STRATEGIES FOR UTILIZING 
OVERPROCESSED SOYBEAN MEAL: 
II. LYSINE SUPPLEMENTATION

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Primary Audience: Quality Assurance Personnel, Nutritionists, Researchers

SUMMARY

Four experiments were conducted to determine the amount of lysine needed to overcome the negative effects of feeding overprocessed soybean meal (SBM) to broiler chicks. Overprocessed SBM reduced 15-day body weight and increased feed:gain ratio. The addition of graded levels of lysine significantly (P < .05) increased body weight to a level similar to that of controls, thus overcoming the effects of overprocessing. In Experiment 1, feeding moderately overprocessed SBM (55% protein solubility [PS]) required the addition of 0.082% lysine to overcome the effects of overprocessing. In Experiments 2, 3, and 4, when feeding slightly overprocessed SBM (68, 66, and 66% PS), the addition of 0.072, 0.032, and 0.054% lysine, respectively, was required to achieve the same body weight as control groups.

On the basis of these studies, it is suggested that overprocessed SBM can be included in practical diets if the PS is known and adequate supplemental lysine is incorporated in the ration.

Key words: Broilers, lysine, overprocessing, protein solubility, soybean meal
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DESCRIPTION OF PROBLEM

Soybeans and soybean meal (SBM) require heat-treatment in order to be of satisfactory nutritional quality for use in poultry rations. Proper heat processing is required to destroy antinutritive factors naturally present in raw soybeans and also to remove solvent remaining from the oil extraction process. However, excessive heat treatment reduces the nutritive value of SBM by negatively affecting protein quality and/or decreasing the availability of certain amino acids [1, 2, 3]. Lee and Garlich [4], using a method of processing designed to simulate industry conditions, reported no differences in amino acid content between control and overprocessed meals. The same authors, however, found that although true amino acid availability assayed with adult roosters was not significantly different for control and overprocessed meals, there

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were significant differences in apparent amino acid availability to growing chicks.

Carpenter [5] reported that many of the amino acids in early Maillard reaction products are released during acid hydrolysis and are detectable by ion-exchange chromatography. However, such products usually are not available to the animal for protein synthesis. Parsons et al. [2] reported a reduction in both total and available levels of certain amino acids in overheated SBM.

These observations were supported by recent work by Aburto et al. [6], who were able to overcome the effects of severe SBM overprocessing through lysine supplementation. While the availabilities of amino acids other than lysine may well be affected by excessive heat treatment, these amino acids might not become limiting in a grain-soybean meal diet.

The objective of this set of studies was to determine how much lysine needs to be added to overcome the negative effects of SBM overprocessing on broiler performance. In previous studies at this laboratory [6], the SBM used in test diets was severely overheated. In the present studies, the degree of overheating was limited to that which might reasonably be expected under practical conditions.

MATERIALS AND METHODS

In four experiments graded levels of lysine were added to a diet containing overheated SBM. The basal diet (reported previously) [6] had been formulated to be marginal in lysine even when properly processed SBM was used in the ration. While the NRC [7] requirement for lysine in broiler starter diets is 1.1%, this figure has recently been questioned by Vazquez and Pesti [8]. It is the belief of the authors that a starter diet containing 1.1% lysine but adequate in other amino acids would be at best marginal in lysine. Thus, were the availability of lysine to be further compromised by overheating, the resulting diet should be deficient in this amino acid. Chicks consuming such diets would be sensitive to level of lysine supplementation.

The approach followed in these studies is presented in Figure 1. Beginning with the basal diet containing properly processed SBM but marginal in lysine, overprocessing of the SBM component of the ration was intended to produce a growth depression due to an aggra-

vated deficiency of this amino acid. The amount of lysine needed to support the same growth in chicks receiving overprocessed SBM as in the control group (with standard SBM) should approximate the quantity damaged by excessive heat treatment.

Dehulled, solvent-extracted SBM was obtained from commercial sources. To achieve overheating, subsamples of the same batch were spread in thin layers (approximately 2.5 cm in depth) onto aluminum pans and autoclaved at 121°C and 15 kpa for approximately 30 and 40 min; no moisture was added. Each batch of meal was emptied from pans after autoclaving, air dried, and homogenized prior to laboratory analysis. Protein solubility (PS) in 0.2% KOH was determined by the method described by Araba and Dale [9] and urease activity (UA) evaluated as described by Caskey and Knapp [10].

