EFFICIENT & ECOLOGICALLY-FRIENDLY PIG AND POULTRY PRODUCTION.

A WHOLE-SYSTEMS APPROACH TO OPTIMISING FEED EFFICIENCY AND REDUCING THE ECOLOGICAL FOOTPRINT OF MONOGASTRICS.

BASIC DATA

Funding:
EU-FP7
(€ 6 million)

Start date:
1 February 2013

Duration:
48 months
(2013 to 2016)
ECO-FCE: Effect of early artificial rearing and milk replacer supplementation on growth of pigs (carcass and meat quality traits)

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• Results
  • Pre-weaning survival rate and growth
  • Post-weaning growth
  • Carcass and meat quality traits
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Background

- Low birth weight pigs (L-BtW) are a concern in modern pig production because of:
  - Lower pre-weaning survival rate
  - Lower feed efficiency
  - Impaired carcass and meat quality

Feeding strategies in early life

Impaired myofiber hyperplasia

Berard et al., 2011

The ECO-FCE project is funded by the European Union Seventh Framework Programme (FP7 2007/2013) under grant agreement No. 311794.
Background

- **Survival, growth and hyperplasia is impaired in L-BtW piglets**
  - Consequence of increased litter size resulting in intra-uterine growth restriction (IUGR)

- **Choice of supplementation based on previous studies**
  - L-arginine (Kim and Wu, 2004, Yao et al., 2008)
    - Promotes: Survival, growth and protein synthesis
  - L-carnitine (Lösel et al., 2009; Keller et al., 2011)
    - Promotes: Post natal myofiber hyperplasia in L-BtW piglets
Study objectives

• Objective
  • Improve production efficiency by:
    • Increasing survival
    • Enhancing postnatal myofiber hyperplasia
    • Increasing growth rate

• Alternative to conventional rearing
  • Nursing sow strategies
  • Early artificial rearing in rescue decks
    • Large littermates, whole litter or L-BtW piglets

Modified from Amdi et al., 2015

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Materials and Methods

All piglets born from hyperprolific sows (>15 born/litter) with a BtW < 1.2 kg
• 48 piglets were artificially reared from d 7-28 of age
• 24 piglets were conventionally reared piglets by their dam sow for 28 d (SOW)

Artificial rearing:
• **Ctrl**: Commercial milk replacer (20.5% protein, 9.5% fat, 18.6 GE MJ/kg DM)
• **CarArg**: Commercial milk replacer supplemented with **0.05% L-carnitine + 1.67% L-arginine**

After weaning:
• Ctrl, CarArg and SOW pigs were fed standard weaning, grower and finisher diet till slaughter at 170 d of age
Materials and Methods

- Traits of interest:
  - Pre-weaning growth
  - Post-weaning growth
    - BW at slaughter (d 170)
    - Daily gain (ADG), feed intake (ADFI), feed efficiency (G:F)
  - Carcass traits
    - Hot and cold carcass weight
    - Lean meat percentage
  - Meat quality traits
    - Drip loss, 24h
Results: Pre-weaning survival and growth

- Low weaning weight -> low DM content of milk replacer
- 0% mortality of artificially reared piglets
- 8% mortality from d 7-28 in the sow herd (loose-housed system)
Results: Post-weaning performance

- No effect on slaughter weight (6 kg difference Ctrl vs. CarArg and Sow)
- Large variation within groups
Results: Post-weaning performance

No difference between groups
Results: Eating behavior

Eating behavior does not explain the difference in final slaughter weight

The ECO-FCE project is funded by the European Union Seventh Framework Programme (FP7 2007/2013) under grant agreement No. 311794.
Results: Carcass traits

- No difference between groups
- Within the artificially reared groups, CarArg tended to increase carcass weight
Results: Meat quality traits

Lower water holding capacity in the Ctrl group (0.05 ≤ P < 0.10)
Conclusions

• Improved survival rate of L-BtW piglets from d 7-28

• No clear supplemental effect on pre- and post weaning growth

• Growth performance of L-BtW is not compromised by artificial rearing

• Selected meat quality traits are not compromised in the CarArg group
Perspectives

• Milk replacer needs optimization
  • Dry matter, protein and fat content, plus amino acid and fatty acid composition needs adjustment
  • Is the assumption correct that sow milk is optimal for L-BtW piglets?

• Considering earlier artificial rearing
  • In some countries rearing d 3 is allowed
  • Survival rate lowest first four days after farrowing
  • L-BtW piglets most vulnerable
Thank you for your interest
Exp. 1

- 3 week trial:
  - Restricted feeding
  - Day 7 – 28.
  - Piglets weighed weekly and feed intake measured daily.
- Slaughtered day 28:
  - Blood samples
  - Carcass composition
  - Organ weights
  - Collecting Semitendinosus muscle:
    - Myofiber number and size (histology)
    - Energy metabolism in muscle (enzym activity)
    - Gene expression analysis of myogenic- and proteasome related genes.

