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Influence of Adding Synthetic Lysine in Corn-Soy Diets for Commercial Leghorns

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Abstract: An experiment was conducted as a 2 x 5 factorial to determine if increasing dietary lysine in corn-soy diets formulated based on lysine improves egg weight (EW) and egg production (EP) in commercial Leghorns. A set of five corn-soy diets with similar levels of energy were formulated based on lysine to contain 0.97, 0.92, 0.87, 0.83 and 0.79% lysine. These diets contained no synthetic lysine. A second set of five diets were formulated by supplementing 0.097% synthetic lysine to each diet in the first set. Hy-Line W36 hens (n=1,280; 21 wk of age) were randomly assigned in replicates of 16 hens to the ten dietary treatments for 16 weeks. Feed consumption (FC), EP, EW and egg specific gravity (ESG) were measured. Adding synthetic lysine to diets formulated based on lysine had no significant effect on EP, EW, ESG or FC of hens. Also, amino acid density had no effect ($P > 0.05$) on EP, FC, or ESG. However, EW linearly increased ($P < 0.01$) as amino acid density increased. These results indicate that adding 0.097% additional synthetic lysine to corn-soy diets formulated based on lysine containing 0.79 to 0.97% lysine had no significant influence on performance of commercial Leghorns.

Key words: Amino acid density, egg weight, feed formulation, Leghorns, lysine

Introduction

National Research Council (NRC, 1994) indicates a daily methionine (M) plus cystine (C) requirement of 580 mg/hen and of 690 mg/hen for lysine (L) for the White-Egg layers consuming approximately 100 g feed/hen/d. These recommended values suggest a ratio of 0.84 between M+C and L. Based on the NRC recommended values of M+C and L for the laying hens, many diets were formulated based on L to contain a M+C/L ratio of 0.83. Harms and Ivey (1993) suggested that lysine is the second limiting amino acid in corn-soy diets after methionine. Previous studies have indicated that hens fed diets formulated based on protein using a M+C/L ratio of 0.68 produced more and heavier eggs than hens fed diets formulated based on lysine using a M+C/L ratio of 0.83 (Roland *et al*., 1995). Although the amount of methionine was similar in diets from the two formulation methods, more and heavier eggs were produced by hens fed diets formulated based on protein, however, hens fed diets formulated based on lysine produced more profits (Roland *et al*., 1995; Sohail and Roland, 1997). It was unclear why hens fed diets formulated based on lysine having methionine levels similar to diets formulated based on protein were unable to produce eggs similar in weight and number to hens fed diets formulated based on protein. It is possible that amino acid deficiency rather than protein per se may have been responsible for the lower egg production and egg weight (Sohail and Roland, 1997). Although hens fed diets formulated based on lysine were meeting the NRC recommendation, they consumed 150 to 200 mg less lysine/hen/d than hens fed diets formulated based on protein (Roland *et al*.,1995; Sohail and Roland, 1997). Because corn-soy diets formulated based on protein are high in lysine contents, it is possible that hens fed diets formulated based on lysine might be deficient in lysine (Sohail and Roland, 1997). To test this hypothesis, fish meal, which contains more lysine than soybean meal (NRC, 1994), was added as a source of lysine in diets formulated based on lysine to supply the same total sulfur amino acids (TSAA) and protein level but higher lysine (Sohail and Roland, 1997). Extra lysine supplied by fish meal increased egg production (EP) but not egg weight (EW). Because fishmeal contains an amino acid composition different from that of soybean meal (NRC, 1994) and its inclusion was also reported to improve digestibility of histidine, threonine, valine, isoleucine and lysine in ducklings (Farrell and Martin, 1995), it was not clear whether improvement in EP was due to lysine or other amino acids. The objective of this study was to determine if adding synthetic lysine to corn-soy diets formulated based on lysine would improve laying hen performance.

