Comparison of Peanut Meal and Soybean Meal as Protein Supplements for Laying Hens

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ABSTRACT Peanut protein is severely limiting in threonine and has been used to create threonine deficiency in animals. The availability of purified threonine at low cost raises the possibility of economically using peanut meal (PNM) and threonine combinations in poultry diets. An experiment was conducted to compare corn and PNM based diets to corn and soybean meal (SBM) based diets at three protein levels (16, 18.5, and 21%) in diets for 22- to 34-wk-old commercial Leghorns. Birds were housed two per cage with four cages per replicate and six replicates per treatment. Feed consumption, egg production, and feed per dozen eggs were almost identical for PNM (93.8 g/hen per d, 92.2 eggs per 100 hens/d, and 1.22 kg/dozen) and SBM (93.7 g/hen per d, 92.2 eggs per 100 hens/d, and 1.22 kg/dozen). Dietary protein level had no consistent effect on any of these parameters but did significantly improve body weight gains and egg weights (1.2 to 2.5 g/egg). PNM-fed hens laid slightly smaller eggs during the first 6 wk (P < 0.05), but there were no egg size differences during the last 6 wk of the experiment (P > 0.14). PNM-fed hens laid eggs with better interior quality at 26 and 30 wk of age. After 2 wk of storage, Haugh units remained better for eggs from hens fed PNM than SBM when kept refrigerated (4°C; P < 0.05) or at room temperature (20°C; P < 0.10). Egg specific gravity was slightly lower for hens fed PNM. It is concluded that PNM is an excellent ingredient for laying hen diets.

(Key words: peanut meal, soybean meal, Leghorns, protein level)

INTRODUCTION

Edwards and Massey (1941) concluded “The use of peanut meal in feeding poultry has proved satisfactory, economical, and efficient. It furnishes protein of vegetable origin of the highest quality and is palatable and entirely satisfactory when used properly. This holds not only for body growth and maintenance, but also for egg production.” In early studies with expeller processed peanut meal (PNM), PNM protein had to be balanced with animal by-products such as meat scraps, skim milk, or buttermilk to achieve the best performance.

Driggers and Tarver (1958) demonstrated that PNM could replace half the soybean meal (SBM) in broiler diets if lysine or fishmeal was also added to the diet. Douglas and Harms (1959) confirmed that lysine is the first limiting amino acid in corn and PNM broiler diets, and Waldroup and Harms (1963) demonstrated that methionine and tryptophan are next limiting. Rangel-Lugo et al. (1994) used a 20% protein, wheat-and-PNM-based diet and a 25% protein, corn, and SBM-based diet, both supplemented with crystalline amino acids to produce threonine deficiency in broilers.


In contrast, no response to threonine was observed in chicks fed a sorghum, PNM, corn gluten meal, and poultry meal based diet supplemented with L-lysine and DL-methionine (Kidd et al., 1997) in young (1 to 18 d) broilers. PNM has also been used to successfully study methionine deficiency in broilers (Thomas et al., 1991; Baker et al., 1996; Emmert et al., 1996).

The two major nutritional concerns with feeding PNM to poultry have been 1) its low level of threonine (because purified methionine and lysine have been available at affordable prices for some time) and 2) its vitamin content (Ogunmodede, 1981; Oloyo and Ogunmodede, 1998). The major non-nutritional concern about feeding
TABLE 1. Composition of the experimental diets

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Composition (%)</th>
<th>Composition (%)</th>
<th>Composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, ground</td>
<td>66.760</td>
<td>57.963</td>
<td>49.158</td>
</tr>
<tr>
<td>Peanut meal</td>
<td>21.355</td>
<td>28.415</td>
<td>35.476</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Poultry grease</td>
<td>2.072</td>
<td>3.718</td>
<td>5.363</td>
</tr>
<tr>
<td>L-Threonine</td>
<td>0.057</td>
<td>0.078</td>
<td>0.099</td>
</tr>
<tr>
<td>L-Tryptophan</td>
<td>0.040</td>
<td>0.042</td>
<td>0.044</td>
</tr>
<tr>
<td>DL-Methionine</td>
<td>0.210</td>
<td>0.261</td>
<td>0.322</td>
</tr>
<tr>
<td>L-Lysine ( \text{HCl} )</td>
<td>0.343</td>
<td>0.391</td>
<td>0.446</td>
</tr>
<tr>
<td>Limestone</td>
<td>7.675</td>
<td>7.645</td>
<td>7.614</td>
</tr>
<tr>
<td>Defluorinated phosphate</td>
<td>0.864</td>
<td>0.862</td>
<td>0.860</td>
</tr>
<tr>
<td>Common salt</td>
<td>0.300</td>
<td>0.300</td>
<td>0.300</td>
</tr>
<tr>
<td>Vitamin premix(^{1})</td>
<td>0.250</td>
<td>0.250</td>
<td>0.250</td>
</tr>
<tr>
<td>Mineral premix(^{2})</td>
<td>0.075</td>
<td>0.075</td>
<td>0.075</td>
</tr>
</tbody>
</table>

