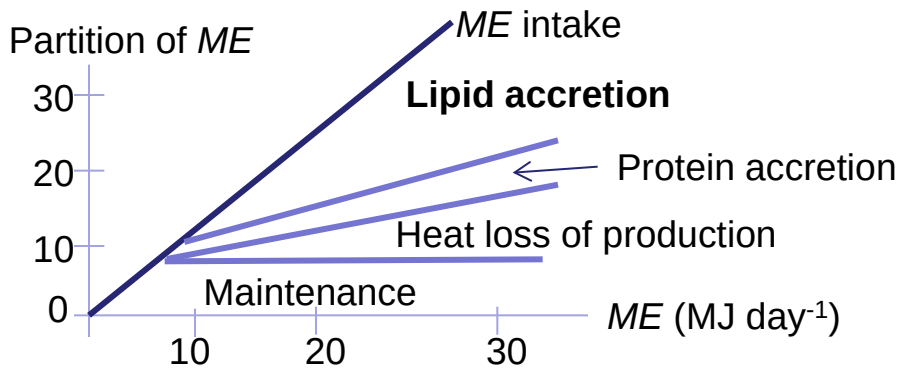
[2]UMR LGC, 31326 Castanet-Tolosan, France

Florence.gondret@rennes.inra.fr

Adipose tissue triggers the efficiency of pig production

- ❖ Fatter carcasses are economically depreciated
- ❖ Fat requires more energy to deposit than muscle

Partition of metabolisable energy (*ME*) in a pig of 60 kg BW



- ❖ Fatty animals are generally less efficient

But this is not always true !

- ❖ Feed restriction led to a decrease in body fat content with a minor or no improvement on G:F
- ❖ Refeeding after restriction improved G:F but also increased the rate of lipid deposition

Heyer et al., 2007; Oresanya et al., 2008

To clarify the relationships between adipose tissue and feed efficiency in growing pigs

