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# Amino Acid Density and L-Threonine Responses in Ross Broilers[1,2]

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**Abstract:** An experiment was conducted to determine the effects of feeding broilers diets differing in amino acid density during the finisher period. Also, the impact of L-threonine addition to high (H) or low (L) amino acid density diets was determined. Ross x 708 male broiler chicks were placed in floor pens and fed common diets from d 1 to 34 that met or exceeded NRC (1994) recommendations. From d 35 to 55, broilers were fed diets consisting of H (digestible Lys of 0.88%, TSAA of 0.69%, and Thr of 0.59%) or L (digestible Lys of 0.82%, TSAA of 0.64%, and Thr of 0.55%) amino acid density, with or without dietary L-threonine (9 replications each of 4 treatments). On d 55, live performance and carcass characteristics were determined. There were no interactions or L-threonine effects ($P>0.05$) on live performance or carcass traits of broilers. Body weight and feed intake did not differ due to amino acid density. Birds fed diets containing H amino acid density had higher ($P< 0.05$) breast meat yield ($P = 0.06$ relative to BW; $P = 0.01$ relative to carcass weight) and lower ($P<0.05$) feed conversion and percentage abdominal fat than birds fed diets with L amino acid density. Minimizing essential amino acid excesses through dietary L-threonine inclusion did not improve or adversely affect performance. An economic analysis indicated that decreasing amino acid density (H to L) in 35 to 55 d broilers resulted in an income loss of $0.10/live bird.

**Key words:** Amino acid density, broiler, threonine, carcass yield

## Introduction

Maximizing monetary margins over input costs in integrated broiler operations, or any other sales driven business, must be a key goal to attain long term profits. Because feed represents over half the live production costs in an integrated broiler operation, feed cost reduction rather than feed cost optimization is often employed. Furthermore, change occurs continuously within and between commercial broiler strains (i.e., growth and tissue accretion rates) deeming nutritional optimization as problematic. Hence, feeding programs should be strain specific (Smith and Pesti, 1998), while addressing feed cost optimization.

In an effort to optimize feed cost and overall profit, research studies delineating the impact of amino acid density in high yield commercial broiler strain crosses have increased. Both early and late developing broiler strains have been shown to have suppressed breast and thigh yields during summer months when amino acid density is reduced (Dozier and Moran, 2001). Live performance and carcass responses of male broilers to amino acid density is greater than that of female broilers (Lemme *et al.*, 2003; Eits *et al.*, 2003; Corzo *et al.*, 2004; Kidd *et al.*, 2004). Feeding Hybro-G broilers low and high planes of balanced amino acids to energy (11 to 26 and 26 to 41 d) showed benefits to high amino acids in both periods, and that the broiler's response was dependent on the early (11 to 26 d) period (Eits *et al.*, 2003). Research evaluating the impact of amino acid density in commercial broilers (Ross 308, Ross 508, and Arbor Acres Plus) demonstrated the positive impact of high amino acid density diets (unbalanced and balanced), in addition to accentuating the importance of amino acid nutrition from d 0 to 14 (Lemme *et al.*, 2003; Corzo *et al.*, 2004; Kidd *et al.*, 2004). Because high amino acid nutrition early in a bird's life is economically desirable, this research was conducted to assess the impact of feeding low and high amino acid planes of nutrition in the finishing period. It was also an objective to determine the impact of L-threonine addition to the diets differing in amino acid density.

## Materials and Methods

**Birds and management:** Three hundred-fifty Ross x 708 male broiler chicks were obtained from a commercial hatchery, divided into two groups, and placed in two equally constructed and designed rooms measuring 4.6 x 9.0m. Vaccination program consisted of Marek's virus *in ovo* at d 18 of incubation, and a coarse spray of Newcastle disease virus and infectious bronchitis virus