Composition by analysis

- **Protein:** 21.00 21.00 21.00 21.00 21.00 21.00
- **ME\(_g\) (kcal/g):** 2.90 2.90 2.90 2.90 2.90 2.90
- **Crude fiber:** 4.63 4.63 4.63 4.63 4.63 4.63
- **Threonine:** 0.58 0.58 0.58 0.58 0.58 0.58
- **Lysine:** 0.88 0.88 0.88 0.88 0.88 0.88
- **Methionine + cystine:** 0.79 0.79 0.79 0.79 0.79 0.79
- **Tryptophan:** 0.22 0.22 0.22 0.22 0.22 0.22
- **Isoleucine:** 0.64 0.64 0.64 0.64 0.64 0.64
- **Valine:** 0.65 0.65 0.65 0.65 0.65 0.65

1. Trace mineral premix provided the following in milligrams per kilogram of diet: Mn, 60; Zn, 50; Fe, 30; Cu, 5; I, 1.5.
2. Vitamin premix provided the following per kilogram of diet: vitamin A, 6,614 IU from trans-retinyl acetate; cholecalciferol, 705 IU; vitamin E, 13 IU from all-rac-tocopherol acetate; riboflavin, 6.6 mg; Ca pantothenate, 12 mg; nicotinic acid, 39 mg; vitamin B12, 0.011 mg; thiamine, 1.3 mg (as menadione sodium bisulfate complex); folic acid, 0.72 mg; D-biotin, 0.055 mg; thiamine, 1.1 mg (as thiamine mononitrate); ethoxyquin, 125 mg.
3. Estimated from ingredient composition tables (NRC, 1994).
5. Degussa Corporation, Allendale, NJ.

PNM has been its aflatoxin content: peanuts with evidence of mold may not be sold for human consumption but are crushed for oil and meal production (Dehuri et al., 1994; Samuel et al., 2002; Thirumala-Devi et al., 2002). Aflatoxicosis is a genuine concern for poultry producers, and aflatoxin levels should be monitored in feed ingredients.

Because the relatively recent introduction of purified threonine at affordable prices for animal production, Costa et al. (2001) demonstrated that broilers fed a diet based on corn and a modern solvent extracted PNM supplemented with methionine, lysine, and threonine performed satisfactorily compared to those fed balanced corn- and SBM-based diets. Indeed, in parts of the world, PNM is the standard protein source against which other ingredients are compared (Cilly et al., 1977; Krishnappa et al., 1979; Olomu and Offiong, 1980, 1985; Onwudike, 1986; Ologhobo, 1991; Aletor and Ononimoyo, 1992; Rashesheker et al., 1993; Sharma et al., 1993; Venkataraman et al., 1994; Nagalakshmi et al., 1996; Begum et al., 1997; Donkoh et al., 1999; Adeyemi et al., 2001; Naulaia and Singh, 2002).

The experiment reported here was conducted to test the hypothesis that layers fed corn- and PNM-based diets would perform as well as those fed corn- and SBM-based diets, when adequately supplemented with methionine, lysine, and threonine. The protein sources were compared at three protein levels.

**MATERIALS AND METHODS**

Hyline W-36 White Leghorn pullets\(^ {3}\) were reared according to the breeder’s management guide.\(^ {3}\) When the birds were 21 wk of age, two birds were housed per 30.5 by 40.6 cm wire cage, given feed and water ad libitum, and subjected to 15L:9D per day. Six replicates of four cages each were randomly assigned to each diet. The PNM was guaranteed to have less than 9 \( \mu \text{g} \) aflatoxin/kg. Feeding of the experimental diets began when the...
birds were 22 wk of age. The experiment had a 2 × 3 factorial arrangement of treatments with three levels of protein (16, 18.5, and 21%) and two protein sources (SBM and PNM; Table 1). Amino acid minimums were kept proportional to dietary protein level.

