EVALUATION OF DOSE-RESPONSE DATA AND IMPLICATIONS FOR COMMERCIAL FORMULATION OF BROILER DIETS

S. MACK, D. HÖHLER and M. PACK

Summary

The database of this paper consists of nine published dose-response experiments with methionine plus cystine (Met+Cys) and five with lysine (Lys). These data were consolidated with a particular focus on their economic implications for practical feed formulation and bird performance. Minimum feed cost per kg live weight gain and minimum feed cost per kg breast meat were chosen as performance indicators. They are meaningful for the overall profitability of a poultry production enterprise as they can be easily calculated and they combine input and output variables which cover the whole production process. Case scenarios were drafted for the effect of dietary Met+Cys and Lys on economics based on the dose-response data and current prices for feed and supplemented amino acids. The calculations show that the optimum dietary amino acid content is largely influenced by the production goals “live bird” or “breast meat”.

I. INTRODUCTION

Most managers of modern poultry enterprises agree that their foremost business objective is profitability. Typically, profitability is defined by criteria like net income and return on investment. The difficulty is that these criteria involve a large number of variables. Therefore, they are not suitable as tools for everyday management decisions in a business which typically consists of different segments like feed mill, hatchery, live production and processing. This conflict often leads company management to focus on performance indicators like feed cost per ton, feed to gain ratio, livability, uniformity, carcass yield etc. They can be directly measured and attributed to the different segments of the operation thereby facilitating the decision making process. Additionally, benchmarking systems implemented in each segment for factors such as “lowest feed cost” or “highest livability”, combined with a salary bonus, help to translate business decisions into action. Many of these performance indicators serve to de-link the enterprise into discrete business units. But does this disintegrative way of management really lead to the best overall profit for the operation? Trade-offs between the different criteria exist. For example, lowest feed cost per ton will most likely not lead to the best live production performance or carcass quality. The difficulty for company management using this approach is, firstly, to define the right criteria on which to focus and, secondly, to balance them in such a way that the bottom-line objective of maximizing profit is met. Indicators for overall profitability of livestock production are only meaningful if they comprise the whole production chain, combining key input (feed and supplement cost) and output variables (marketed product). Moreover, they should be easy to calculate, based on current price and animal performance data. The indicators “minimum feed cost per kg live weight gain” or “minimum feed cost per kg breast meat” meet these prerequisites whilst focusing on different production goals. The amino acids lysine (Lys) and methionine plus cystine (Met+Cys) will be used as the variable factors in the present paper. Their concentration in the feed has a large effect on a number of efficiency measures in the various segments of an

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integrated broiler operation (feed cost, live performance, carcass quality). Hence, they may serve as good examples for demonstrating the effect of different decision-making strategies on overall profitability.

II. METHODS

The database of this paper consists of nine published dose-response studies with Met+Cys and five published experiments with Lys. The table gives details of the experimental designs. All experiments were conducted within a similar range of dietary Met+Cys and Lys levels of 0.60% to 0.96% and 0.79% to 1.25%, respectively. Four to six incremental levels of synthetic DL-methionine or L-lysine were added to a deficient basal diet. Data comprised the grower period of male or mixed-sex broiler chickens of commercial crosses within the range of 7 to 42 days of age. The economically relevant performance criteria weight gain, feed to gain ratio and breast meat yield in g per kg live weight at slaughter were chosen as bases for an economical evaluation. Due to the different experimental conditions and their effect on the general level of performance, the criteria had to be transformed to a relative scale. The performance data were subjected to exponential regression analysis (Schutte and Pack, 1995a) separately for each experiment. The maximum response in performance as described by the asymptote of the regression was set at 100. Then, the performance at each tested amino acid level was expressed as a percentage of the asymptotic value. Thereafter, relative performance values from each experiment were pooled. Each data point represented four to eight replicates of 17 to 50 birds. Subsequently the pooled data were subjected to exponential regression analysis. This gave for each performance criterion one dose-response curve describing the effect of graded dietary amino acid content on relative animal performance.

In order to calculate the economic indicators “feed cost per kg live weight gain” and “feed cost per kg breast meat” assumptions had to be made for actual bird performance as well as for cost of feed and cost of supplemented amino acids. Asymptotic values of the regression curves which represent maximum performance were set at 2000 g live weight gain, 1.8 kg feed per kg of live weight gain and 160 g breast meat yield per kg live weight and reflect commercial practice. Performance at all other points on the curve were calculated from the relative performance at the specific amino acid content in the feed. Cost of basal feed without Met or Lys supplementation, DL-methionine and L-lysine HCl were set at 0.14 US$, 2.5 US$ and 2.0 US$, respectively. Based on the dose-response curves and the aforementioned price assumptions, the cost per kg feed and the economically relevant performance indicators “feed cost per kg live weight gain” and “feed cost per kg breast meat” were calculated for a wide range of dietary amino acid levels.

