“Dynamic Ideal Protein”:
A novel approach to feeding lactating sows

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The key to establishing nutrient requirements for lactating sows is not limited to maximizing milk yield for nursing pigs, but extends also to maintaining optimum body condition for the subsequent parities (Noblet et al., 1990; Pettigrew et al., 1992a; 1992b; NRC, 1998).

Modern sows are leaner and more productive than those used 20 yr ago (MLC, 1979; 1999). However, modern sows have a low appetite as a result of selection for leanness (Kanis, 1990). Thus, modern sows are often in a catabolic state during lactation due to a high demand of nutrients for milk production and as a result of inadequate feed intake especially in primiparous sows. Excessive tissue loss during lactation is one of the important reasons for reproductive failure of sows during subsequent parities (Reese et al., 1982a; 1982b; Jones and Stahley, 1995). Litter size is an essential factor to consider when establishing nutrient requirements for lactating sows. As litter size increases, sows need increased amounts of nutrients for the maintenance and growth of lactating mammary glands (Kim et al., 1999) and for increased milk production (King, 1991; Whittemore, 1993). When dietary nutrient supply does not meet the amount required to support large litters, tissue mobilization occurs (Kim and Easter, 2000).

To minimize excess tissue mobilization of lactating sows with a low appetite, lactation diets should be designed to provide nutrients with maximum efficiency. Thus, knowledge of which nutrients are limiting for supporting maintenance and production of lactating sows is essential to achieving this goal. Limiting essential amino acids can be predicted by considering the balance between output (i.e., milk amino acids and amino acids used for mammary gland growth) and input (i.e., amino acids mobilized from the tissues).

The objective of our study was to characterize amino acid mobilization among body tissues of the sow and to determine the order of limiting amino acids and ideal amino acid pattern for primiparous sows during lactation.

Twenty-eight primiparous sows (Camborough-15, Pig Improvement Company, Lexington, KY) were used and allotted to have litter sizes of 6, 7, 8, 9, 10, 11, or 12 pigs (n=4)

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within 2 d postpartum. Sows were allowed to consume a restricted amount of diet (85% of nutrients for the maximum mammary gland growth as previously reported from Kim et al., 1999b) during lactation. This was done so that clear responses in nutrient mobilization from body tissues would occur as litter size increased. Sows were killed on d 21 of lactation and the carcass, liver, gastrointestinal tract, reproductive tract, mammary gland, and other viscera were separated, weighed, ground, and analyzed for dry matter, crude protein, and amino acids. Simple linear equations were obtained for each amino acid within tissues as a function of litter size.

**Approach**

From simple linear equations, the amount of each amino acids additionally mobilized as litter size increased by one pig was obtained (Factor 1). In the meanwhile, the amount of each amino acids additionally secreted as a milk protein and additionally used for mammary gland growth and maintenance as litter size increased by one pig were obtained as well (Factor 2).

Diet should provide adequate amino acids to balance out the differences between Factor 1 and Factor 2. However, the amino acid profiles of Factor 1 and Factor 2 are not identical. Thus, dietary amino acid profile should be adjusted according to the levels of Factor 1 and Factor 2.

Amino acids in the milk and used for mammary glands (Factor 1) are relatively fixed components which means that the milk production is rather ‘demand driven’ by the litter. Sows trying to provide adequate milk to the litter until they reach a limit imposed by the nutrients for milk production. Within this limitation, the level of tissue mobilization can change depending on milk production and feed intake of the sows. Thus, dietary amino acid profile should be adjusted according to the level of tissue mobilization. This is the concept of ‘Dynamic Ideal Protein’ as a feeding strategy for lactating sows.

**Limiting amino acids changes depending on the level of tissue protein mobilization**

The amount of essential amino acids obtained from the difference between the amount mobilized and the amount secreted as a milk or used for mammary gland is the amount that should be compensated from dietary amino acids and we believe this represents the ideal amino acid pattern, an ever-changing or “dynamic” value.

Based on assumption that sows are consuming a common corn-soybean meal based lactation diet (71.1% corn and 22.8% soybean meal), using true ileal digestibility (Stein et al. 1998), threonine was shown to be the first limiting amino acid, equal to (or followed by ) lysine for our first-parity lactating sows that were experiencing significant tissue mobilization (Table 1).

In a situation where sows are experiencing minimal body weight losses, a different order of amino acid limitation is likely. As tissue mobilization becomes less important, the amino acid profile in milk and mammary gland tissue becomes a major factor influencing the ideal amino acid pattern for lactating sows. As tissue mobilization level was reduced from the 100% level in our study to 0% (no mobilization), valine becomes more limiting than threonine for lactating sows (Table 1).
Conclusions

The body condition and expected level of amino acid mobilization are important factors that must be considered in designed diets for lactating sows. The ideal amino acid pattern for lactating sows is dynamic and depends on the expected body weight loss of sows during lactation. We believe that applying ‘dynamic ideal protein’ can provide a valid basis for estimating the amino acid needs of lactating sows under specific herd circumstances. For sows having a low appetite during lactation, threonine is a critical amino acid, whereas valine becomes increasingly important for sows having a high appetite during lactation. Lysine is the principal limiting amino acid in the both cases.

References

Table 1. Ideal amino acid pattern and the order of limiting amino acids as tissue mobilization level from a sow differs during lactation

<table>
<thead>
<tr>
<th>Level of tissue protein mobilization</th>
<th>100%</th>
<th>80%</th>
<th>40%</th>
<th>10%</th>
<th>0%</th>
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<tbody>
<tr>
<td><strong>Ideal amino acid pattern relative to lysine</strong></td>
<td></td>
<td></td>
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<tr>
<td>Lysine</td>
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<td>100</td>
<td>100</td>
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<td>Threonine</td>
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<td>Valine</td>
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<tr>
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<td>56</td>
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<tr>
<td>Phe + Tyr</td>
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<td>123</td>
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<td>Histidine</td>
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<td>36</td>
<td>38</td>
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</table>

**Order of limiting amino acids**

| First limiting          | Threonine | Lysine | Lysine | Lysine | Lysine |
| Second limiting         | Lysine    | Threonine | Threonine | Valine | Valine |
| Third limiting          | Valine    | Valine | Valine | Threonine | Threonine |
| Fourth limiting         | Phe + Tyr | Isoleucine | Isoleucine | Isoleucine | Isoleucine |
| Fifth limiting          | Isoleucine | Phe + Tyr | Histidine | Histidine | Histidine |