Early-life fructooligosaccharides supplementation changes later pig immune and growth response

Emmanuelle Apper (1), Christine Meymerit (2), Jean-Christophe Bodin (3), Frédérique Respondek (1)

(3) Jefo Europe, 2 Rue Claude Chappe, 44470 Carquefou, France
(2) Interface Elevage, Route de Pau, 64 410 Vignes, France
(1) Tereos Syral, Z.I. et Portuaire, B.P. 32, 67390 Marckolsheim, France
What are short-chain Fructo-Oligo-Saccharides (scFOS)?

- Non viscous and soluble fibre defined as prebiotic
- Obtained from sugar beet, by a bioenzymatic reaction:

“A dietary prebiotic is a selectively fermented ingredient that results in specific changes, in the composition and/or for activity in the gastrointestinal microbiota, thus conferring benefit(s) upon host health” (ISAPP, 2008)
scFOS in early-life: recent insights

Le Bourgot et al., in press, PlosOne:

Long-time effect on immunity and performance?
Immupig in farm: objectives

To investigate in a commercial farm:

- Effects of a scFOS dietary supplementation on
  - reproductive performance of sows

- Effects of a scFOS early dietary supplementation on
  - adaptative immunity of weaning piglets
  - performance of pigs from birth to slaughtering
Materials and methods

Sows: n=65/group, 2 replicates

Maltodextrins 10 g/d

scFOS 10 g/d

Gestation: 5 days  
Lactation: 21 days

Post-weaning

Common conventional diets

Farrowing  
Weaning

Slaughtering

Reproductive performance: present cycle and cycle n+1 → ANOVA and ANCOVA

Age, fat and muscle percentage at slaughtering → ANOVA

Blood specific IgG titration → FCA

Colostrum D0, n = 30

Vaccin D49, n = 40

Vaccin D70

Serum D48  
Serum D70  
Serum D91
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scFOS improve reproductive performance of sows

- No effect on litter characteristics but:

<table>
<thead>
<tr>
<th></th>
<th>CTRL</th>
<th>scFOS</th>
<th>SD</th>
<th>scFOS effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farrowing duration, h</td>
<td>3.23</td>
<td>2.59</td>
<td>1.18</td>
<td>0.01</td>
</tr>
<tr>
<td>Backfat thickness at weaning, mm*</td>
<td>14.1</td>
<td>14.9</td>
<td>4.40</td>
<td>0.09</td>
</tr>
<tr>
<td>Prolificity on the next reproductive cycle</td>
<td>14.9</td>
<td>16.2</td>
<td>3.31</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Positive indicators of health of sows

Trend for more born piglets on the next reproductive cycle

* Result also observed by Le Bourgot et al., in press

Potential effects of scFOS on Intestinal transit? On insulin resistance of sows?
**scFOS do not modify immune quality of colostrum**

<table>
<thead>
<tr>
<th>Item</th>
<th>Diet</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CTRL</td>
<td>scFOS</td>
</tr>
<tr>
<td>Number of sows</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>IgG, mg/mL</td>
<td>72.6</td>
<td>78.8</td>
</tr>
<tr>
<td>IgA, mg/mL</td>
<td>10.1</td>
<td>10.9</td>
</tr>
</tbody>
</table>

- Not in accordance with Le Bourgot et al. (in press)
- Supplementation duration at the end of gestation (5 vs 28 days)?
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The immune response after vaccination of piglets fed with scFOS is stimulated.

D91-D48: Chi-square: $p = 0.05$; No effect of sow supplementation.

Higher titration: immune response is boosted.

Lower titration:

- Piglets fed scFOS are associated with higher titration.
- Piglets fed CTRL are associated with lower titration.

Titration method: indirect hemagglutination.
The immune response after vaccination of piglets fed with scFOS is stimulated.

Le Bourgot et al., 2013

**Specific anti-flu IgG**

Le Bourgot et al., 2013

Relationship between immune response and Lactobacilli in mice

Vos et al., 2010

**Fig. 3.** Partial correlation plot of the cecal lactobacilli and the DTH response. The relationship between the relative amount of cecal lactobacilli and the magnitude of the DTH response, corrected for antigen dose and supplementation group, was visualized by plotting the residuals of both parameters against each other.
The immune response after vaccination of piglets fed with scFOS is stimulated

Weaning diet
Vaccine

CTRL scFOS
CTRL scFOS
Δ (DO)

Specific anti-flu IgG

*, p < 0.05

Le Bourgot et al., 2013

Increased SCFA in caecum of pigs when their dams fed scFOS

Le Bourgot et al., in press

scFOS
Microbiota
Immune response ??
Immupig in farm: objectives

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  - performance of pigs from birth to slaughtering
Early-life supplementation with scFOS affects performance at slaughtering

(N = 769) Treatments

<table>
<thead>
<tr>
<th>Item</th>
<th>CTRL/CTRL</th>
<th>CTRL/scFOS</th>
<th>scFOS/CTRL</th>
<th>scFOS/scFOS</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at slaughtering, d.</td>
<td>191.6a</td>
<td>185.0b</td>
<td>186.5b</td>
<td>184.1c</td>
<td>5.48</td>
</tr>
<tr>
<td>Muscle, %</td>
<td>63.9</td>
<td>65.1</td>
<td>63.7</td>
<td>64.6</td>
<td>0.32</td>
</tr>
<tr>
<td>Fat*, %</td>
<td>16.2</td>
<td>15.9</td>
<td>16.7</td>
<td>16.0</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Not same metabolic pathways between maternal and young scFOS supplementation?