Materials and Methods

A study was conducted using randomized complete block design with a 2 x 5 factorial arrangement of treatments. In the first set corn-soy diets were formulated to supply 0.97, 0.92, 0.87, 0.83 and 0.79% lysine with no synthetic lysine added (Table 1) and maintaining a constant M+C/L ratio of 0.83. The second set of five diets was formulated by supplementing 0.097% synthetic lysine to the first set. These diets were fed ad libitum in mash form throughout the trial. Hy-Line W36 hens (n = 1,280; 21 wk of age) were randomly and equally assigned as replicates to the ten dietary treatments for 16 weeks. Each treatment contained eight replicates of 16 hens, housed four birds per cage (40.6

Table 1: Ingredients and nutrient composition of experimental diets formulated based on lysine

Ingredients	Diet				
	1[1]	2	3	4	5
	(%)				
Corn (8.6%)[2]	59.09	61.19	63.49	65.35	67.15
SBOM (48%)[2]	27.00	25.16	23.31	21.83	20.35
Granular limestone[3]	7.07	7.07	7.08	7.08	7.08
Hard shell[3]	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate[4]	1.84	1.85	1.86	1.87	1.88
Poultry oil	1.81	1.59	1.14	0.80	0.50
Salt (NaCl)	0.48	0.45	0.46	0.44	0.42
Vitamin premix[5]	0.25	0.25	0.25	0.25	0.25
Mineral premix[6]	0.25	0.25	0.25	0.25	0.25
DL-Methionine[7]	0.217	0.185	0.163	0.143	0.124
Nutrient composition					
Crude protein, %	18.04	17.34	16.65	16.10	15.54
ME, kcal/kg	2803	2814	2809	2809	2812
Methionine + cystine, %	0.81	0.76	0.72	0.69	0.65
Methionine, %	0.52	0.48	0.45	0.43	0.40
Lysine, %	0.97	0.92	0.87	0.83	0.79
Tryptophan, %	0.24	0.23	0.22	0.21	0.20
Threonine, %	0.67	0.64	0.61	0.59	0.57
Isoleucine, %	0.90	0.86	0.82	0.79	0.75
Calcium[8], %	4.00	4.00	4.00	4.00	4.00
Total phosphorus, %	0.67	0.66	0.66	0.65	0.65
Non-phytate P, %	0.45	0.45	0.45	0.45	0.45

[1]Synthetic lysine (78.6%) from BioKyowa Inc., Cape Girardeau, MO. 63701 was added (0.097%) to diets 1-5 to formulate diets 6 to 10. [2]Amino acid analysis of corn and soybean oil meal was determined by chemical analysis. [3]Calcium carbonate was supplied as limestone (16 x 120 U.S. mesh, 0.125 mm to 1.19 mm) and hard shell (4 x 8 U.S. mesh, 2.36 x 4.75 mm), Franklin Industrial Minerals, Lowell, FL. [4]Dynafos ®, IMC-Agrico Feed Ingredients, Bannockburn, IL 60015. Contains Ca 21.7%; P 18.5%. [5]Provided per kg of diet: vitamin A (as retinyl acetate), 8,000 IU; cholecalciferol, 2,200 ICU; vitamin E (as DL-alpha tocopheryl acetate), 8 IU; vitamin B_{12}, 0.02 mg; riboflavin, 5.5 mg; D-calcium pantothenic acid, 13 mg; niacin, 36 mg; choline, 500 mg; folic acid, 0.5 mg; vitamin B_1 (thiamin mononitrate), 1 mg; pyridoxine hydrochloride, 2.2 mg; d-biotin, 0.05mg; vitamin K (menadione sodium bisulfite complex), 2 mg. [6]Provided per kg of diet: manganese (manganous oxide), 65 mg; iodine (ethylene diamine dihydriodide), 1 mg; iron (ferrous carbonate), 55 mg; copper (copper oxide), 6 mg; zinc (zinc oxide), 55 mg; selenium (sodium selenite), 0.3 mg. [7]Degussa Corporation, Ridgefield Park, NJ.

cm x 45.7cm), in four adjacent cages. Hens in each replicate shared a feed trough and had access to Hart cups for drinking water. The replicates were equally distributed into the upper and lower cage levels to minimize cage level effect. An average daily house temperature of approximately 25.6 °C was maintained (28.9 °C during the day and 20 °C during the night). A step-up photoperiod increased light by 15 min per wk until 16 h light: 8 h dark was reached. Response criteria used to determine hen performance were: feed consumption (FC), EP, EW, egg specific gravity (ESG) and mortality. The FC and EP were measured weekly and mortality was recorded daily. The EW and ESG were measured biweekly from all eggs laid on two consecutive days. The ESG was determined using gradient saline solutions varying in specific gravity from 1.060 to 1.100 in 0.005 unit increments (Strong, 1989).