Body fat = genetics + environment

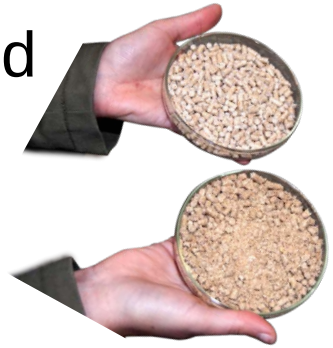
Within the LW breed

Divergent selection on **RFI***

6th to 8th generations

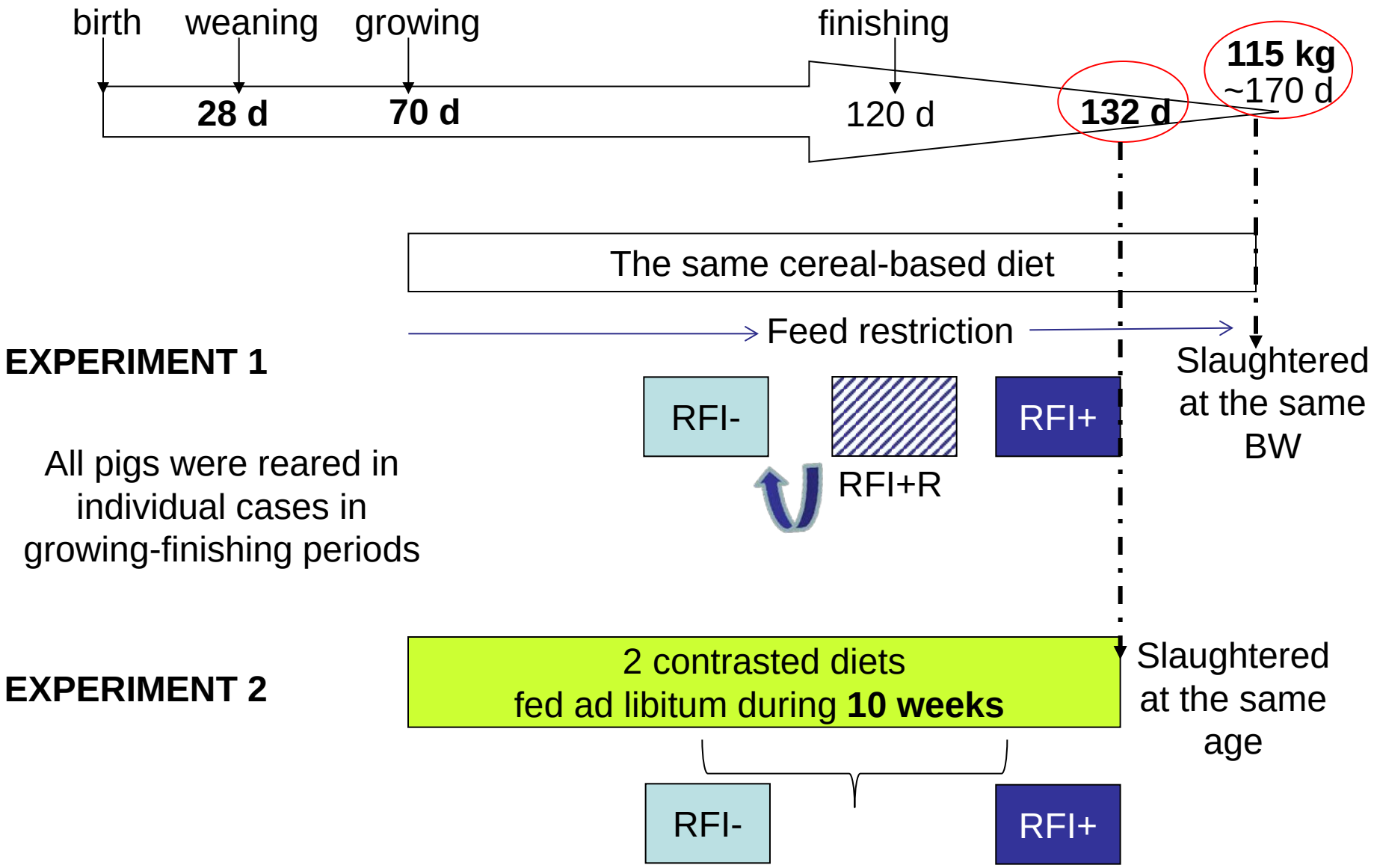
Amount of feed

Source of the feed energy



*Residual feed intake = the difference between observed feed intake and expected feed intake (based on growth potential and body composition) *Gilbert et al., 2007*

- Aim of the study



- Experimental design overview

Exp. 2

LF diet
High starch
Low fat (2%)

Wheat, barley

HF diet
High fibers
High fat (7%)

Crushed straw

Oils

Rapeseed + soya

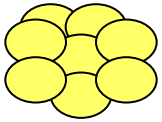
	LF	HF
***ME* (MJ/kg)**	**12.9**	**12.9**
NE (MJ/kg)	9.6	9.8
Ingredients, %		
Crude proteins	**17.0**	**17.0**
Fat	**2.1**	**7.2**
Starch	46	33
Cellulose	1.0	2.2
NDF	12.0	19.0
ADF	3.6	8.2

Body lipids must be synthesized *de novo* from carbohydrates

Dietary lipids can be used for fat deposition

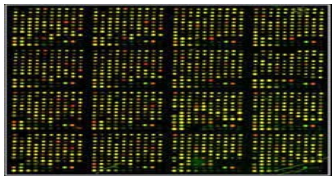
- Experimental diets differed in feed energy sources (exp. 2)

❖ Body weight and feed consumption (distribution – refusals) were individually recorded