All eggs laid on 2 consecutive d during each 2-wk period were weighed. Egg production and feed consumption were calculated on a hen-day basis. Haugh units, egg specific gravity, and yolk color were measured after 4, 8, and 12 wk of feeding the diets, (using a reflectance spectrophotometer4 and a Roche Color Fan5). In addition, Haugh units were recorded for eggs collected at 30 wk of age and stored for 14 d at two temperatures (4 and 20°C). The experiment began in June, and minimum temperatures were maintained at 20°C, but the only cooling was by fan ventilation. For analysis, the 12 wk experiment was arbitrarily divided into 4-wk periods. Body weight was measured at the beginning of the experiment. The data were subjected to analysis of variance and means were separated by Duncan’s new multiple range test following analysis of variance.

**RESULTS**

The chemical analyses of the diets compared favorably with the nutrient values predicted from NRC (1994) ingredient composition tables (Table 1). Only 3 of 288 hens died during the experiment, and this mortality was not related to dietary treatment. Egg production peaked at 95.1 ± 0.8% at wk 24 for the corn- and PNM-fed hens and 96.4 ± 0.8% at wk 25 for the corn- and SBM-fed hens. Production remained above 88.8% for all treatment groups through wk 34, and there were no significant differences in egg production detected due to protein source or protein level (Table 2). Egg mass output results were similar to egg production results.

Significant interactions between protein source and level were observed for feed consumption and BW gain. Hens fed the low protein corn- and PNM-based diet ate the least and had the smallest BW gains, whereas hens fed the high protein corn- and PNM-based diet ate the most and had the largest BW gains. No differences were observed for feed efficiency in terms of feed per egg or per kilogram of eggs produced. Average egg size was affected by protein source during the first half of the experiment (Table 3). Protein level was consistently proportional to egg weight with observed differences (P < 0.01) for five of the six times eggs were weighed while the birds were being fed the experimental diets.

Interior egg quality, as indicated by Haugh units, was consistently better for the corn- and PNM-fed hens (P < 0.05) when the hens were 26 and 30, but not 34, wk of age (Table 4). The differences in interior quality were still evident after 2 wk of storage. Similar mean differences due to protein source when eggs were held at 4 or 20°C were observed (2.87 vs. 2.74 Haugh units), but because variability was higher in eggs stored at 20°C, significant differences were detected after storage at 4 but not 20°C.

The PNM-fed hens laid eggs with slightly less redness in their yolks than SBM fed hens at 26 and 30 wk of age (P < 0.05; Table 5). Increasing the protein level of hen diets (less corn) decreased the redness of the yolks at

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4Minolta Chroma Meter CR-300, Minolta Corp., Ramsey, NJ.
5Hoffman-LaRoche, Inc., Nutley, NJ.
26, 30, and 34 wk of age ($P < 0.05$). Increasing dietary protein level (less corn) also decreased the amount of yellowness observed in the yolks at 30 and 34 wk of age ($P < 0.05$). The differences measured spectrophotometrically were also detected visually using the Roche Color Yellowness meter. Yolks appeared slightly darker with more corn and SBM vs. PNM (Table 6). The specific gravity was lower in eggs from PNM fed hens at 26, 30, and 34 wk of age (Table 7).

### DISCUSSION

These results demonstrate that modern solvent-extracted PNM can provide the major portion of dietary protein, nitrogen, and vitamin B-12 to laying hens. The efficiency of PNM as a dietary ingredient is not compromised when 18% SBM or 30% PNM is substituted for corn in the diet. The use of solvent-extracted PNM has a number of advantages, including lower costs, higher protein content, and better availability than traditional peanut meals.
TABLE 5. The color of eggs produced by hens fed corn and peanut meal (PNM) or corn and soybean meal (SBM) based diets from 22 to 34 wk of age, measured spectrophotometrically

