Is Phase Feeding Really Worth the Hassle?

Bob Goodband, Mike Tokach, Jason Woodworth, Steve Dritz, and Joel DeRouchey,

KSUSwine.org
Mitzi Paloma, ch f 3
2:03.1
Outline

• Definitions – Digestible AA and Net Energy
• Practical steps in diet formulation
• Effects of phase feeding
• Feed Budgeting
Standardized Ileal AA Digestibility

H. H. Stein
Amino Acid Digestibility

- Total
  - Apparent digestible
    - Standardized digestible

Ingredient content
- Doesn’t tell you what pig uses

Ingredient – remaining at ileum
- Doesn’t count for endogenous losses

Ingredient – standardized losses at ileum
Regression Analysis to Predict Growth Performance from Dietary Net Energy in Growing-Finishing Pigs

- Low energy diets typically reduce feed cost but also lower growth performance.
- Prediction of growth and feed efficiency is essential to quantify the feeding value of dietary energy.
- NE is the most accurate system to evaluate the effect of energy on growth.

![Diagram of energy levels: Gross Energy (GE) → Digestible Energy (DE) → Metabolizable Energy (ME) → Net Energy (NE) → Fecal energy, Urine energy, Gas energy, Heat increment.]

K-STATE Research and Extension
Predicted ADG of pigs fed varying levels of dietary net energy (NE)
What are the production system’s goals?

- Is the system reaching their packer’s ideal weight range or not (fixed time basis)?
- Are there plenty of days available to take pigs to heavier weights?
- This will help establish a practical energy density of the diet.
  - Added fat or lower energy, high byproduct-based diets
Steps in Diet Formulation

1. Determine the most economical energy level
2. Determine the lysine:calorie ratio to use for the genetics and production situation
3. Determine the ratio for the other amino acids
4. Determine the ratio of phosphorus to energy
5. Set levels of vitamins, trace minerals, calcium, salt, and other ingredients.
Effect added fat on growth performance of finishing pigs 36 to 59 kg

Linear, $P < 0.01$
Quadratic, $P = 0.57$
SEM = 14.9

ADG, g

<table>
<thead>
<tr>
<th>Added Fat, %</th>
<th>ADG, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>811</td>
</tr>
<tr>
<td>2</td>
<td>831</td>
</tr>
<tr>
<td>4</td>
<td>858</td>
</tr>
<tr>
<td>6</td>
<td>895</td>
</tr>
</tbody>
</table>

De La Llata et al., 2001
Steps in Diet Formulation

1. Determine the most economical energy level

2. Determine the lysine:calorie ratio to use for the genetics and production situation

3. Determine the ratio for the other amino acids

4. Determine the ratio for phosphorus to energy

5. Set levels of vitamins, trace minerals, calcium, salt, and other ingredients.
Effects of dietary NE with constant SID Lys:NE ratio or constant percentage SID Lys on growth performance of growing-finishing pigs

<table>
<thead>
<tr>
<th>Formulation Method</th>
<th>Low Control</th>
<th>Medium Constant Lys:NE</th>
<th>High Constant Lys:NE</th>
<th>Medium Constant Lys %</th>
<th>High Constant Lys %</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADG, g</td>
<td>984</td>
<td>1016</td>
<td>1043</td>
<td>997</td>
<td>1002</td>
</tr>
</tbody>
</table>

Ratio vs constant P = 0.10
Lys:NE, linear P = 0.022

Marcal et al., 2016
Effects of dietary NE with constant SID Lys:NE ratio or constant percentage SID Lys on growth performance of growing-finishing pigs

![Graph showing SID Lys intake, g/d]  

- **Low Control**: 19.0 g/d  
- **Medium**: 21.3 g/d  
- **High**: 22.0 g/d  
- **Medium Constant Lys:NE**: 19.4 g/d  
- **High Constant Lys %**: 18.5 g/d

- **Ratio vs constant P < 0.001**  
- **Lys:NE, linear P < 0.001**

Marcal et al., 2016
Once we determine lysine requirements, what about the other amino acids?
<table>
<thead>
<tr>
<th>Amino Acid</th>
<th>Ratio</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lysine, % of diet</td>
<td>0.60</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Threonine, % of diet</td>
<td>0.40</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Threonine, % of lysine</td>
<td>67%</td>
<td>67%</td>
<td></td>
</tr>
</tbody>
</table>

When we increased lysine, we need to increase the other amino acids proportionally.
Effects of Removing Too Much Soybean Meal on Finishing Pig Growth Performance

