LCA results on a low emission farming concept in highly integrated pig and poultry production

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Future sustainability of food value chain depends on three dimensions of innovation

- **Ecological Footprint**
  - Low Emission

**Sustainable Nutrition**

- Modern nutrition concepts (SID, NE)
- Improved livestock and manure management
- Low protein diets

**Efficiency**

- Least cost feed formulation
- Feed/protein optimization
- Nutrient utilization
- Efficient ingredients

**Food Quality and Safety**

- Animal welfare
- Gut health solution concepts
- Save and healthy food chain
- Performance and nutritional additives

- Population growth
- Affordable protein

- End-consumer needs
- Food ethics
Environmental Impact Categories most relevant and critical for livestock

- Climate change
  - Global Warming Potential
- Energy and resource efficiency
  - Primary Energy Demand
- Air, Soil and Water Quality
  - Excretion of excess nitrogen and phosphorus leading to eutrophication
  - Ammonia emissions largely responsible for acidification (fish mortality, forest decline, biodiversity)
- Land use, Land use change
- Water footprint
- Biodiversity
Low Emission Farm – a concept to lower the environmental footprint of animal farms

Basic idea:
Combination of

- **NUTRIENT** management
- **EMISSION** and **WASTE** management
- Recycling of energy and increased energy efficiency
- Closed Nutrient Cycle
- Additional use of further processed as P / N – fertilizer on farm level
- Additional business opportunities
Low protein and low phosphor diets – the nutrition part of LEF

• High protein diets are imbalanced in the amino acid profile

• Supplementing feed amino acids (AA) restore the imbalance and leads to crude protein (CP) reduction

• CP reduction lowers nitrogen content in excreted manure (~10% by 1% lower CP)

• CP reduction lowers water consumption of animals and thus manure volume (~3-5% by 1% lower CP)

• Phytase reduces phosphorus excretion by up to 60% and saves finite mineral phosphate sources
The LEF Concept – combining state of the art management of nutrients, emissions and energy and creating new business opportunities

- Animal House
- Private Housing
- Local Industry
- Heat / Electricity
- Raw CH₄
- Biogas Fermenter
- Co-ferments
- Manure
- Green H₂
- Compressing
- Pure CH₄
- Gas Storage Bottles
- Gas Storage Tanks
- BG Fuel
- BG CH₄
- Independent local Infrastructure
- BG CHP
1 t of average pig feed calculated according to the composition of diets (gestation, lactation, pre-starter, starter, growing, finishing) (see SFIS-report IFIF 2015)

<table>
<thead>
<tr>
<th>Composition in kg/t</th>
<th>A1 AA / -Ph</th>
<th>A2 +AA / -Ph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>344.39</td>
<td>381.51</td>
</tr>
<tr>
<td>Corn</td>
<td>145.60</td>
<td>143.47</td>
</tr>
<tr>
<td>Barley</td>
<td>213.82</td>
<td>288.10</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>11.03</td>
<td>21.98</td>
</tr>
<tr>
<td>Rapeseed meal</td>
<td>3.26</td>
<td>54.35</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>232.29</td>
<td>67.13</td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>6.93</td>
<td>2.99</td>
</tr>
<tr>
<td>Extruded soybean grain</td>
<td>8.72</td>
<td>0.16</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.00</td>
<td>4.04</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.00</td>
<td>1.44</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.00</td>
<td>0.42</td>
</tr>
<tr>
<td>Tryptophane</td>
<td>0.00</td>
<td>0.22</td>
</tr>
<tr>
<td>Phytase</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Mono-calcium phosphate</td>
<td>6.94</td>
<td>7.01</td>
</tr>
<tr>
<td>Salt</td>
<td>4.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>15.61</td>
<td>15.78</td>
</tr>
<tr>
<td>Vitamin premix</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Dried whey</td>
<td>2.41</td>
<td>2.41</td>
</tr>
</tbody>
</table>
Nutritional information for 1 ton of average pig feed, calculated according to the composition of diets (gestation, lactation, pre-starter starter, growing, finishing) (see SFIS-report IFIF 2015)