Day-old male (Ross × Ross) broiler chicks were used in all experiments. Chicks were housed in electrically heated battery brooders with wire mesh floors. Feed and water were provided ad libitum; all experiments were conducted from 1 to 15 days of age. At the termination of each study, birds were weighed by pen and feed consumption determined. The same basal formula [6] was used in all experiments. The only modification between trials was in degree of overheating of SBM.

EXPERIMENT 1

The control SBM was determined to have a PS of 80%, and the overprocessed SBM 55% PS. Four replicates of 10 male chicks each per pen were assigned to each of six dietary treatments (control SBM, Control + 0.12% lysine, overprocessed SBM, and overprocessed + 0.04, 0.08, or 0.12% lysine).

EXPERIMENT 2

The control SBM again had a PS of 80% and the overprocessed SBM was moderately overheated, having 68% PS. This degree of overprocessing, however, was more representative of what would be found in commercial conditions. Four replicates of 10 male chicks each per pen were assigned to each of six dietary treatments (control SBM, Control + 0.12% lysine, overprocessed SBM, and overprocessed + 0.04, 0.08, or 0.12% lysine).
EXPERIMENT 3

The control SBM had a PS of 80% and the overprocessed SBM 66% PS. Four replicates of 10 male chicks each per pen were assigned to each of seven dietary treatments (control SBM, Control + 0.16% lysine, overprocessed SBM, and overprocessed + 0.04, 0.08, 0.12, or 0.16% lysine).

EXPERIMENT 4

The fourth experiment was conducted to confirm the results of the previous experiments and to evaluate the supplementation of levels of lysine higher than those employed in Experiment 3. The control SBM had a PS of 80% and the overprocessed SBM 66% PS. Six replicates of 10 chicks each per pen were assigned to each of eight dietary treatments (control SBM, Control + 0.12% lysine, overprocessed SBM, and overprocessed + 0.04, 0.08, 0.12, 0.16, or 0.2% lysine).

Using the Statistical Analysis System [11], the data from each experiment were analyzed on a pen basis by a one-way ANOVA. Significant differences between treatment means were estimated by using Duncan’s multiple range test [12]. Both simple and multiple regression analysis for levels of lysine were performed for body weight in all the experiments in an attempt to quantify the amount of lysine required to overcome the effects of overprocessing.

RESULTS AND DISCUSSION

In each of four experiments, a significant (P < .05) growth response was obtained when lysine was added to the control diet containing standard SBM. This confirmed that the level of lysine in this ration was in fact deficient and validated its use in these experiments. These observations support the view of Vazquez and Pesti [8] that the NRC [7] lysine requirement for starting broiler chicks may be too low.

In Experiment 1, feeding overprocessed SBM significantly (P < .05) reduced body weight and increased feed:gain ratio (Table 1). The addition of increasing levels of lysine produced significant (P < .05) increases in body weight (Figure 1).
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TABLE 1. Effect of lysine addition on performance of broiler chickens fed overprocessed soybean meal (Experiment 1)

<table>
<thead>
<tr>
<th>TREATMENTS</th>
<th>BODY WEIGHT</th>
<th>FEED CONSUMED</th>
<th>FEED-GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>391b</td>
<td>594b</td>
<td>1.41b</td>
</tr>
<tr>
<td>Control + 0.12% Lys</td>
<td>411b</td>
<td>566b</td>
<td>1.38b</td>
</tr>
<tr>
<td>Overprocessed D</td>
<td>361c</td>
<td>560b</td>
<td>1.55b</td>
</tr>
<tr>
<td>Overprocessed + 0.04% Lys</td>
<td>381b</td>
<td>539b</td>
<td>1.42b</td>
</tr>
<tr>
<td>Overprocessed + 0.08% Lys</td>
<td>393b</td>
<td>589b</td>
<td>1.50b</td>
</tr>
<tr>
<td>Overprocessed + 0.12% Lys</td>
<td>417b</td>
<td>583b</td>
<td>1.41b</td>
</tr>
</tbody>
</table>

A Lysine added as L-lysine.
B Means of four pens per treatment with 10 chicks per pen.
C Protein solubility 80%.
D Protein solubility 55%.
** Means within each column with no common superscript are significantly different (P < .05).