De La Llatta, et al., 2000

Linear, (P < 0.01)
Value of increased growth rate

• Cost of F/G is easy to calculate
• Cost of increased ADG depends on situation
  – Pigs can achieve the same market weight regardless of dietary energy (more days on feed)
    • Excess space – Value of gain = 0 or near 0
  – Market weight will increase when higher energy diets are fed (constant days on feed)
    • Limited space – Value of gain = market price or greater
Is Phase Feeding Worth the Hassel???
<table>
<thead>
<tr>
<th>Weight, kg</th>
<th>MAX</th>
<th>SID</th>
<th>SID/MAX</th>
<th>2-PHASE</th>
<th>1 Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 to 50</td>
<td>1.13</td>
<td>1.02</td>
<td>1.02</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>50 to 70</td>
<td>0.96</td>
<td>0.87</td>
<td>0.87</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>70 to 100</td>
<td>0.82</td>
<td>0.76</td>
<td>0.82</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>100 to 127</td>
<td>0.77</td>
<td>0.67</td>
<td>0.77</td>
<td>0.77</td>
<td>0.96</td>
</tr>
</tbody>
</table>
Effect of Phase Feeding Strategies on Body Weight (day 25)

**SID Lys**

<table>
<thead>
<tr>
<th>Strategy</th>
<th>BW (kg)</th>
<th>P&lt;0.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX</td>
<td>49.4</td>
<td><img src="a" alt="" /></td>
</tr>
<tr>
<td>STD</td>
<td>49.0</td>
<td><img src="ab" alt="" /></td>
</tr>
<tr>
<td>STD/MAX</td>
<td>48.4</td>
<td><img src="bc" alt="" /></td>
</tr>
<tr>
<td>2-PHASE</td>
<td>48.0</td>
<td><img src="c" alt="" /></td>
</tr>
<tr>
<td>1-PHASE</td>
<td>48.0</td>
<td><img src="c" alt="" /></td>
</tr>
</tbody>
</table>
### Effect of Phase Feeding Strategies on Body Weight (day 53)

<table>
<thead>
<tr>
<th>SID Lys</th>
<th>MAX</th>
<th>STD</th>
<th>STD/MAX</th>
<th>2-PHASE</th>
<th>1-PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.96</td>
<td>73.8</td>
<td>72.7</td>
<td>72.5</td>
<td>73.4</td>
<td>73.4</td>
</tr>
</tbody>
</table>

**P > 0.10**

Menegat et al, 2017
Effect of Phase Feeding Strategies on Body Weight (day 81)

Menegat et al, 2017
Effect of Phase Feeding Strategies on Body Weight (day 117)

P > 0.10

<table>
<thead>
<tr>
<th>SID Lys</th>
<th>MAX</th>
<th>STD</th>
<th>STD/MAX</th>
<th>2-PHASE</th>
<th>1-PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.77</td>
<td>129.7</td>
<td>127.1</td>
<td>129.4</td>
<td>129.8</td>
<td>129.8</td>
</tr>
</tbody>
</table>

Menegat et al, 2017
Effect of Phase Feeding Strategies on Net Revenue

Revenue, $

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Revenue, $</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX</td>
<td>113.07</td>
</tr>
<tr>
<td>STD</td>
<td>110.80</td>
</tr>
<tr>
<td>STD/MAX</td>
<td>112.77</td>
</tr>
<tr>
<td>2-PHASE</td>
<td>113.65</td>
</tr>
<tr>
<td>1-PHASE</td>
<td>113.65</td>
</tr>
</tbody>
</table>

P > 0.10
Effect of Phase Feeding Strategies on Feed Cost Per Pig

Menegat et al, 2017
Effect of Phase Feeding Strategies on Income over Feed Cost

P<0.05

Menegat et al, 2017
Summary

• Feeding lysine levels for maximum growth and efficiency in either a 2- or 4-phase feeding program results in the same growth performance and feed cost.