❖ Subcutaneous adipose tissue was sampled at the end of each experiment  Backfat

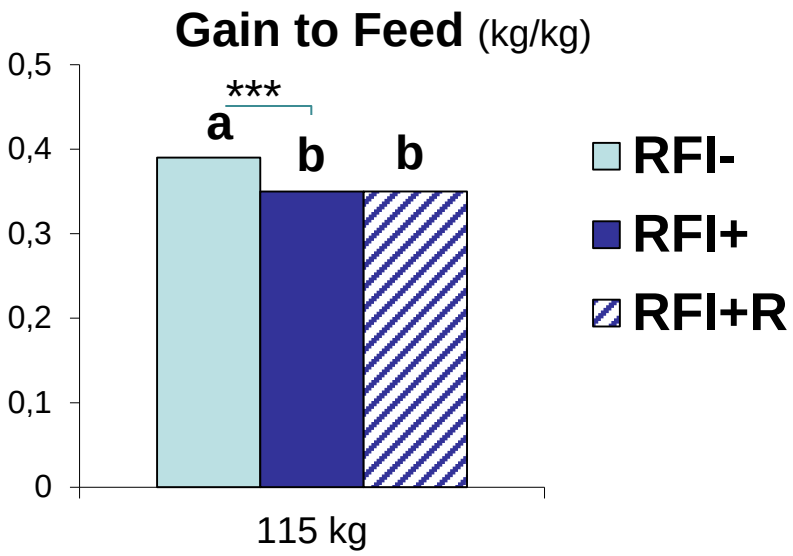
❖ Data on adipose tissue concerned:

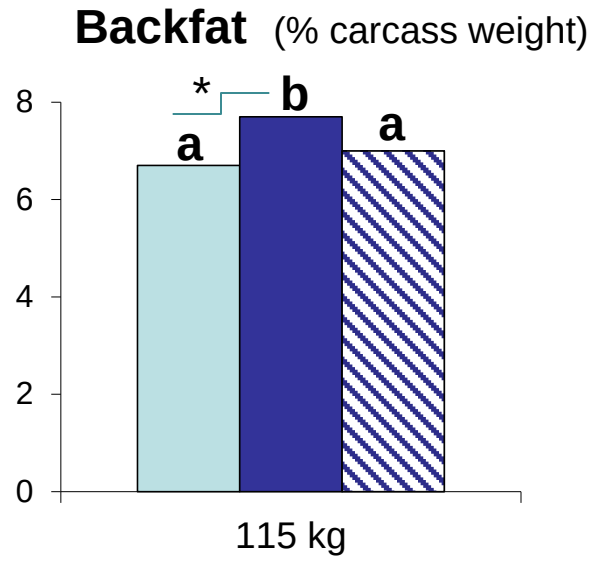
- Tissue lipid content
- Specific activities of key enzymes
- High-throughout put transcriptomic analysis