Table 1: Test diets (%) and nutrient composition

| Ingredients | High density | | Low density | |
|---|---|---|---|---|
| | - L-Threonine | + L-Threonine | - L-Threonine | + L-Threonine |
| Corn | 67.592 | 70.250 | 71.179 | 73.497 |
| Soybean meal | 22.109 | 19.672 | 19.092 | 16.967 |
| Poultry fat | 4.478 | 4.095 | 3.874 | 3.540 |
| Poultry meal | 2.500 | 2.500 | 2.500 | 2.500 |
| Dicalcium Phosphorus | 1.310 | 1.327 | 1.330 | 1.345 |
| Limestone | 0.901 | 0.906 | 0.908 | 0.913 |
| NaCl | 0.489 | 0.489 | 0.488 | 0.488 |
| Premix[1] | 0.250 | 0.250 | 0.250 | 0.250 |
| DL-Met | 0.163 | 0.185 | 0.141 | 0.160 |
| L-Lys Hcl | 0.111 | 0.188 | 0.128 | 0.195 |
| Sacox 60 | 0.050 | 0.050 | 0.050 | 0.050 |
| Hy D | 0.025 | 0.025 | 0.025 | 0.025 |
| Choline Cl | 0.025 | 0.033 | 0.034 | 0.041 |
| L-Threonine | 0 | 0.034 | 0 | 0.029 |
| Calculated composition[2] | | | | |
| d Lys, % | 0.88 | 0.88 | 0.82 | 0.82 |
| d TSAA, % | 0.69 | 0.69 | 0.64 | 0.64 |
| d Thr, % | 0.59 | 0.59 | 0.55 | 0.55 |
| d Ile, % | 0.65 | 0.62 | 0.60 | 0.57 |
| d Val, % | 0.74 | 0.70 | 0.69 | 0.66 |
| d Trp, % | 0.19 | 0.18 | 0.17 | 0.16 |
| d Arg, % | 1.05 | 0.98 | 0.96 | 0.90 |
| CP, % | 17.84 | 17.01 | 16.70 | 15.98 |
| ME, kcal/kg | 3,225 | 3,225 | 3,225 | 3,225 |
| Ca, % | 0.80 | 0.80 | 0.80 | 0.80 |
| Avail. Phosphorus, % | 0.40 | 0.40 | 0.40 | 0.40 |
| Na, % | 0.22 | 0.22 | 0.22 | 0.221 |

[1]Premix provided the following per kg of diet: Vitamin A (Vitamin A acetate) 7,718 IU; cholecalciferol 2,200 IU; Vitamin E (source unspecified) 10 IU; menadione, 0.9 mg; $B_{12}$, 11mg; choline, 379 mg; riboflavin, 5.0 mg; niacin, 33 mg; D-biotin, 0.06 mg; pyridoxine, 0.9mg; ethoxyquin, 28mg; manganese, 55mg; zinc, 50mg; iron, 28mg; copper, 7mg; iodine, 1mg; selenium, 0.2mg.
[2]Digestible coefficients were based on True digestibility of essential amino acids for poultry, Revision 7, Ajinomoto Heartland LLC.

at 1 d of age. Subsequent vaccinations were not administered. Birds were provided 23 h light until termination of the experiment.

**Design, Measurements and dietary treatments:** At 35 d of age, birds were transferred to the experimental facility randomly, placed in floor pens (36 pens measuring 1.08 $m^2$ each), and weighed by pen (9 birds per pen). The experimental facility was a curtain-sided house. Forced-air gas heaters were used for heating. Cooling was accomplished with evaporative cool cells and negative pressure ventilation. Each pen contained a pan feeder, a nipple drinker line (4 nipples per pen), and soft - wood shavings as bedding. The soft - wood shavings had been previously used as bedding for numerous flocks. Experimental feed was weighed by pen, added to the pan feeders (16 kg capacity), and birds consumed the experimental diets to d 55. Live performance measurements for the 35 to 55 d period consisted of BW gain, feed intake, feed conversion, (using the weight of mortality to correct feed consumption data), and mortality. All diets were steam pelleted and were based on corn, soybean meal, and poultry meal (Table 1). Diets were formulated on the following digestible amino acid ratios to lysine: total sulfur amino acids, 78; threonine, 67; isoleucine, 73; valine, 84; tryptophan, 21; and arginine, 117. Dietary treatments consisted of high (H) or low (L) amino acid density with or without the inclusion of L-threonine (4 treatments each having 9 replications). Therefore, diets differed only in amino acid levels as amino acid ratios to lysine were similar. L-threonine was allowed to enter least cost formulation and the isoleucine minimum served as the nutrient constrain in formulation to which crude protein was set in the treatment diets containing L-threonine. Composite samples of test diets were obtained after pelleting to assure nutrient values were in agreement with those calculated.