• A broad range of lysine specifications within the levels tested herein can be utilized in grow-finish diets without compromising income over feed cost.
## Feed Budgeting

### 2- or 3-phases

<table>
<thead>
<tr>
<th>Initial wt</th>
<th>Final wt</th>
<th>F/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>115</td>
<td>2.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial wt</th>
<th>Final wt</th>
<th>kg/pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>70</td>
<td>117</td>
</tr>
<tr>
<td>70</td>
<td>115</td>
<td>145</td>
</tr>
<tr>
<td>115</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td>115</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td>115</td>
<td>115</td>
<td>0</td>
</tr>
<tr>
<td>115</td>
<td>115</td>
<td>0</td>
</tr>
</tbody>
</table>
# Feed Budgeting

## 4-phases with different F/G

### K-State Grow-Finish Feed Budget

<table>
<thead>
<tr>
<th>Initial wt</th>
<th>Final wt</th>
<th>F/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>115</td>
<td>2.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial wt</th>
<th>Final wt</th>
<th>kg/pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>45</td>
<td>53</td>
</tr>
<tr>
<td>45</td>
<td>70</td>
<td>64</td>
</tr>
<tr>
<td>70</td>
<td>95</td>
<td>76</td>
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<tr>
<td>95</td>
<td>115</td>
<td>69</td>
</tr>
<tr>
<td>115</td>
<td>115</td>
<td>0</td>
</tr>
</tbody>
</table>

### K-State Grow-Finish Feed Budget

<table>
<thead>
<tr>
<th>Initial wt</th>
<th>Final wt</th>
<th>F/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>115</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial wt</th>
<th>Final wt</th>
<th>kg/pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>45</td>
<td>57</td>
</tr>
<tr>
<td>45</td>
<td>70</td>
<td>69</td>
</tr>
<tr>
<td>70</td>
<td>95</td>
<td>81</td>
</tr>
<tr>
<td>95</td>
<td>115</td>
<td>74</td>
</tr>
<tr>
<td>115</td>
<td>115</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Feed Budget**

- **Closeout Feed Efficiency**

---

This table provides a feed budget calculation for different weight phases with varying F/G ratios.

*K-State Grow-Finish Feed Budget*

*Knowledge for Life*
Conclusions

• We have made no allowance for nitrogen excretion.
• Using a feed budget can simplify when to order and change diets.
• When it comes down to it, I’d sure feel a lot more comfortable with a 4- to even 3-phase feeding program.
Thank You!!

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Effect of Phase Feeding Strategies on Initial Weight (day 0)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>BW, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX</td>
<td>27.9</td>
</tr>
<tr>
<td>STD</td>
<td>27.9</td>
</tr>
<tr>
<td>STD/MAX</td>
<td>27.9</td>
</tr>
<tr>
<td>2-PHASE</td>
<td>27.9</td>
</tr>
<tr>
<td>1-PHASE</td>
<td>27.9</td>
</tr>
</tbody>
</table>

Menegat et al, 2017
The End !!!!
Thank You!!!!!
Effect of Phase Feeding Strategies on Growth Performance (day 0 to 25)

- **ADG, kg**
  - MAX: 0.86\(^a\)
  - STD: 0.84\(^a\)
  - STD/MAX: 0.83\(^{ab}\)
  - 2-PHASE: 0.80\(^b\), 0.80\(^b\)

- **F/G**
  - MAX: 1.93\(^b\)
  - STD: 1.95\(^{ab}\)
  - STD/MAX: 1.99\(^a\)
  - 2-PHASE: 1.96\(^{ab}\)
  - 1-PHASE: 1.96\(^{ab}\)

P<0.05

Menegat et al, 2017
Effect of Phase Feeding Strategies on Growth Performance (day 25 to 53)

- **ADG, kg**
  - MAX: 0.87<sup>ab</sup>
  - STD: 0.85<sup>b</sup>
  - STD/MAX: 0.85<sup>b</sup>
  - 2-PHASE: 0.90<sup>a</sup>
  - 1-PHASE: 0.90<sup>a</sup>

- **F/G**
  - MAX: 2.44<sup>a</sup>
  - STD: 2.47<sup>a</sup>
  - STD/MAX: 2.45<sup>a</sup>
  - 2-PHASE: 2.29<sup>b</sup>
  - 1-PHASE: 2.29<sup>b</sup>

P > 0.05

Menegat et al, 2017
Value of increased growth rate

• Cost of F/G is easy to calculate
• Cost of increased ADG depends on situation
  – Pigs can achieve the same market weight regardless of dietary energy (more days on feed)
    • Excess space – Value of gain = 0 or near 0
  – Market weight will increase when higher energy diets are fed (constant days on feed)
    • Limited space – Value of gain = market price or greater
Effect of Phase Feeding Strategies on Growth Performance (day 53 to 81)

Menegat et al, 2017

P<0.05
Effect of Phase Feeding Strategies on Growth Performance (day 81 to 117)