Data were subjected to ANOVA (Steel and Torrie, 1980) using General Linear Model procedure of SAS (SAS Institute, 1989). Regression analysis was conducted using orthogonal contrasts (Fisher and Yates, 1963). The statistical model (Cochran and Cox, 1957) used to determine performance criteria was:

$$Y_{ijkl} = F + L_i + M_j + C_k + LM_{ij} + LC_{ik} + MC_{jk} + LMC_{ijk} + e_{ijkl}$$

Where Y_{ijkl} is the individual observation, F is the overall mean, L_i is the lysine effect, D_j is the amino acid density effect, C_k is the cage level effect, LD_{ij}, LC_{ik}, DC_{jk}, and LDC_{ijk} are interactions and e_{ijkl} is the random error.

Results and Discussion

Feed consumption: Hens on average consumed approximately 82 g feed/hen/d (Table 2). Increasing amino acid density or supplementing feed by adding 0.097% synthetic lysine to diets formulated based on

Table 2: Influence of adding synthetic lysine to diets formulated[1] based on lysine and amino acid density on feed consumption of hens.

Dietary treatment	Feed consumption (g) by week				
	4	8	12	16	Average[2]
Lysine	NS[3]	NS	NS	NS	NS
Diets without added lysine (WL)	77.1	81.7	88.3	89.1	81.8
Diets with added lysine (AL)	76.7	82.3	88.4	89.3	81.9
SEM	0.35	0.49	0.60	0.45	0.33
Amino acid density	NS	NS	NS	NS	NS
1	77.0	82.2	88.1	89.1	81.7
2	77.6	81.3	88.6	90.2	82.2
3	76.8	82.8	88.7	89.3	81.9
4	76.2	81.9	87.8	90.1	82.0
5	77.1	81.7	88.5	87.4	81.3
SEM	0.56	0.77	0.95	0.72	0.52
Lysine x Amino acid density	NS	NS	NS	NS	NS
WL x 1	77.4	80.8	87.1	88.2	81.1
x 2	77.2	80.9	88.7	90.4	82.0
x 3	77.4	83.6	90.3	90.2	82.6
x 4	76.5	82.0	87.7	90.0	82.3
x 5	77.1	81.2	87.5	86.9	81.1
AL x 1	76.6	83.6	89.2	90.0	82.3
x 2	77.9	81.7	88.4	90.0	82.5
x 3	76.2	82.0	87.1	88.3	81.3
x 4	75.8	81.7	88.0	90.2	81.8
x 5	77.1	82.3	89.4	88.0	81.5
SEM	0.79	1.09	1.35	1.02	0.74

[1]WL diets 1 to 5 were formulated based on lysine keeping methionine (M) plus cystine (C) to lysine (L) ratio constant at 0.83 to supply 0.97, 0.92, 0.87, 0.83 and 0.79% lysine. AL diets 1 to 5 were formulated by adding 0.097% synthetic lysine to WL diets 1 to 5. [2]Average of 16 weeks. [3]NS = not significant (P > 0.05).

Table 3: Influence of adding synthetic lysine to diets formulated based on lysine[1] on lysine intake of hens

Diets		Dietary lysine (%)	Lysine Intake (mg)
Without added lysine (WL)	1	0.970	787
	2	0.920	754
	3	0.870	719
	4	0.830	683
	5	0.790	640
With added lysine (AL)	1	1.046	861
	2	0.996	822
	3	0.946	769
	4	0.906	741
	5	0.866	706

[1]WL diets 1 to 5 were formulated based on lysine keeping methionine (M) plus cystine (C) to lysine (L) ratio constant at 0.83 to supply 0.97, 0.92, 0.87, 0.83 and 0.79% lysine. AL diets 1 to 5 were formulated by adding 0.097% synthetic lysine to WL diets 1 to 5.

lysine had no effect on FC (P > 0.05). Hens consumed 640 to 787 mg lysine/hen/d when fed diets containing 0.79 to 0.97% lysine (Table 3). Supplementing 0.097% synthetic lysine to these diets increased lysine intake from 706 to 861 mg lysine/hen/d. These results were in agreement with the results of Prochaska *et al.* (1996), where incorporation of supplemental lysine had no significant effect on FC of hens fed diets containing 0.72, 0.89 and 1.15% lysine.