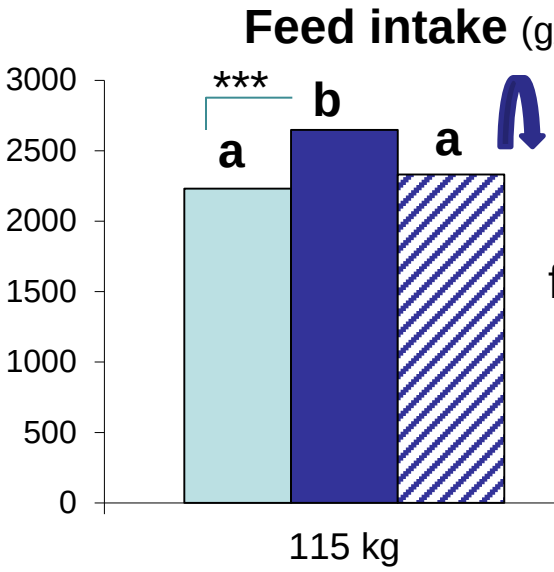


Agilent, 44 K porcine pan-genomic oligo microarray

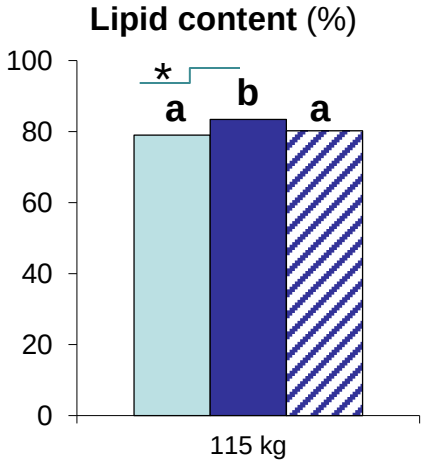
Exp. 1

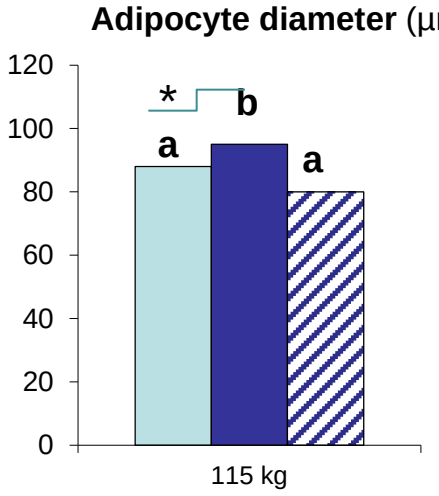






-19% of voluntary feed intake





N = 14-17 pigs/group

- Results: RFI+ pigs are fatter because they eat more

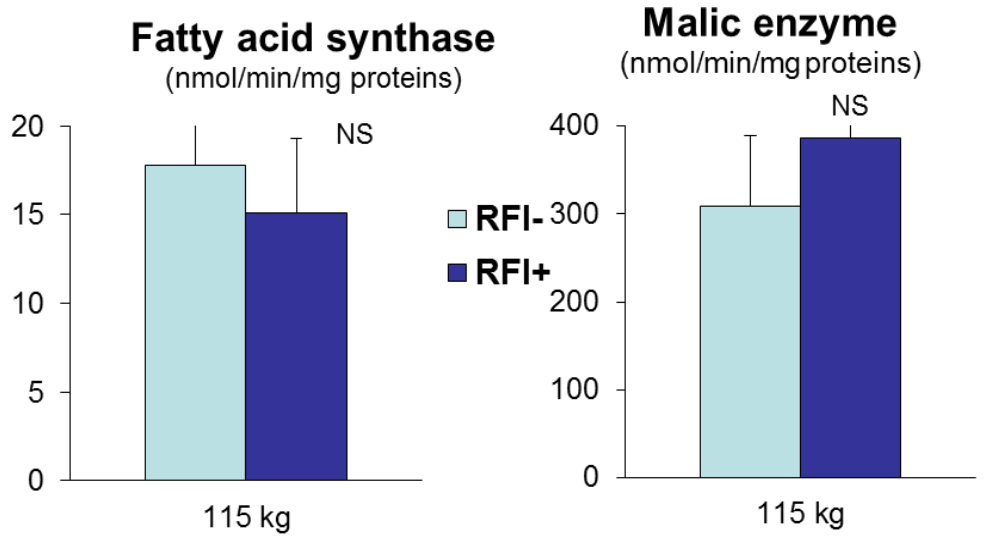
Exp. 1 Transcriptomic analysis of subcutaneous adipose tissue

~ 600 DE-probes ($P < 0.01$) between RFI- and RFI+ pigs

Functional analysis of DE-genes

No differences between lines in gene expressions related to lipid synthesis

This was confirmed by the lack of differences of lipogenic enzymes activities between RFI lines