ADG, kg

<table>
<thead>
<tr>
<th></th>
<th>MAX</th>
<th>STD</th>
<th>STD/MAX</th>
<th>2-PHASE</th>
<th>1-PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.85</td>
<td>0.83</td>
<td>0.85</td>
<td>0.84</td>
<td>0.84</td>
</tr>
</tbody>
</table>

F/G

<table>
<thead>
<tr>
<th></th>
<th>MAX</th>
<th>STD</th>
<th>STD/MAX</th>
<th>2-PHASE</th>
<th>1-PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.16a</td>
<td>3.20</td>
<td>3.20</td>
<td>3.28</td>
<td>3.28</td>
</tr>
</tbody>
</table>

P > 0.10

Menegat et al, 2017
Conclusions

• A single-phase feeding program will not necessarily affect overall growth performance based on compensatory gain.

• However, a single-phase feeding program will be approximately $3.00 less profitable than a 2 or 4 phase program.
Average Daily Gain
Early Finishing: day 0 to 55, (30 to 77 kg)

P <0.01

Main et al, 2003
Average Daily Gain
Day 83 to 104, (90 to 115 kg)

Below
At
Above
Below
At
Above

Late Finishing
Early Finishing

Below
Below

Early, P<0.01
Late, Linear P<0.01

Main et al, 2003
Average Daily Gain
Overall: day 0 to 104, (30 to 115 kg)

Late Finishing
Early Finishing
Below  At  Above
Below  At  Above

780  812  821  798  825  834

SE = .02
Early, P<0.01
Late, Linear P<0.01

Main et al, 2003
Sale Weight

Early, P<0.003
Late, P<0.002

Main et al, 2003
Lean Percentage

Below

At

Above

Late Finishing

Early Finishing

SE = 0.16%

Early, P>0.14

Late, Quad P<0.01

Early \times Late, P<0.01

Main et al, 2003
Income over Feed Costs

SE = $1.33
Early, P>0.62
Late, Lin P<0.02

Main et al, 2003
Summary

• These studies suggest that as long as lysine requirements are being met in mid-late finishing (80 kg to slaughter), feeding slightly below the lysine requirement for optimal performance in early finishing reduces feed costs, and without sacrificing overall IOFC.
Effect of Phase Feeding Strategies on Growth Performance (day 0 to 117)

ADG, kg

<table>
<thead>
<tr>
<th></th>
<th>MAX</th>
<th>STD</th>
<th>STD/MAX</th>
<th>2-PHASE</th>
<th>1-PHASE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>0.88</td>
<td>0.85</td>
<td>0.87</td>
<td>0.88</td>
<td>0.88</td>
</tr>
</tbody>
</table>

F/G

<table>
<thead>
<tr>
<th></th>
<th>MAX</th>
<th>STD</th>
<th>STD/MAX</th>
<th>2-PHASE</th>
<th>1-PHASE</th>
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<tbody>
<tr>
<td></td>
<td>2.62</td>
<td>2.64</td>
<td>2.63</td>
<td>2.60</td>
<td>2.60</td>
</tr>
</tbody>
</table>

P<0.05

Menegat et al, 2017
Income over Feed Costs
day 0 to 55, (30 to 77 kg)

Assumes: $ 40.00/cwt live
IOFC = Value of Gain – Cost of Gain
SE = $0.26
P < 0.01

Main et al, 2003
Standardized Ileal Digestibility

- Standardized ileal digestibility (SID)- takes into account nutrients from digestive enzymes and slough intestinal cells
  - Measures enzyme and sloughed cell contributions by feeding nutrient free diet
  - greatest precision potential
  - requires cannula and nutrient free diet
Standardized Ileal AA Digestibility
Effect added fat on growth performance of finishing pigs 36 to 120 kg

Linear, $P < 0.01$
Quadratic, $P = 0.49$
SEM = 12.5

ADG, g

Added Fat, %

0  2  4  6

737  741  779  782

De La Llata et al., 2001
Amino Acid Digestibility

Total
↓
Apparent digestible
↓
Standardized digestible

Ingredient content
• Doesn’t tell you what pig uses

Ingredient – remaining at ileum
• Doesn’t count for endogenous losses

Ingredient – standardized losses at ileum
Evaluation of valine:lysine ratio on growth performance of nursery pigs (7 to 12 kg)

Quadratic (P < 0.05)

Nemecheck et al. 2010
Effect of Phase Feeding Strategies on Feed Cost Per Kg Gain

Menegat et al, 2017