Cost / kg feed =

\[ \text{Basal feed cost} + ((\text{cost / unit supplemented test amino acid} - \text{cost / unit basal feed}) \times \text{(supplemented amino acid units)})] \]

Feed cost / kg live weight gain =

\[ (\text{kg feed / kg live weight gain}) \times \text{cost / kg feed} \]

Feed cost / kg breast meat =

\[ (\text{Feed cost / kg live weight gain}) / (\text{kg breast meat / kg live weight gain}) \]
Table. Design of the dose-response experiments.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Sex1</th>
<th>Strain2</th>
<th>Trial period (days of age)</th>
<th>Diet composition3</th>
<th>Energy content (MJ ME/kg)</th>
<th>Crude protein content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Met+Cys</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># 1</td>
<td>M</td>
<td>Ross</td>
<td>15-35</td>
<td>Sr, Sy</td>
<td>12.6</td>
<td>20.5</td>
</tr>
<tr>
<td># 2</td>
<td>M</td>
<td>Ross</td>
<td>15-35</td>
<td>Sr, Sy</td>
<td>12.6</td>
<td>24.2</td>
</tr>
<tr>
<td># 3</td>
<td>50% M, 50% F</td>
<td>Ross</td>
<td>14-38</td>
<td>M, Sy</td>
<td>13.4</td>
<td>22.7</td>
</tr>
<tr>
<td># 4</td>
<td>M</td>
<td>Cobb</td>
<td>15-33</td>
<td>W, M, Sy</td>
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</tr>
<tr>
<td># 5</td>
<td>M</td>
<td>Ross</td>
<td>14-35</td>
<td>Sr, M, P, Sy</td>
<td>12.4</td>
<td>23.3</td>
</tr>
<tr>
<td># 6</td>
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<td>Ross</td>
<td>10-35</td>
<td>Sr, M, P, Sy</td>
<td>13.6</td>
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</tr>
<tr>
<td># 7</td>
<td>M</td>
<td>Ross</td>
<td>7-35</td>
<td>M, Sy</td>
<td>13.2 Grower, 13.6 Finisher</td>
<td>20.9 Grower, 20.2 Finisher</td>
</tr>
<tr>
<td># 8</td>
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<td>Ross</td>
<td>20-40</td>
<td>M, Sy</td>
<td>13.0</td>
<td>19.0</td>
</tr>
<tr>
<td># 9</td>
<td>50% M, 50% F</td>
<td>Ross</td>
<td>21-42</td>
<td>M, Sy</td>
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<tr>
<td>Lys</td>
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<td></td>
<td></td>
</tr>
<tr>
<td># 10</td>
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<td>Ross</td>
<td>20-40</td>
<td>M, Sy</td>
<td>13.2</td>
<td>19.0</td>
</tr>
<tr>
<td># 11</td>
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<td>ISA</td>
<td>20-40</td>
<td>M, Sy</td>
<td>13.2</td>
<td>19.0</td>
</tr>
<tr>
<td># 12</td>
<td>M</td>
<td>Ross, Hu x Pe</td>
<td>15-40</td>
<td>M, Sr, Sy</td>
<td>13.4</td>
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<td># 13</td>
<td>M</td>
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<td>M, Sr, Sy</td>
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<tr>
<td># 14</td>
<td>M</td>
<td>Ross</td>
<td>22-42</td>
<td>M, Sr, Sy</td>
<td>13.4</td>
<td>19.5</td>
</tr>
</tbody>
</table>

1 M=male, F=female
2 Hu=Hubbard, Pe=Peterson
3 W=wheat, Sr=sorghum, M=maize, Sy=soybean meal, P=peas

III. RESULTS

Drawing conclusions on economically optimum amino acid levels in feed requires a solid base of performance data from dose-response experiments carried out over a sensitive and practically relevant range of amino acid concentration in the diet. Pooled data from the included studies which were transformed to a relative scale show a consistent response in bird performance to increasing levels of dietary Met+Cys (Figures 1 to 3) and lysine (Figures 6 to 8). Exponential regression analysis describes these dose-response relations well.

(a) Response to dietary Methionine plus Cystine content

Under the given set of conditions feed cost per kg live weight gain reached a minimum at 0.90 % Met+Cys and increased thereafter (Figure 4). The shape of this response curve was determined, firstly, by the lower feed to gain ratio which approaches an asymptote with rising dietary Met+Cys concentration, and secondly, by the linear, ever increasing feed cost with higher Met+Cys content. The response in feed cost per kg breast meat to a higher dietary Met+Cys content was affected not only by the feed to gain ratio but also by the increasing breast meat portion of the live weight. This extra benefit included in the economic calculation shifted the optimum dietary Met+Cys concentration to 0.98 % (Figure 5).
Figures 1 to 3. Relative response in weight gain, feed to gain ratio and breast meat yield (% of live weight) to graded levels of dietary Met+Cys.

Figures 4 and 5. Effect of dietary Met+Cys content on feed cost per kg live weight gain and feed cost per kg breast meat yield
(b) Response to dietary Lysine content

Although the database for Lys comprised less studies than that for Met+Cys there was a consistent curvilinear response in relative bird performance to increasing dietary lysine concentration (Figures 6 to 8). Under the given set of conditions, feed cost per kg live weight gain and feed cost per kg breast meat were lowest at 1.03% and 1.16% dietary Lys, respectively (Figures 9 and 10).

Figures 6 to 8. Relative response in weight gain, feed to gain ratio and breast meat yield (% of live weight) to graded levels of dietary Lys.
Figures 9 and 10. Effect of dietary Lys content on feed cost per kg live weight gain and feed cost per kg breast meat yield.

IV. DISCUSSION AND CONCLUSIONS

Feed represents over 60 percent of the total production cost per bird and is worthy of close scrutiny. However, one has to keep in mind that lowering feed cost per ton does not automatically mean higher profitability.

In general, the process of deciding on raw material quality and nutrient specifications in feed should start with defining the properties of the desired product. The present paper shows large differences in economically optimum dietary amino acid levels depending on the product to be marketed. This approach may well be extended to other nutrients and is meant to serve as a general tool to decide about diet specifications in a meaningful way.

REFERENCES