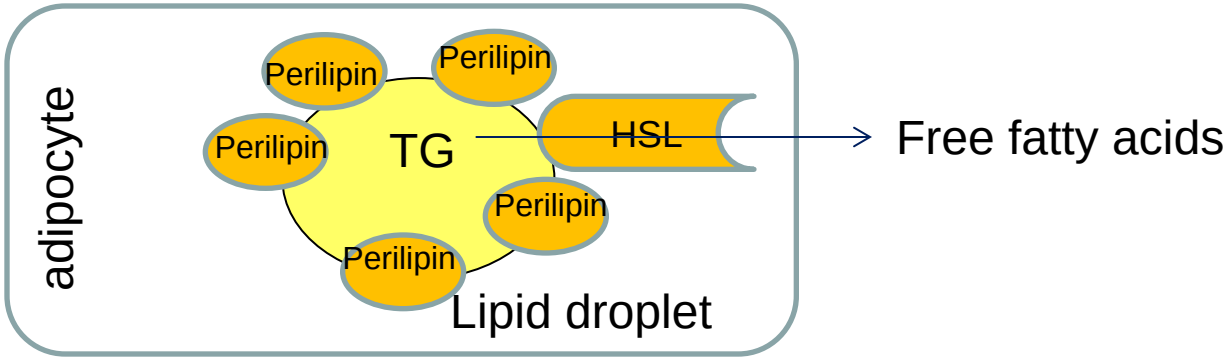
- Results: lipid synthesis did not vary between RFI lines

Exp. 1

RFI+ pigs

Down-regulation of genes related to lipolysis such as perilipin (*PLIN1*), caveolin-1 and the hormone-sensitive lipase (*HSL*) in RFI+ pigs

Lipolysis ↘ ?



Functional analysis of DE-genes

Down-regulation of energy-related pathways*

Generation of precursor metabolites and energy (11 genes)

Oxidation-reduction process (22 genes)

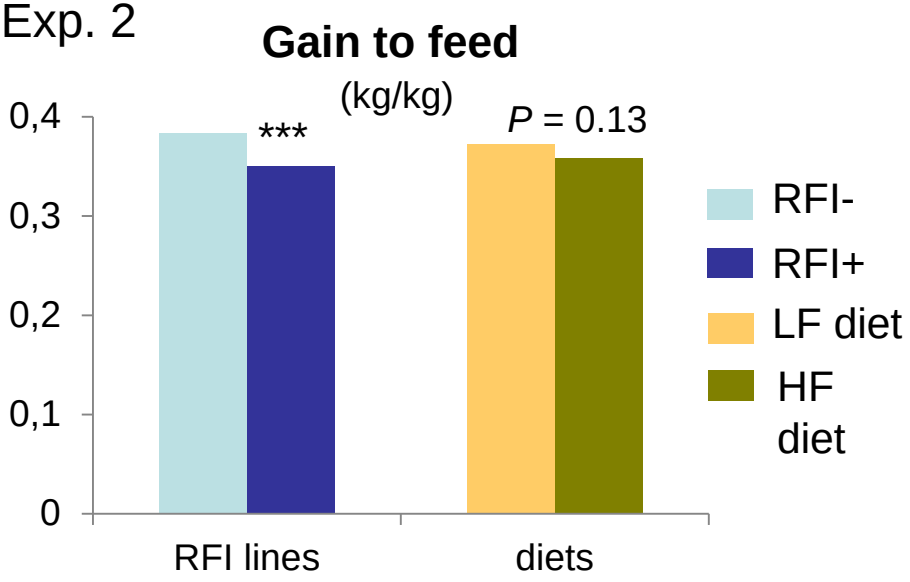
Electron chain transport (7 genes)

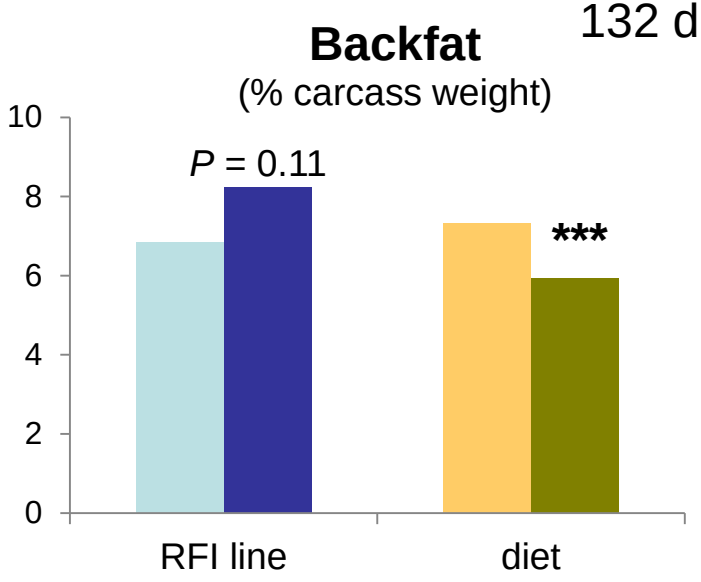
***50% of gene transcripts encoding mitochondrial proteins are decreased with the onset of obesity (= adipose tissue development) in mice** *(Wilson-Fritch et al., 2004)*