<table>
<thead>
<tr>
<th>Content</th>
<th>Unit</th>
<th>A1 -AA/-Ph</th>
<th>A2 +AA/-Ph</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCR (fattening)</td>
<td>kg/kg</td>
<td>2.75</td>
<td>2.75</td>
</tr>
<tr>
<td>Crude protein</td>
<td>kg/t</td>
<td>180.8</td>
<td>138.4</td>
</tr>
<tr>
<td>Total P</td>
<td>kg/t</td>
<td>5.39</td>
<td>5.40</td>
</tr>
<tr>
<td>DE</td>
<td>kcal/kg</td>
<td>3255</td>
<td>3147</td>
</tr>
<tr>
<td>ME</td>
<td>kcal/kg</td>
<td>3107</td>
<td>3026</td>
</tr>
<tr>
<td>NE</td>
<td>kcal/kg</td>
<td>2298</td>
<td>2298</td>
</tr>
<tr>
<td>Digestible lysine (SID)</td>
<td>kg/t</td>
<td>7.83</td>
<td>7.80</td>
</tr>
<tr>
<td>Digestible P (Apparent)</td>
<td>kg/t</td>
<td>2.48</td>
<td>2.48</td>
</tr>
</tbody>
</table>
1 ton of average feed for broilers, calculated according to the composition of diets (pre-starter, starter, finisher) (see SFIS-report IFIF 2015)

<table>
<thead>
<tr>
<th>Composition in kg/t</th>
<th>A1 -AA/-Ph</th>
<th>A2 +AA/-Ph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>0.00</td>
<td>453.95</td>
</tr>
<tr>
<td>Maize</td>
<td>392.23</td>
<td>242.01</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>27.63</td>
<td>0.00</td>
</tr>
<tr>
<td>Rapeseed meal</td>
<td>77.07</td>
<td>17.79</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>448.75</td>
<td>223.26</td>
</tr>
<tr>
<td>Rapeseed oil</td>
<td>20.00</td>
<td>20.00</td>
</tr>
<tr>
<td>Lysine</td>
<td>0.00</td>
<td>2.65</td>
</tr>
<tr>
<td>Threonine</td>
<td>0.00</td>
<td>0.69</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.00</td>
<td>1.93</td>
</tr>
<tr>
<td>Phytase</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Mono-calcium phosphate</td>
<td>10.64</td>
<td>11.03</td>
</tr>
<tr>
<td>Salt</td>
<td>3.76</td>
<td>3.61</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.00</td>
<td>0.40</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>14.93</td>
<td>17.70</td>
</tr>
<tr>
<td>Vitamin Premix</td>
<td>5.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>
Nutritional information for 1 ton of average broiler feed, calculated according to the composition of diets (pre-starter, starter, finisher) (see SFIS-report IFIF 2015)

<table>
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<tr>
<th>Content</th>
<th>Unit</th>
<th>A1 -AA/-Ph</th>
<th>A2 +AA/-Ph</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCR</td>
<td>kg/kg</td>
<td>2.01</td>
<td>1.85</td>
</tr>
<tr>
<td>Crude protein</td>
<td>kg/t</td>
<td>265.12</td>
<td>178.55</td>
</tr>
<tr>
<td>Total P</td>
<td>kg/t</td>
<td>7.29</td>
<td>6.10</td>
</tr>
<tr>
<td>ME</td>
<td>kcal/kg</td>
<td>2831</td>
<td>3082</td>
</tr>
<tr>
<td>Digestible lysine</td>
<td>kg/t</td>
<td>13.37</td>
<td>9.70</td>
</tr>
<tr>
<td>Digestible methionine</td>
<td>kg/t</td>
<td>3.74</td>
<td>4.38</td>
</tr>
<tr>
<td>Digestible methionine + Cysteine</td>
<td>kg/t</td>
<td>7.62</td>
<td>7.27</td>
</tr>
<tr>
<td>Digestible threonine</td>
<td>kg/t</td>
<td>9.19</td>
<td>6.30</td>
</tr>
<tr>
<td>Digestible tryptophane</td>
<td>kg/t</td>
<td>2.81</td>
<td>1.85</td>
</tr>
</tbody>
</table>
Cradle to gate LCA including manure effects using GaBi data sets

1st approach: use IPCC data for emissions

Emissions from storage

- \( \text{NH}_3 \)
- \( \text{N}_2\text{O} \)
- \( \text{CH}_4 \)

Influencing factors

- Time of storage
- Temperature
- Climate zone
- Covered/uncovered MMS
- Natural crust cover
- Liquid/solid storage / mixing regime
- Rainfall, weather
- Soil type
- Crops / plants on field
- Residue composition
- Application technology/spreading
- Seasonal point of manure application

Emissions from field application

- \( \text{NH}_3 \)
- \( \text{N}_2\text{O} \)
- \( \text{CH}_4 \)
- \( \text{NO}_3 \)
GWP reduction potential by using amino acids and different biogas options: Pigs

GWP (100) excl. biogenic carbon [kg CO₂e/1.000 kg live weight] incl. dLUC emissions

- Pig ref.: 3.599 kg CO₂e/1.000 kg live weight
- Pig AA: 1.944 kg CO₂e/1.000 kg live weight
- Pig BG CHP: 1.944 kg CO₂e/1.000 kg live weight
- Pig BG CH4: 1.944 kg CO₂e/1.000 kg live weight
- Pig BG fuel: 1.944 kg CO₂e/1.000 kg live weight