**Measurements:** Pen BW were obtained at d 33 and 55.

Table 2: Impact of diets differing in amino acid density with or without L-Thr on live performance and carcass traits in Ross x 708 male broilers from 35 to 55 d

| Dietary treatments[1] | | BW gain | Feed intake | Feed conversion | Carcass yield[3] | Carcass yield[4] | Breast yield[5] | Breast yield[6] | Abdominal fat[7] |
|---|---|---|---|---|---|---|---|---|---|
| Diet | L-Thr[2] | Kg | g/bird/d | Kg/Kg | (%) | | | | |
| H | | 1.664 | 194[a] | 2.34[a] | 72.36 | 74.32 | 22.43 | 30.17[a] | 1.96[a] |
| L | | 1.608 | 197[b] | 2.53[b] | 71.98 | 74.18 | 21.83 | 29.43[b] | 2.20b |
| | - | 1.647 | 196 | 2.42 | 72.43 | 74.45 | 22.21 | 29.82 | 2.06 |
| | + | 1.625 | 195 | 2.44 | 71.91 | 74.04 | 22.05 | 29.78 | 2.14 |
| H | - | 1.668 | 194 | 2.33 | 72.52 | 74.46 | 22.50 | 30.43 | 1.92 |
| H | + | 1.659 | 194 | 2.35 | 72.19 | 73.89 | 22.36 | 30.13 | 2.00 |
| L | - | 1.626 | 198 | 2.52 | 72.33 | 74.44 | 21.92 | 29.43 | 2.14 |
| L | + | 1.590 | 196 | 2.53 | 71.62 | 74.20 | 21.75 | 29.42 | 2.27 |
| SEM | | 0.033 | 2 | 0.061 | 0.44 | 0.44 | 0.30 | 0.27 | 0.06 |
| Source of Variation | | | | | | | | | |
| Diet | | 0.100 | 0.206 | 0.011 | 0.400 | 0.758 | 0.063 | 0.012 | 0.001 |
| L-Thr | | 0.502 | 0.589 | 0.807 | 0.252 | 0.366 | 0.606 | 0.871 | 0.067 |
| Diet x L-Thr | | 0.682 | 0.709 | 0.987 | 0.681 | 0.716 | 0.965 | 0.888 | 0.717 |

[1]Diets were formulated to meet digestible ratios to lysine and thus, although diet density differs, diet ratios to Lys do not. CP levels for H and L in the diets without L-Thr (-) were 17.84 and 16.70, respectively, and CP levels for H and L in the diets with L-Thr (+) were 17.01 and15.98, respectively.

[2]L-Thr (L-threonine) was allowed to enter formulation freely in diets series (+), and its inclusion level in the H and L diets was 0.034 and 0.029, respectively.

[3]Represents carcass without abdominal fat relative to processing BW. BW at processing averaged 3.6 kg/bird.

[4]Represents carcass with abdominal fat relative to processing BW.

[5]Represents Pectoralis major, Pectoralis minor, and back rib meat (skin-less, bone-less) relative to live BW at processing.

[6]Represents Pectoralis major, Pectoralis minor, and back rib meat (skin-less, bone-less) relative to carcass weight.

[7]Represents abdominal fat relative to processing BW.

Mortality was measured daily. Body weight gain, feed intake, and feed conversion were measured for the 35 to 55 d period. Six birds per pen were selected for processing at d 55, weighed in a group, and transported to the pilot processing plant. Processing methodology follows that previously described (Kidd *et al.*, 2002). Carcass measurements obtained were carcass weight, abdominal fat weight, and total breast meat weight (skinless).

**Economic model program:** Using Microsoft Excel (2002), a program was created to assess monetary income for broiler chickens in a de-bone market fed H or L amino acid density because these diets differed greatly in cost and impact bird performance in differing manners. The cost inputs in the model were based on February 2005 ingredient and chicken prices ($ 1.51 USD for skinless breast meat) and broiler performance was taken from responses presented herein as affected by dietary amino acid density with and without L-threonine. Diet costs for H and L, without L-threonine, were $154.02 and $148.50 USD/metric ton, respectively. The amino acid contributing feed ingredient prices ($, USD) per metric ton were: corn, 87.08; soybean meal, 214.94; poultry meal, 209.43, DL-methionine, 1873.83; and L-lysine HCl, 1653.38. The mathematical calculations in the economic program were used to calculate monetary return per bird.

**Statistical analysis:** The design was a randomized complete block. The four treatments of the factorial arrangement of two amino acid densities and two L-threonine levels were analyzed using the General Linear Models procedure of SAS (SAS Institute, 1998) Differences among means ($P \leq 0.05$) were separated with repeated t test using the LSMEANS option of SAS (SAS Institute, 1998). Pen was the experimental unit for all analyses.