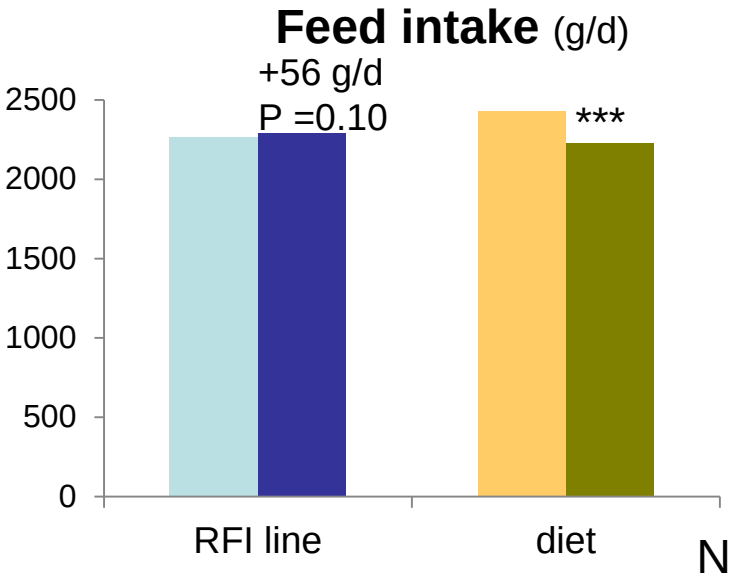
- Results: Low lipolysis and down-regulation of mitochondrial energy-yielding pathways in RFI+ pigs