Comparison with Pig ref.:
- Pig AA: -176 kg CO₂e/1.000 kg live weight
- Pig BG CHP: -143 kg CO₂e/1.000 kg live weight
- Pig BG CH4: -143 kg CO₂e/1.000 kg live weight
- Pig BG fuel: -185 kg CO₂e/1.000 kg live weight

-GWP reduction potential by using amino acids and different biogas options: Pigs-
Eutrophication reduction potential by using amino acids and different biogas options: Pigs

EP [kg PO$_4$e/1.000 kg live weight]

- Pig ref.: 8.1 kg PO$_4$e, 6.4 kg fuel, 9.3 kg CH$_4$, total EP 23.9 kg PO$_4$e
- Pig AA: 7.1 kg PO$_4$e, 4.2 kg fuel, 17.6 kg CH$_4$, total EP 28.5 kg PO$_4$e
- Pig BG CHP: >0.1 kg PO$_4$e, 7.1 kg fuel, 0.4 kg CH$_4$, total EP 13.4 kg PO$_4$e
- Pig BG CH4: >0.1 kg PO$_4$e, 7.1 kg fuel, 0.4 kg CH$_4$, total EP 13.4 kg PO$_4$e
- Pig BG fuel: >0.1 kg PO$_4$e, 7.1 kg fuel, 0.4 kg CH$_4$, total EP 13.4 kg PO$_4$e

The reduction potential compared to the reference is -44%.
GWP reduction potential by using amino acids and different biogas options: Broilers

GWP (100) excl. biogenic carbon [kg CO$_2$e/1.000 kg live weight] incl. dLUC emissions

- Broiler ref.: 4.609 kg CO$_2$e
- Broiler AA: 2.628 kg CO$_2$e
- Broiler BG CHP: 2.628 kg CO$_2$e
- Broiler BG CH4: 2.628 kg CO$_2$e
- Broiler BG fuel: 2.628 kg CO$_2$e

- Reductions:
  - -43% for Broiler BG CHP
  - -47% for Broiler BG fuel

Legend:
- Feedmix
- Farm & Hatchery
- Storage / biogas
- field appl
- purification + losses
- credit energy
- credit natural gas
- credit fuel
Eutrophication reduction potential by using amino acids and different biogas options: Broilers

EP [kg PO₄e/1.000 kg live weight]
### Acidification reduction potential by using amino acids and different biogas options

#### AP [kg SO$_2$e/1,000 kg live weight]

<table>
<thead>
<tr>
<th></th>
<th>Broiler</th>
<th>Pigs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference (AA-)</td>
<td>65.3</td>
<td>50.1</td>
</tr>
<tr>
<td>AA+</td>
<td>31.7 (-51.5%)</td>
<td>34.3 (-31.5%)</td>
</tr>
<tr>
<td>BG CHP</td>
<td>15.3 (-76.3%)</td>
<td>16.3 (-67.5%)</td>
</tr>
<tr>
<td>BG CH4</td>
<td>16.3 (75.0%)</td>
<td>17.0 (-66.1%)</td>
</tr>
<tr>
<td>BG Fuel</td>
<td>16.2 (-75.2%)</td>
<td>16.9 (-66.3%)</td>
</tr>
</tbody>
</table>
Further treatment of fermentation rest leads to a more flexible and more ecological organic fertilizer management.

**Diagram:**
- **Input Water**
- **Fermenter**
  - Biogas
  - Digestate
- **SEPURAN® Biogas Cleaning**
  - Other gas
  - CH4 gas
- **Dewatering**
- **MAP* Unit**
  - Membrane separation (e.g., RO)
  - MAP as fertilizer
  - Water for discharge or reuse

MAP: Magnesium-Ammonium-Phosphate
MgNH₄PO₄ • 6 H₂O
Conclusion and outlook

• Agriculture is responsible for about 20% of global GHG emissions, ¾ of that for livestock

• Globally GHG emissions are dominated by ruminants; significant N and P emissions from poultry and swine

• Manure management practice and temperature have a dominant influence on GHG formation during manure storage \(\rightarrow\) cover for storage tanks necessary

• Diets with amino acids have a significant reduction potential for N emissions and related acidification and eutrophication potentials; GHG reduction’s significance is strongly connected with LUC and Soy from South America

• Several measures can help to reduce impacts on every production stage; e.g. farming and fertilizer use and application, feeding strategies/low protein diets; manure management to recover energy and avoid emissions from storage

• Biogas can significantly reduce emissions from manure storage and offset farm emissions by credits for electricity/heat, natural gas or even diesel replacement

• Lowering feed protein content further using more AA and digestate treatment offer further emission reduction potential.