* Piglet scFOS: P = 0.064

Sustainable effects of early-life nutrition with scFOS

→ epigenetic modifications?

→ Importance of early colonisation of microbiota?

Apper et al., submitted in JAPAN
Immupig in farm: conclusions

- Dietary scFOS supplementation tend to improve physiological status of sows
- Dietary scFOS supplementation in early life of piglets
  - Boosts adaptative immune response of weaning piglets
  - Increases performance of pigs at slaughtering
- Mechanisms involved remain unclear but are probably related to precoce microbiota colonisation and epigenetic effect
Thank you for your attention!

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Questions?
Importance of *peri-partum* nutrition for the entire life

Early nutrition

Epigenetic

Protein deprivation

Diseases, growth performance, ...

Disturbance of glucose tolerance (Zambrano et al., 2006)
Greater proliferation rate of adipocytes (Bol et al., 2008)

No data on prebiotic short-chain fructooligosaccharides
## Diets used in the experiment

<table>
<thead>
<tr>
<th>Item</th>
<th>Gestation diet</th>
<th>Lactation diet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chemical Analysis, % as DM</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>15.9</td>
<td>19.8</td>
</tr>
<tr>
<td>Fat</td>
<td>3.0</td>
<td>4.8</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>6.8</td>
<td>3.5</td>
</tr>
<tr>
<td>Ash</td>
<td>6.5</td>
<td>8.0</td>
</tr>
<tr>
<td>DM, % as fed</td>
<td>87.3</td>
<td>87.4</td>
</tr>
<tr>
<td>DE, MJ/kg of DM</td>
<td>15.0</td>
<td>16.4</td>
</tr>
<tr>
<td>Lys</td>
<td>0.70</td>
<td>1.16</td>
</tr>
<tr>
<td>Daily allowance, kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d 1 to d 36:</td>
<td>3.0</td>
<td>Ad libitum</td>
</tr>
<tr>
<td>d 37 to d 80:</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>d 81 to d 112:</td>
<td>3.5</td>
<td></td>
</tr>
</tbody>
</table>
## Diets used in the experiment

<table>
<thead>
<tr>
<th>Period</th>
<th>Pre-starter</th>
<th>Starter</th>
<th>Pre-growing</th>
<th>Growing</th>
<th>Finishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of pigs, day</td>
<td>20-40</td>
<td>41-64</td>
<td>65-103</td>
<td>104-148</td>
<td>148-Slaughter</td>
</tr>
<tr>
<td>DM, % as fed</td>
<td>88.7</td>
<td>86.9</td>
<td>87.0</td>
<td>87.2</td>
<td>86.9</td>
</tr>
</tbody>
</table>

### Chemical Analysis, % as DM

<table>
<thead>
<tr>
<th>Component</th>
<th>Pre-starter</th>
<th>Starter</th>
<th>Pre-growing</th>
<th>Growing</th>
<th>Finishing</th>
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<tr>
<td>CP</td>
<td>21.0</td>
<td>21.4</td>
<td>20.9</td>
<td>19.8</td>
<td>18.8</td>
</tr>
<tr>
<td>Fat</td>
<td>7.4</td>
<td>2.0</td>
<td>2.7</td>
<td>3.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>4.0</td>
<td>4.2</td>
<td>4.5</td>
<td>5.6</td>
<td>4.4</td>
</tr>
<tr>
<td>Ash</td>
<td>8.0</td>
<td>7.5</td>
<td>6.5</td>
<td>6.1</td>
<td>5.9</td>
</tr>
<tr>
<td>DE, MJ/kg of DM</td>
<td>16.7</td>
<td>15.2</td>
<td>15.3</td>
<td>15.3</td>
<td>15.6</td>
</tr>
<tr>
<td>NE, MJ/kg of DM</td>
<td>11.8</td>
<td>10.7</td>
<td>10.8</td>
<td>10.9</td>
<td>11.2</td>
</tr>
<tr>
<td>Lys</td>
<td>1.59</td>
<td>1.40</td>
<td>1.20</td>
<td>1.11</td>
<td>0.94</td>
</tr>
<tr>
<td>Daily allowance, kg</td>
<td>0.38</td>
<td>0.92</td>
<td>1.75</td>
<td>2.60</td>
<td>2.45</td>
</tr>
</tbody>
</table>
Results:
Immune quality of colostrum and milk

- Increased IgA (+plgR) level: Swanson et al., 2002; Hosono et al., 2003; Nakamura et al., 2004
- Increased B-cell, plasmocyte level: Manhart et al., 2003
- Increased mammary specific receptors, homing: Salmon et al., 2009
- Increased plasmocyte level: Salmon et al., 2009
- Increased IgA level: Le Jan, 1993

scFOS bibliography
General immune bibliography