| Source | Level (%) | L (Lightness) | a (Redness) | b (Yellowness) | L (Lightness) | a (Redness) | b (Yellowness) | L (Lightness) | a (Redness) | b (Yellowness) |
|--------|-----------|---------------|-------------|---------------|---------------|-------------|---------------|---------------|-------------|-------------|---------------|
| PNM    | 16.00     | 52.14 ± 0.29  | -1.93 ± 0.15ab | 45.17 ± 0.35  | 53.05 ± 0.42  | -3.54 ± 0.16b | 44.06 ± 0.66a | 53.21 ± 0.27  | -3.17 ± 0.43a | 42.85 ± 0.44b |
| PNM    | 18.50     | 52.28 ± 0.36  | -2.78 ± 0.19a  | 43.16 ± 0.83  | 52.55 ± 0.29  | -3.15 ± 0.19b  | 42.22 ± 0.61ab | 52.54 ± 0.44  | -3.95 ± 0.11a  | 41.84 ± 0.37b |
| PNM    | 21.00     | 51.75 ± 0.16  | -3.43 ± 0.17a  | 41.64 ± 0.62  | 52.35 ± 0.37  | -4.25 ± 0.08a  | 41.00 ± 0.69a  | 52.18 ± 0.12  | -4.75 ± 0.13a  | 39.33 ± 0.47a |
| SBM    | 16.00     | 52.22 ± 0.42  | -1.77 ± 0.16a  | 44.81 ± 0.92  | 53.51 ± 0.30  | -2.99 ± 0.09a  | 43.81 ± 0.83a  | 53.59 ± 0.27  | -3.58 ± 0.17a  | 43.68 ± 0.50a |
| SBM    | 18.50     | 52.14 ± 0.26  | -2.31 ± 0.18a  | 38.31 ± 7.68  | 52.03 ± 0.15  | -3.31 ± 0.10ab | 43.37 ± 0.73ab | 52.45 ± 0.32  | -3.71 ± 0.14ab | 43.03 ± 0.69ab |
| SBM    | 21.00     | 52.84 ± 0.39  | -3.18 ± 0.18a  | 42.92 ± 0.68  | 52.59 ± 0.39  | -4.12 ± 0.24c  | 41.61 ± 0.41bc | 52.77 ± 0.78  | -4.50 ± 0.14cd | 40.04 ± 0.50f |

Main effect means

PNM: 18.50 52.78 ± 0.26  52.05 ± 0.39c  44.06 ± 0.66a  52.54 ± 0.44  41.84 ± 0.37b  52.18 ± 0.12  41.00 ± 0.69a  39.33 ± 0.47a

SBM: 16.00 52.22 ± 0.42  52.51 ± 0.30  43.16 ± 0.83  52.35 ± 0.37  41.64 ± 0.62  52.18 ± 0.12  41.00 ± 0.69a  39.33 ± 0.47a

ANOVA

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Pr &gt; F</th>
<th>Source × level</th>
<th>df</th>
<th>Pr &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.0555</td>
<td>0.0046</td>
<td>0.6199</td>
<td>0.3753</td>
<td>0.0097</td>
</tr>
<tr>
<td>Level</td>
<td>2</td>
<td>0.7522</td>
<td>0.0001</td>
<td>0.4141</td>
<td>0.3251</td>
</tr>
<tr>
<td>Source × level</td>
<td>2</td>
<td>0.0796</td>
<td>0.6527</td>
<td>0.6150</td>
<td>0.3335</td>
</tr>
<tr>
<td>Error</td>
<td>30</td>
<td>0.1278</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values with no common superscript differ (P < 0.05) when tested with Duncan’s new multiple range test following analysis of variance.

Values represent the mean ± standard error of six replicate groups of 12 hens each.

References (Page 1278)
TABLE 6. The color of eggs produced by hens fed corn and peanut meal (PNM) or corn and soybean meal (SBM) based diets from 22 to 34 wk of age, measured with a roche color fan1