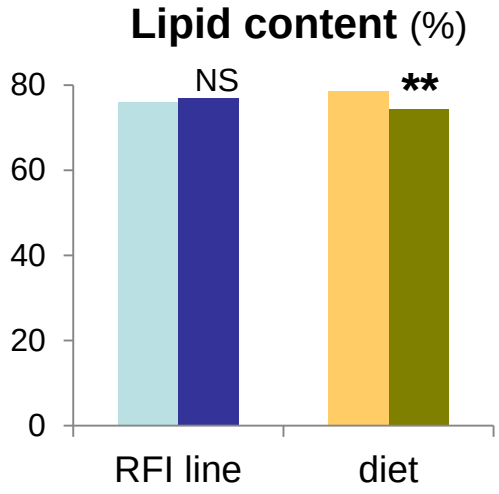
Exp. 2

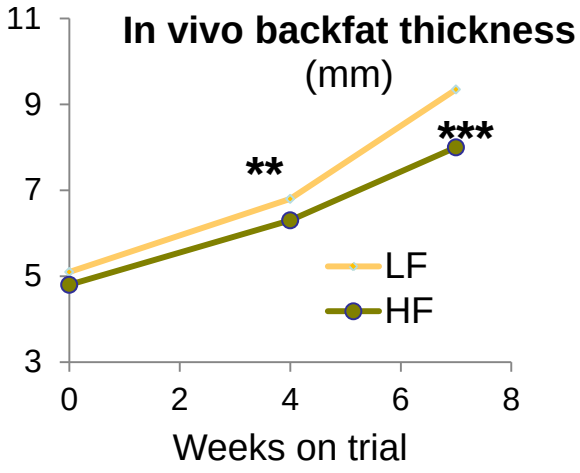
132 d of age









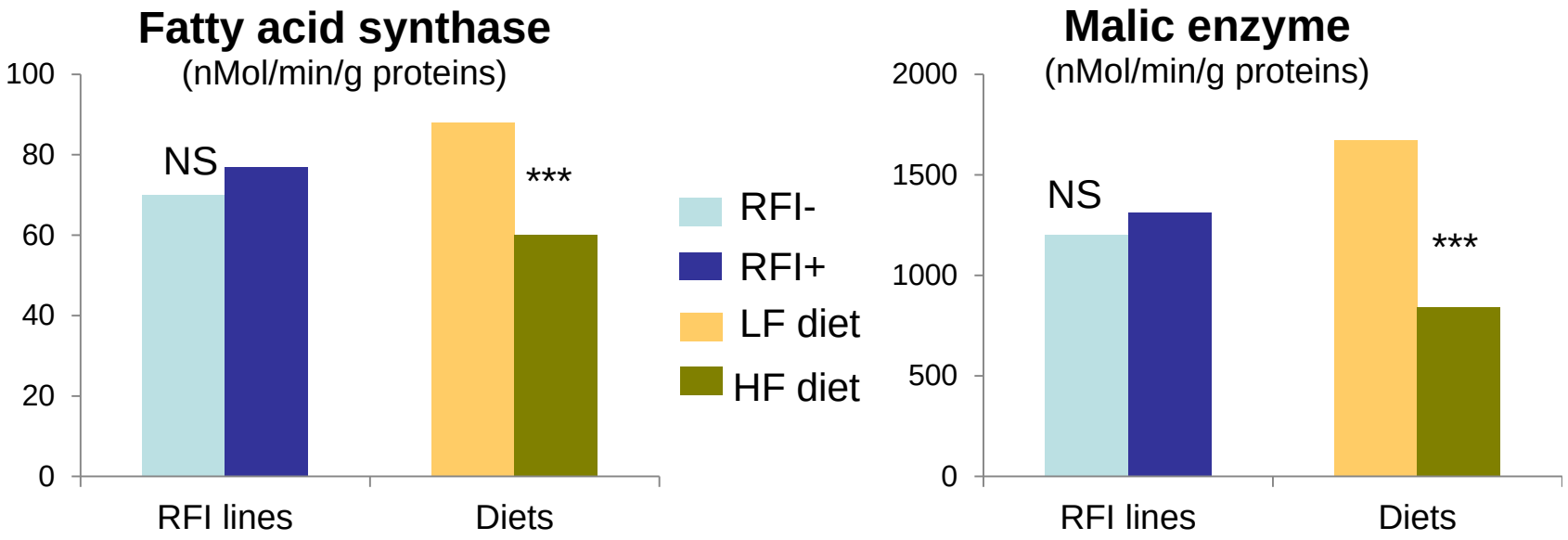


N = 12 pigs/group

- Results: Irrespective of line, pigs fed diet HF are leaner, because they eat less …(no line x diet interactions on pig performance)

Exp. 2 Specific activities of lipogenic enzymes were monitored in subcutaneous adipose tissue

