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

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Adipose tissue triggers the efficiency of pig production

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

- Fatty animals are generally less efficient

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

But this is not always true!
To clarify the relationships between adipose tissue and feed efficiency in growing pigs

Body fat = genetics + environment

- 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
EXPERIMENT 1

All pigs were reared in individual cases in growing-finishing periods.

EXPERIMENT 2

2 contrasted diets fed ad libitum during 10 weeks.

Slaughtered at the same BW and age.

• Experimental design overview
Exp. 2

**LF diet**
- High starch
- Low fat (2%)

**HF diet**
- High fibers
- High fat (7%)

<table>
<thead>
<tr>
<th>Ingredients, %</th>
<th>LF</th>
<th>HF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude proteins</td>
<td>17.0</td>
<td>17.0</td>
</tr>
<tr>
<td>Fat</td>
<td>2.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Starch</td>
<td>46</td>
<td>33</td>
</tr>
<tr>
<td>Cellulose</td>
<td>1.0</td>
<td>2.2</td>
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<tr>
<td>NDF</td>
<td>12.0</td>
<td>19.0</td>
</tr>
<tr>
<td>ADF</td>
<td>3.6</td>
<td>8.2</td>
</tr>
</tbody>
</table>

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.

• Data on adipose tissue concerned:
  - Tissue lipid content
  - Specific activities of key enzymes
  - High-throughput put transcriptomic analysis

Agilent, 44 K porcine pan-genomic oligo microarray
**Exp. 1**

**Gain to Feed (kg/kg)**
- RFI-: 0.4
- RFI+: 0.3
- RFI+R: 0.4

**Backfat (% carcass weight)**
- RFI-: 6
- RFI+: 8
- RFI+R: 6

**Feed intake (g/d)**
- RFI-: 2500
- RFI+: 3000
- RFI+R: 2500

-19% of voluntary feed intake

**Lipid content (%)**
- RFI-: 80
- RFI+: 80
- RFI+R: 80

**Adipocyte diameter (µm)**
- RFI-: 100
- RFI+: 120
- RFI+R: 100

- Results: RFI+ pigs are fatter because they eat more
Transcriptomic analysis of subcutaneous adipose tissue

\( \sim 600 \) DE-probes \((P < 0.01)\) between RFI- and RFI+ pigs

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.
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-Fritich et al., 2004)

Results: Low lipolysis and down-regulation of mitochondrial energy-yielding pathways in RFI+ pigs
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
Specific mitochondrial enzyme activities were monitored in backfat.

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

*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.
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