Weight, with the largest increase being at the highest level of lysine (0.12% L-lysine). By using regression analysis, it was found that addition of 0.082% lysine was required for the groups fed overprocessed SBM (55% PS) to achieve the same body weight as controls. In Experiment 2, the reduction in body weight produced by feeding overprocessed SBM (Table 2) was not as large as in Experiment 1. The addition of 0.072% lysine overcame the effect of feeding slightly overprocessed SBM (68% PS) and increased body weight to the same level as controls. In Experiment 3, the addition of 0.032% lysine was required to overcome the growth depression (Table 3). In Experiment 4, the addition of 0.054% lysine overcame the effect of feeding overprocessed SBM. The addition of a higher level of lysine (0.20% L-lysine) did not produce any additional response in body weight (Table 4). In previous studies Aburto et al. [6] reported that when feeding extremely heat-damaged SBM (35% PS) higher levels of lysine (0.24% L-lysine) were required to achieve the body weight of controls. The results of the present studies support the findings of Parsons et al. [2], who reported that the concentration and availability of lysine decreased in overprocessed SBM as heating time increased. Therefore, when feeding only moderately

TABLE 2. Effect of lysine addition on performance of broiler chickens fed overprocessed soybean meal (Experiment 2)

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>BODY WEIGHT</th>
<th>FEED CONSUMED</th>
<th>FEED-GAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>408b</td>
<td>572</td>
<td>1.40b</td>
</tr>
<tr>
<td>Control + 0.12% Lys</td>
<td>423b</td>
<td>578</td>
<td>1.37b</td>
</tr>
<tr>
<td>Overprocessed D</td>
<td>389b</td>
<td>562</td>
<td>1.45b</td>
</tr>
<tr>
<td>Overprocessed + 0.04% Lys</td>
<td>410b</td>
<td>569</td>
<td>1.39b</td>
</tr>
<tr>
<td>Overprocessed + 0.08% Lys</td>
<td>414b</td>
<td>581</td>
<td>1.40b</td>
</tr>
<tr>
<td>Overprocessed + 0.12% Lys</td>
<td>422b</td>
<td>579</td>
<td>1.37b</td>
</tr>
</tbody>
</table>

A Lysine added as L-lysine.
B Means of four pens per treatment with 10 chicks per pen.
C Protein solubility 80%.
D Protein solubility 68%.
** Means within each column with no common superscript are significantly different (P < .05).

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TABLE 3. Effect of lysine addition on performance of broiler chickens fed overprocessed soybean meal (Experiment 3)

<table>
<thead>
<tr>
<th>TREATMENT A</th>
<th>BODY WEIGHT B</th>
<th>FEED CONSUMED B</th>
<th>FEED:GAIN B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control C</td>
<td>391 d</td>
<td>594 b</td>
<td>1.41 ab</td>
</tr>
<tr>
<td>Control + 0.16% Lys</td>
<td>411 b</td>
<td>566 b</td>
<td>1.38 b</td>
</tr>
<tr>
<td>Overprocessed</td>
<td>383 b</td>
<td>583 b</td>
<td>1.52 a</td>
</tr>
<tr>
<td>Overprocessed + 0.04% Lys</td>
<td>394 b,d</td>
<td>566 b</td>
<td>1.44 b,b</td>
</tr>
<tr>
<td>Overprocessed + 0.08% Lys</td>
<td>405 b,ce</td>
<td>577 b</td>
<td>1.43 b,b</td>
</tr>
<tr>
<td>Overprocessed + 0.12% Lys</td>
<td>412 b</td>
<td>559 b</td>
<td>1.36 b</td>
</tr>
<tr>
<td>Overprocessed + 0.16% Lys</td>
<td>413 b</td>
<td>622 b</td>
<td>1.51 b</td>
</tr>
</tbody>
</table>

A: Lysine added as L-lysine. 
B: Means of four pens per treatment with 10 chicks per pen. 
C: Protein solubility 80%. 
D: Protein solubility 66%. 
* a-d Means within each column with no common superscript are significantly different (P < .05).