Egg production: All hens peaked around 89 to 92%, laying 90% and above for a period of 8 wk (Table 4). Increasing amino acid density had no significant effect on EP (P > 0.05), although adding lysine numerically increased EP of hens fed 4 of the 5 diets. There was no significant effect (P > 0.05) of increasing dietary lysine (0.097%) on EP. This was contrary to the report of Prochaska *et al.* (1996), where increasing lysine intake from 638 to 828 and 1,062 mg lysine/hen/d in 26 wk old hens increased EP. However, Prochaska *et al.*, 1996. used sorghum rather than corn in their experimental diets.

Egg weight: Egg weight increased linearly as amino acid density was increased (P < 0.01; Table 5). This increase in EW was observed within four weeks and

Table 4: Influence of adding synthetic lysine to diets formulated[1] based on lysine and amino acid density on egg production of hens

Dietary treatment	Hen day egg production (%) by week				
	4	8	12	16	Average[2]
Lysine	NS[3]	NS	NS	NS	NS
Diets without added lysine (WL)	89.40	89.90	90.10	84.70	89.00
Diets with added lysine (AL)	89.40	90.30	90.90	84.90	89.80
SEM	0.760	0.61	0.58	0.65	0.44
Amino acid density	NS	NS	NS	NS	NS
1	90.90	92.00	92.20	86.40	90.70
2	90.00	90.60	89.60	84.50	89.70
3	89.80	89.80	90.90	85.90	89.90
4	87.80	88.60	89.40	83.40	88.30
5	88.30	89.60	90.40	83.80	88.60
SEM	1.19	0.960	0.91	1.03	0.70
Lysine x Amino acid density	NS	NS	NS	NS	NS
WL x 1	90.90	92.10	91.10	85.80	90.20
WL x 2	89.60	89.10	88.10	84.40	88.80
WL x 3	91.60	91.30	92.40	86.10	90.30
WL x 4	88.50	87.80	89.40	83.50	88.00
WL x 5	86.40	89.40	89.30	83.60	87.80
AL x 1	91.00	91.90	93.20	86.90	91.20
AL x 2	90.40	82.10	91.20	84.60	90.50
AL x 3	88.10	88.30	89.40	85.80	89.40
AL x 4	87.20	89.30	89.40	83.30	88.60
AL x 5	90.20	89.70	81.40	83.90	89.50
SEM	1.69	1.36	1.29	1.46	0.99

[1]WL diets 1 to 5 were formulated based on lysine keeping methionine (M) plus cystine (C) to lysine (L) ratio constant at 0.83 to supply 0.97, 0.92, 0.87, 0.83 and 0.79% lysine. AL diets 1 to 5 were formulated by adding 0.097% synthetic lysine to WL diets 1 to 5. [2]Average of 16 weeks. [3]NS = not significant (P > 0.05).

Table 5: Influence of adding synthetic lysine to diets formulated[1] based on lysine and amino acid density on egg weight of hens

Dietary treatment	Egg weight (g) by week				
	4	8	12	16	Average[2]
Lysine	NS[3]	*	NS	NS	NS
Diets without added lysine (WL)	50.10	53.30	55.70	57.70	53.50
Diets with added lysine (AL)	49.70	53.40	55.60	57.7 0	53.40
SEM	0.14	0.16	0.15	0.17	0.12
Amino acid density	*L[5]	**L	**L	**L	**L
1	50.20	53.90	56.20	58.00	53.80
2	50.30	53.70	56.30	58.60	53.90
3	50.00	53.40	55.70	57.60	53.50
4	49.40	53.00	55.20	57.30	53.10
5	49.40	52.60	55.00	56.90	52.80
SEM	0.23	0.25	0.23	0.26	0.19
Lysine x Amino acid density	NS	NS	NS	NS	NS
WL x 1	50.30	53.50	55.90	57.40	53.60
x 2	50.50	53.60	56.50	58.80	53.90
x 3	49.80	53.30	55.50	57.60	53.40
x 4	49.90	53.00	55.50	57.30	53.40
x 5	49.90	52.80	55.40	57.10	53.00
AL x 1	50.10	54.20	56.40	58.50	54.10
x 2	50.10	53.80	56.20	58.50	53.90
x 3	50.20	53.50	56.00	57.60	53.60
x 2	49.00	52.90	54.90	57.20	52.90
x 2	49.00	52.40	54.70	56.60	52.60
SEM	0.32	0.35	0.33	0.37	0.27