## Results and Discussion

The diets formulated to differ in amino acid density were easily achieved as calculated amino acid and protein composition was in agreement with analyzed levels. The ability of a diet reduced in CP to support growth and tissue accretion needs of male broilers in the finishing period was tested. Moreover, a further decrease in the amino acid pattern was accomplished by the dietary inclusion of L-threonine in an average inclusion level of 320g/metric ton. It must be pointed out that although the H and L diets had a decrease in CP with the addition of L-threonine, 0.83% and 0.72%, respectively, they met the essential amino acid ratios to lysine. Hence, the diets fortified with L-threonine fostered minimization of essential amino acid excesses: which can be costly. No interactions or L-threonine effects occurred in the results presented herein (Table 2), indicating that diets minimized for amino acid excesses (i.e., those

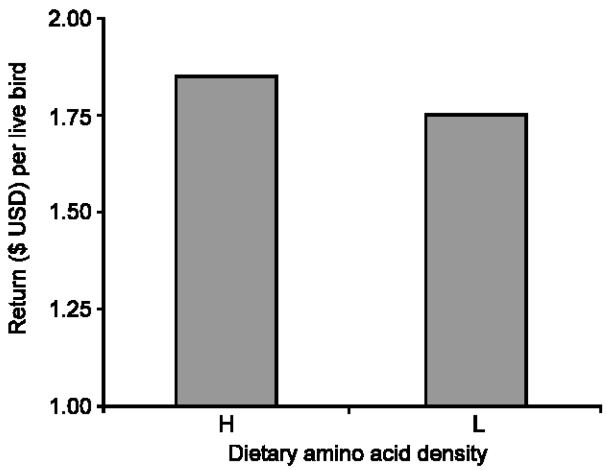


Fig. 1: Impact of amino acid diet density from d 35 to 55 on monetary income per bird at d 55. Bars represent income in $ USD for birds fed H diets and birds fed L diets. Growth performance inputs in the economic model from 1 to 34 d were the same between treatments. Diet costs for H and L in $ USD/metric ton were 154.02 and 148.50, respectively.

containing L-threonine) resulted in equal bird responses in comparison to birds fed diets without L-threonine and marginally higher in CP. These results agree with past findings in that the dietary inclusion of L-threonine (up to 600 g/metric ton) did not affect growth or carcass attributes in broilers in comparison to birds fed diets without L-threonine (Kidd *et al*., 2002). Thus, although the diets in the research presented herein and that of Kidd *et al*. (2002) had adequate levels of essential amino acids, the marginal reduction in levels of the less limiting amino acids (i.e., isoleucine, valine, arginine, and tryptophan) did not impair growth or carcass characteristics.

Body weight, feed intake, carcass yield, and breast meat yield relative to live body weight did not differ in birds fed varying levels of amino acid density. However, birds fed H amino acid density had lower ($P < 0.05$) feed conversion and abdominal fat, and greater ($P < 0.05$) breast meat yield relative to carcass containing abdominal fat percentage than birds fed L amino acid density diets. These findings are in agreement with recent research on amino acid density in male broilers (Eits *et al*., 2003; Lemme *et al*., 2003; Corzo *et al*., 2004; Kidd *et al*., 2004).

The research by Kidd *et al*. (2002) points to economic advantages of dietary L-threonine inclusion as indicated by good broiler performance in diets with marginally reduced CP and cost. However, determining the economic optimization of amino acid feed programs in high yield broilers is problematic. An economic model was created to assess monetary income in a practical situation in dietary treatments presented herein that differed ($P < 0.05$; i.e., amino acid density), as diets differing in L-threonine did not differ. Hence, broiler growth and carcass trait predictions using means generated from birds fed H and L diets was compared in a model using February 2005 feed ingredient prices in the United States. Although the L diet was lower ($5.52 USD/metric ton) in cost compared to the H diet, it resulted in a net loss of $0.10/bird to market as compared to birds fed the H diet (Fig. 1). It has been suggested that feeding programs designed to meet amino acid needs of high yield broilers must not be low in any critical amino acid minimum in pre-starter or starter periods (Kidd *et al*., 2004). Eits *et al*. (2003) indicated that amino acid feeding programs from 11 to 26 and 26 to 41 d of age should both be optimized to support good growth and breast accretion. Although decreasing amino acid density results in large decreases in diets costs, especially in the finishing periods, care must be taken as results presented herein indicate that the feed reduction cost as achieved by dietary amino acid density reduction may not be profitable.

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Abbreviation key: H (high), L (low)