TABLE 4. Effect of lysine addition on performance of broiler chickens fed overprocessed soybean meal (Experiment 4)

<table>
<thead>
<tr>
<th>TREATMENT A</th>
<th>BODY WEIGHT B</th>
<th>FEED CONSUMED B</th>
<th>FEED:GAIN B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control C</td>
<td>409 b</td>
<td>550 b</td>
<td>1.35 b,b</td>
</tr>
<tr>
<td>Control + 0.12% Lys</td>
<td>444 b,b</td>
<td>571 b</td>
<td>1.29 c</td>
</tr>
<tr>
<td>Overprocessed</td>
<td>390 b</td>
<td>512 b</td>
<td>1.32 b,b</td>
</tr>
<tr>
<td>Overprocessed + 0.04% Lys</td>
<td>410 b</td>
<td>550 b</td>
<td>1.34 b,b</td>
</tr>
<tr>
<td>Overprocessed + 0.08% Lys</td>
<td>423 b</td>
<td>568 b</td>
<td>1.34 b,b</td>
</tr>
<tr>
<td>Overprocessed + 0.12% Lys</td>
<td>435 b</td>
<td>564 b</td>
<td>1.30 b,b</td>
</tr>
<tr>
<td>Overprocessed + 0.16% Lys</td>
<td>446 b</td>
<td>571 b</td>
<td>1.28 c</td>
</tr>
<tr>
<td>Overprocessed + 0.20% Lys</td>
<td>440 b,ce</td>
<td>600 b</td>
<td>1.36 a</td>
</tr>
</tbody>
</table>

A: Lysine added as L-lysine. 
B: Means of four pens per treatment with 10 chicks per pen. 
C: Protein solubility 80%. 
D: Protein solubility 66%. 
* a-d Means within each column with no common superscript are significantly different (P < .05).

Overprocessed SBM, less lysine supplementation would be required to overcome the effects of overheating.

According to these studies, diets with moderately overprocessed SBM needed approximately 0.08%, and slightly overprocessed needed about 0.05% additional lysine to overcome the negative impact of overheating. It is important to note that the basal diets were formulated to contain approximately 30% SBM in all experiments. If more or less than 30% SBM is used, proportionally more or less lysine should be supplemented.

Veltmann, Jr. et al. [13] added 0, 0.03, 0.05, and 0.08% lysine-HCL to subnormal, normal, overheated, and severely overheated SBM, respectively. Their results showed a variable response to lysine supplementation with a tendency toward improved performance when lysine was added to a diet containing overprocessed SBM. Araba and Dale [9], and Parsons et al. [2], and Aburto et al. [6] found
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a significant positive response to lysine supplementation.

The addition of increasing levels of lysine not only overcame the effects associated with feeding overprocessed SBM but also increased body weight to a level similar to that of groups fed the control SBM supplemented with lysine. This can be taken as further confirmation that overprocessed SBM can in fact be employed in practical rations if adequate additional lysine is provided.

It was noted that in Experiments 3 and 4, but not in Experiments 1 and 2, that the highest level of lysine supplementation was accompanied of a significant deterioration in feed conversion. As it is doubtful these levels of supplementation would be adequate to cause an amino acid antagonism or imbalance, the cause of the increased feed:gain ratios is unclear.

CONCLUSIONS AND APPLICATIONS

1. Feeding moderately overprocessed SBM as the main source of dietary protein reduced 15-day body weight and increased feed:gain ratio.
2. The addition of lysine to the diets of broiler chicks fed overprocessed SBM significantly (P < .05) increased body weight, achieving gains similar to those of controls, and overcoming the negative effects of overprocessing.
3. On the basis of these studies, it is suggested that moderately overprocessed SBM (55 to 70% PS) can be employed in practical diets if adequate lysine is added to the ration.

REFERENCES AND NOTES


Using true digestibility assays, Parsons et al. [2] showed that in addition to the effects of overheating on total lysine concentration, the digestibility of the lysine remaining in overprocessed SBM was reduced according to the severity of overprocessing. They further reported that the same effect was observed for cysteine, histidine, and aspartate. These results, taken together with those of Araba and Dale [9] and Aburto et al. [6], strongly suggest that the decrease in lysine availability is of the most concern under practical conditions.

Quality control programs should attempt to prevent the reception of overprocessed or underprocessed SBM. However, rejecting overprocessed SBM may under some circumstances (such as limited inventories of ingredients) prevent the manufacture of feed. Under these conditions, addition of lysine (based on PS) should largely overcome negative performance of poultry.