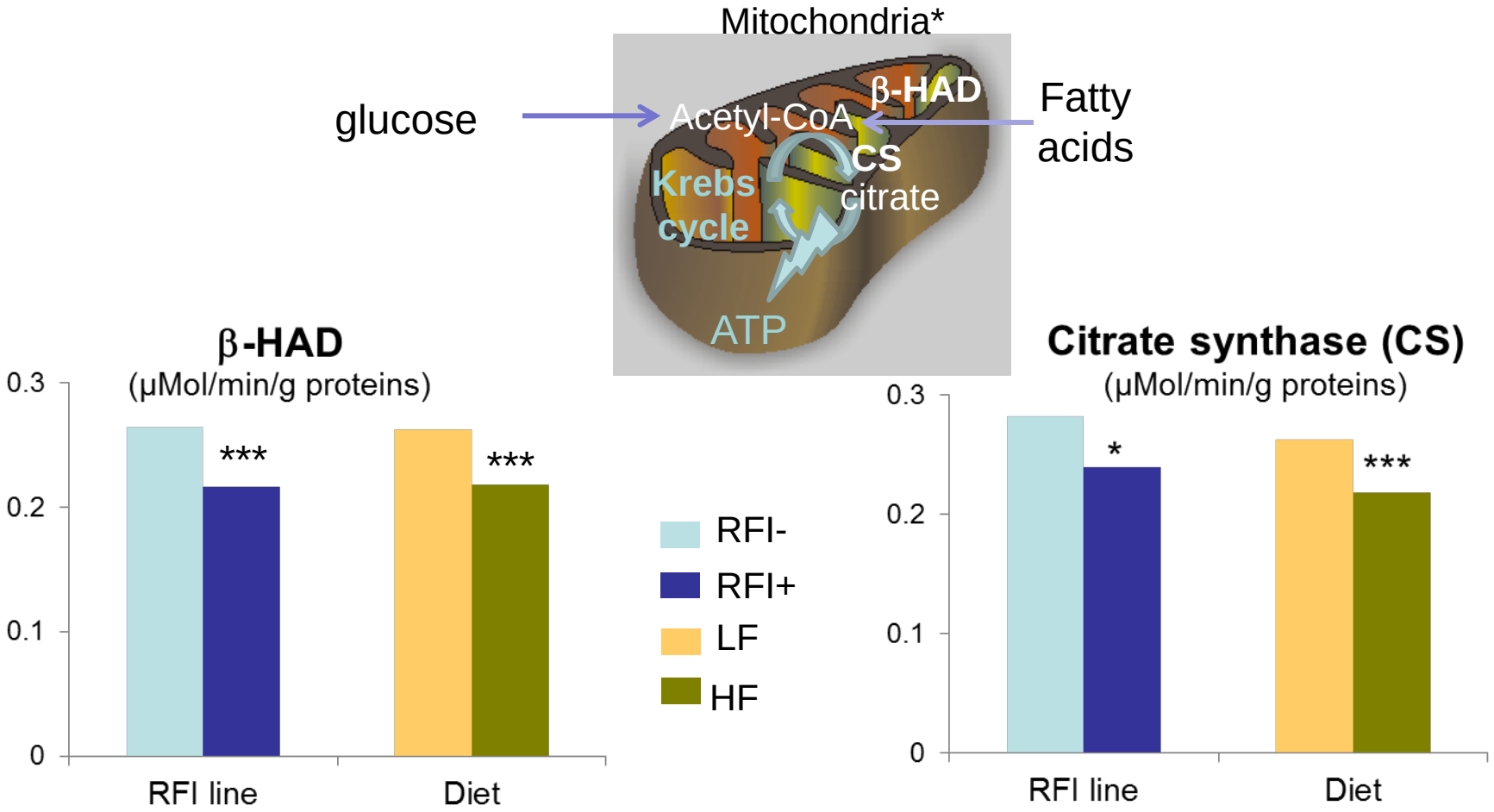
Glucose --------> fatty acids



HF diet: high fat and high fiber contents
LF diet: rich in starch (carbohydrates)

- Results (exp. 2): no differences between lines in lipogenic activities, which were reduced when fed diet HF compared with diet LF

Exp. 2 Specific mitochondrial enzyme activities were monitored in backfat



***Mitochondrial remodeling is associated with the onset of obesity (= adipose tissue development) in mice** *(Wilson-Fritch et al., 2004)*

- Results: RFI+ pigs had lower mitochondrial catabolic enzyme activities in adipose tissue, and this was accentuated when fed diet HF

- Feed efficiency and body fat phenotype are not strictly related. This depends on feed intake and diet composition

  ↳ Pigs eating more (e.g.; RFI+ line, diet LF) are fatter

- The selection for RFI did not change the potential for lipid synthesis (gene expression, enzyme activities) in adipose tissue

- The less genetically-efficient pigs showed a down-regulation in mitochondrial catabolism for energy generation in adipose tissue

  ↳ Mitochondrial pathways, which have been largely ignored in adipose tissue, must be considered in future studies

Conclusions

Acknowledgements

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)
- Program FatInteger (ANR-SVSE7-004)