<table>
<thead>
<tr>
<th>Source</th>
<th>Level (%)</th>
<th>26</th>
<th>30</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNM</td>
<td>16.00</td>
<td>9.89 ± 0.19</td>
<td>8.67 ± 0.38</td>
<td>6.89 ± 0.24ab</td>
</tr>
<tr>
<td>PNM</td>
<td>18.50</td>
<td>9.00 ± 0.23</td>
<td>8.72 ± 0.34</td>
<td>6.44 ± 0.24ab</td>
</tr>
<tr>
<td>PNM</td>
<td>21.00</td>
<td>8.94 ± 0.50</td>
<td>8.06 ± 0.33</td>
<td>5.83 ± 0.28ab</td>
</tr>
<tr>
<td>SBM</td>
<td>16.00</td>
<td>9.22 ± 0.49</td>
<td>9.11 ± 0.20</td>
<td>7.40 ± 0.22ab</td>
</tr>
<tr>
<td>SBM</td>
<td>18.50</td>
<td>9.61 ± 0.22</td>
<td>8.67 ± 0.19</td>
<td>7.11 ± 0.14ab</td>
</tr>
<tr>
<td>SBM</td>
<td>21.00</td>
<td>8.94 ± 0.32</td>
<td>8.44 ± 0.14</td>
<td>5.78 ± 0.22ab</td>
</tr>
</tbody>
</table>

Main effect means
PNM 9.28 ± 0.21 8.48 ± 0.20 6.39 ± 0.17
SBM 9.26 ± 0.23 8.74 ± 0.12 6.73 ± 0.21

ANOVA
Source df Pr > F Level df Pr > F Source × level df Pr > F
1 0.9460 0.2611 0.2286 0.0771 0.0001 Source × level 0.2039 0.6173 0.2601
2 0.2286 0.0771 0.0001 Error 30 0.4777 0.5816 0.0314
2 0.2286 0.0771 0.0001 Error 30 0.9390 0.2256 0.4296

1Values with no common superscript differ (P < 0.05) when tested with Duncan’s new multiple range test following analysis of variance.
1Values represent the mean ± standard error of six replicate groups of 12 hens each.

TABLE 7. The specific gravity of eggs produced by hens fed corn and peanut meal (PNM) or corn and soybean meal (SBM) based diets from 22 to 34 wk of age1

<table>
<thead>
<tr>
<th>Source</th>
<th>Level (%)</th>
<th>26</th>
<th>30</th>
<th>34</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNM</td>
<td>16.00</td>
<td>1.087 ± 0.001a</td>
<td>1.083 ± 0.001c</td>
<td>1.083 ± 0.001cd</td>
</tr>
<tr>
<td>PNM</td>
<td>18.50</td>
<td>1.087 ± 0.001ab</td>
<td>1.084 ± 0.001bc</td>
<td>1.084 ± 0.001bc</td>
</tr>
<tr>
<td>PNM</td>
<td>21.00</td>
<td>1.085 ± 0.001b</td>
<td>1.083 ± 0.001c</td>
<td>1.081 ± 0.001d</td>
</tr>
<tr>
<td>SBM</td>
<td>16.00</td>
<td>1.088 ± 0.001a</td>
<td>1.087 ± 0.001a</td>
<td>1.086 ± 0.001a</td>
</tr>
<tr>
<td>SBM</td>
<td>18.50</td>
<td>1.088 ± 0.001a</td>
<td>1.086 ± 0.001a</td>
<td>1.085 ± 0.001ab</td>
</tr>
<tr>
<td>SBM</td>
<td>21.00</td>
<td>1.089 ± 0.001a</td>
<td>1.086 ± 0.001a</td>
<td>1.084 ± 0.001abc</td>
</tr>
</tbody>
</table>

Main effect means
PNM 1.086 ± 0.001b 1.083 ± 0.001b 1.082 ± 0.001b
SBM 1.088 ± 0.001a 1.086 ± 0.001a 1.085 ± 0.001a

ANOVA
Source df Pr > F Level df Pr > F Source × level df Pr > F
1 0.0016 0.0001 0.0001 Source × level 0.4777 0.5816 0.0314
2 0.2286 0.0771 0.0001 Error 30 0.4777 0.5816 0.0314
2 0.2286 0.0771 0.0001 Error 30 0.4777 0.5816 0.0314
2 0.2286 0.0771 0.0001 Error 30 0.4777 0.5816 0.0314

1Values with no common superscript differ (P < 0.05) when tested with Duncan’s new multiple range test following analysis of variance.
1Values represent the mean ± standard error of six replicate groups of 12 hens each.

ERS, as well as broilers (Costa et al., 2001) support the hypothesis that solvent-extracted PNM can be an excellent replacement for SBM in poultry diets. Future studies on the metabolizable energy content, factors affecting eggshell quality, and amino acid composition and availability (digestibility) of modern peanut cultivars may provide valuable information for egg producers.

REFERENCES