[1]WL diets 1 to 5 were formulated based on lysine keeping methionine (M) plus cystine (C) to lysine (L) ratio constant at 0.83 to supply 0.97, 0.92, 0.87, 0.83 and 0.79% lysine. AL diets 1 to 5 were formulated by adding 0.097% synthetic lysine to WL diets 1 to 5. [2]Average of 16 weeks. [3]NS = not significant (P > 0.05). [4]Linear (L). *P < 0.05; **P < 0.01.

Table 6: Influence of adding synthetic lysine to diets formulated[1] based on lysine and amino acid density on egg specific gravity of hens

Dietary treatment	Egg specific gravity by week			
	4	8	16	Average
Lysine	NS[2]	NS	NS	NS
Diets without added lysine (WL)	1.086	1.085	1.084	1.085
Diets with added lysine (AL)	1.086	1.084	1.084	1.085
SEM	0.0001	0.0002	0.0002	0.0001
Amino acid density	NS	NS	NS	NS
1	1.086	1.085	1.084	1.085
2	1.087	1.084	1.084	1.085
3	1.086	1.085	1.084	1.085
4	1.086	1.085	1.085	1.085
5	1.086	1.085	1.084	1.085
SEM	0.0002	0.0003	0.0003	0.0002
Lysine x Amino acid density	**	NS	NS	*
WL x 1	1.086	1.085	1.084	1.085
x 2	1.087	1.085	1.085	1.086
x 3	1.085	1.085	1.084	1.085
x 4	1.086	1.086	1.084	1.085
x 5	1.086	1.086	1.084	1.085
AL x 1	1.086	1.085	1.084	1.085
x 2	1.086	1.084	1.084	1.084
x 3	1.086	1.085	1.084	1.085
x 4	1.086	1.084	1.085	1.085
x 5	1.086	1.085	1.084	1.085
SEM	0.0003	0.0004	0.0004	0.0002

[1]WL diets 1 to 5 were formulated based on lysine keeping methionine (M) plus cystine (C) to lysine (L) ratio constant at 0.83 to supply 0.97, 0.92, 0.87, 0.83 and 0.79% lysine. AL diets 1 to 5 were formulated by adding 0.097% synthetic lysine to WL diets 1 to 5. [2]NS = not significant (P > 0.05). *P < 0.05; **P < 0.01.

was in agreement with a previous report that increasing amino acid density increased egg weight (Roland *et al.*, 1998). Keshavarz and Jackson (1992) had reported an increase in EW (P < 0.05) as a result of lysine and methionine supplementation, but the EW obtained did not equal that of the positive control group containing 18% protein. Adding synthetic lysine to diets formulated based on lysine had no influence on egg weight (P > 0.05). This was in agreement with some previous research (Prochaska *et al.*, 1996; Sohail and Roland, 1997), but was contrary to the findings of Nathanael and Scott (1980) that increasing lysine intake from 481 to 567 mg/hen/d increased egg weight. The increase in EW due to increased dietary lysine (Nathanael and Scott, 1980) was probably because of the very low lysine (481 mg/hen/d) initially fed.

Egg specific gravity: On average, a significant lysine x amino acid density interaction (P < 0.05) was observed on ESG (Table 6). This interaction was the result of a significantly greater interaction (P < 0.01) observed within the first four weeks of this experiment, which disappeared later. The interaction is believed to be because of the variation in egg size in the early egg production period. Changing the amino acid density did not influence ESG (P > 0.05). The ESG of hens fed diets formulated based on lysine at a ratio of 0.83 was not different from ESG of hens fed 0.097% synthetic lysine.

Addition of synthetic lysine (0.097%) to diets formulated based on lysine had no significant effect on EP or EW of Hy-Line W36 hens. This indicates that corn-soy diets formulated based on lysine to supply 0.79 to 0.97% lysine (15.5 to 18.0% protein) may not be deficient in lysine. It is suspected that corn-soy diets formulated based on lysine might be deficient in non-sulfur containing amino acids other than lysine.

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