### Ingredients, %

<table>
<thead>
<tr>
<th></th>
<th>CTRL</th>
<th>CAR</th>
<th>ARG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whey powder</td>
<td>61.6</td>
<td>61.6</td>
<td>61.6</td>
</tr>
<tr>
<td>Whole milk protein</td>
<td>28.0</td>
<td>28.0</td>
<td>28.0</td>
</tr>
<tr>
<td>Milk protein</td>
<td>6.2</td>
<td>6.2</td>
<td>6.2</td>
</tr>
<tr>
<td>L-arginine, g/kg BW · piglet⁻¹ · d⁻¹</td>
<td>-</td>
<td>-</td>
<td>1.08</td>
</tr>
<tr>
<td>L-carnitine, g piglet · d⁻¹</td>
<td>-</td>
<td>0.40</td>
<td>-</td>
</tr>
</tbody>
</table>

### Analyzed composition, % DM

<table>
<thead>
<tr>
<th></th>
<th>CTRL</th>
<th>CAR</th>
<th>ARG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross energy, MJ/kg DM</td>
<td>17.9</td>
<td>17.9</td>
<td>17.9</td>
</tr>
<tr>
<td>Crude protein</td>
<td>21.1</td>
<td>21.1</td>
<td>21.1</td>
</tr>
<tr>
<td>Crude fat</td>
<td>7.8</td>
<td>7.8</td>
<td>7.8</td>
</tr>
</tbody>
</table>
Results Exp. 1

Key enzyme for following pathways
Citric acid cycle activity
  • Citrate synthase (CS)
Lipid oxidation
  • β-hydroxyacyl-CoA dehydrogenase (HAD)
Glycolytic capacity
  • Lactate dehydrogenase (LDH)

The LDH:CS and LDH:HAD = markers for muscle maturity -> reflect the relative importance of glycolytic compared to oxidative metabolism in muscle.

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dark portion</td>
<td></td>
</tr>
<tr>
<td>CS ($\times 10^{-2}$)</td>
<td>0.428&lt;sup&gt;y&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDH</td>
<td>0.930&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDH:HAD</td>
<td>3.63&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDH:CS</td>
<td>228.84&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Light portion</td>
<td></td>
</tr>
<tr>
<td>CS ($\times 10^{-2}$)</td>
<td>0.405&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDH</td>
<td>1.255&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDH:HAD</td>
<td>7.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>LDH:CS</td>
<td>321.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Conclusion Exp. 1 -> Changes for Exp. 2

- Both supplements positively affect muscle maturation in early life

- No effects of supplements on growth performance and carcass composition
  - Low weaning weight
  - Restricted intake?

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Results Exp. 2

Increase by 30% compared to Exp. 1

Body weight development

<table>
<thead>
<tr>
<th></th>
<th>BtW</th>
<th>d 7</th>
<th>d 28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight, kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

mTOR phosphorylation STM₁

Different superscripts “a” and “b” marks significant difference (P < 0.05) between bars.

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Conclusion Exp. 2

• Compared to Exp. 1, *ad libitum* feeding improves growth and weaning weight

• Molecular effect of supplementation
  • Increased activation of protein synthesis pathway.

• No clear indication that one of the two supplements has an advantage over the other (CAR ↔ ARG)
### Exp. 3

**Optimize milk replacer**

<table>
<thead>
<tr>
<th>Ingredients, %</th>
<th>Sow milk</th>
<th>Exp. 1 &amp; 2</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whey powder</td>
<td>-</td>
<td>61.6</td>
<td>-</td>
</tr>
<tr>
<td>Whole milk protein</td>
<td>-</td>
<td>28.0</td>
<td>-</td>
</tr>
<tr>
<td>Milk protein</td>
<td>-</td>
<td>6.2</td>
<td>26.5</td>
</tr>
<tr>
<td>Butter powder, 75% fat</td>
<td>-</td>
<td>-</td>
<td>51.0</td>
</tr>
<tr>
<td>Glucose</td>
<td>-</td>
<td>1.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

**Analyzed composition, as fed**

<table>
<thead>
<tr>
<th></th>
<th>Sow milk</th>
<th>Exp. 1 &amp; 2</th>
<th>Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter, %</td>
<td>~ 20.0</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Gross energy, MJ</td>
<td>5.5</td>
<td>3.6</td>
<td>5.5</td>
</tr>
<tr>
<td>Crude protein</td>
<td>56.0</td>
<td>42.2</td>
<td>63.2</td>
</tr>
<tr>
<td>Crude fat</td>
<td>83.2</td>
<td>15.6</td>
<td>81.2</td>
</tr>
</tbody>
</table>
Exp. 3

• **Rearing with optimized milk replacer**
  • Massive diarrhea, low growth -> experiment terminated.

• **Speculations regarding diarrhea**
  • DM, protein and/or fat content too high.
Preliminary results of Exp. 4

Pre and post weaning growth of artificially reared piglets (preliminary results)

<table>
<thead>
<tr>
<th>Item</th>
<th>Dietary treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CTRL</td>
</tr>
<tr>
<td>Pre weaning</td>
<td></td>
</tr>
<tr>
<td>Birth weight, kg</td>
<td>1.037</td>
</tr>
<tr>
<td>BW day 7, kg</td>
<td>1.769</td>
</tr>
<tr>
<td>BW day 28, kg</td>
<td>4.343</td>
</tr>
<tr>
<td>ADG d 7-28, kg/d</td>
<td>0.123</td>
</tr>
<tr>
<td>ADFI d 7-28, kg DM/d (pair)</td>
<td>0.273</td>
</tr>
<tr>
<td>Post weaning (PW)</td>
<td></td>
</tr>
<tr>
<td>BW 1 month PW</td>
<td>10.1</td>
</tr>
<tr>
<td>BW 2 month PW</td>
<td>24.5</td>
</tr>
<tr>
<td>ADG Weaning-2 month PW, kg/d</td>
<td>0.338</td>
</tr>
</tbody>
</table>

Length of the large intestine

CTRL CarArg
Results: Organ weights and enzyme activity d 28

- Stomach and liver weight greater in Ctrl piglets. * ($P < 0.05$).
- Greater CS and LDH activity in STM of CarArg pigs ($P < 0.05$).