Does formulation on a Digestible Basis for amino Acid Make Productive and Economic Sense for Laying Hens?

S.A. Adedokun and T.J. Applegate
Email: applegt@purdue.edu; O:765-496-7769
Purdue University – Dept. of Animal Sciences

Introduction

When the price of basic ingredients is high, commercial nutritionists must consider the use of alternative ingredients in their feed formulations. Ultimately, the goals of the commercial nutritionist is to reduce the cost of feed, decrease safety margins, increase the accuracy of predicting performance, and increase the uniformity of product produced. Because formulating based on amino acid digestibility more closely meets the needs of bird, their incorporation reduces nutrient excess, in addition to diet costs. However, in order to effectively use corn, soybean meal, meat and bone meal (MBM), DDGS, as well as alternative ingredients the nutritionist (s) must have good nutritional information about the alternative ingredients. There in-lies the rub. Good nutritional information is not available for many alternatives feed ingredients and nutritionists are not confident about the nutritional values that are available for feed ingredients.

Digestible amino acid values are considered by many to be the best measure of the amino acid value of ingredients. Unfortunately the amount of digestible amino acid data that is available, particularly for some ingredients, is not very large. Commercial nutritionists find it difficult to make the switch to using digestible amino acid values so that they can efficiently use alternative feed ingredients.

The overall objective of this proposal is to build upon previous work funded by the Midwest Poultry Consortium in 2009; wherein amino acid digestibility is being determined on 24 ingredients in laying hens and compared to that of the broiler (the latter comparison through industry matching with Evonik Degussa). Ingredient amino acid digestibility determined in the 2009 grant include: 3 corn, 3 soybean meal, 6 meat and bone meals, 5 bakery by-products, 5 DDGS, and 2 wheat midds samples. Further comparisons through a industry sources have allowed for 3 additional high-protein DDG(s) and several canola meal samples in 2010. Ingredients for this study were collected from throughout the Midwest (NE, MN, KY, IL, IN, OH, MI, and PA).

Thus, the current research provided a continuation of the digestible amino acid concept and hen- specific database of ingredient digestibility by providing a proof-of-concept study demonstrating efficacy and economics of a) total versus digestible amino acid formulation basis and b) level of amino acid formulation.

Materials and Methods

Five hundred and twelve Hyline Variety W36 hens were used in this study. The study was conducted as a 2 x 4 factorial experimental arrangement from 30 to 46 weeks of age. Diets were formulated on a total (TOT) or digestible (DIG) basis (2) as well as by amino acid density (4). All diets used the ratio of amino acid to Lys based on that published in Hyline's management guide for the W36 (2009) as elaborated on in Table 1. Four amino acid density diets were fed (low, medium, medium/high, and high) as described for diets formulated on a total basis in Table 1. For the digestible amino acid diets, the lysine digestibility of similar nutrient specification corn and SBM diets were used to establish the digestible amino acid targets for the low, medium, medium/high and high series diets based on the same targeted intake (700, 750, 800, and 850 mg/h/d) and similar ratios then used versus lysine for the remainder of amino acids. All diets had 6.0% pork meat and bone meal and 10% DDGS (total of 16% of byproduct ingredients). These ingredient inclusions were based in consultation with laying hen nutritionists from NE, IA, MN, IN, and OH to have a "realistic" inclusion of by-product ingredients.

The Low and High diet series for each of the DIG and TOT diets will was made (i.e. as basal diets) and used to mix the Medium and Medium/high diets in differing proportions as to minimize the influence of mixing errors. For this study 48 cages of hens (2 birds per cage, 84 in^2/bird) were fed each diet. Feed intake was determined monthly from 4 cage blocks (12 blocks per diet). Egg production was determined daily, and egg weights determined from a 2 day egg collection on a weekly basis. Every 4 weeks (34, 38, 42, and 46 wk of age), eggs from a 2 day collection were used for determination of specific gravity, egg components (dry shell, albumen, and yolk) from 36 cages per diet. Every 8 weeks (38 and 46 wk of age), the albumen and yolk were retained from the egg break-outs and freeze-dried for determination of solids yield.

Diets were mixed on a monthly basis. Four diets (TOT high, TOT low, DIG high, and DIG low) were analyzed for amino acids content.

Data were analyzed as a 2 x 4 factorial, with curvilinear relationships of amino acid density within each amino acid formulation method (DIG vs TOT). In addition to egg production measures (egg number, egg weight, egg component and solids yield) and feed-to-egg conversion (number and mass); production (egg number and mass) over feed cost was determined for each 6 pen block per diet and return on feed investment evaluated. In the future, a spreadsheet tool will be developed, such that variables such as egg, egg component, and ingredient pricing can be altered and profit/loss determined.

Results and Discussion

As noted in Table 4, feed intake did not differ between experimental groups throughout the course of the study. However, hens on the lowest amino acid intake lost the most BW during this 16 wk laying period (8.1%; Table 5). For egg production (amount and mass), the amino acid density largely affected production (Tables 6-8). While formulation method (digestible vs total) did not drastically impact number or mass of egg produced, there was a trend towards formulation on a digestible basis having improved production for birds fed the “Medium” level versus those fed on a total amino acid basis (3.3 eggs or 15.1 oz more over a 16 wk lay). Thus, this dataset warrants further regression analyses to elucidate these effects.

Table 1. Formulated total amino acid targets for the “total” amino acid series diets.

	Ratio vs Lys	Low	Medium	Medium / High	High	NRC '94	Hyline W36
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Lys	100	700	750	800	850	688	821
Met	48	336	360	384	408	304	395
TSAA	87	609	652.5	696	739.5	584	711
Thr	75	525	562.5	600	637.5	472	618
Trp	23	161	172.5	184	195.5	160	188
Arg	105	735	787.5	840	892.5	700	863
Ile	78	546	585	624	663	648	637
Val	91	637	682.5	728	773.5	700	744

Table 2. Experimental diets (on as fed-basis)[1]

Ingredients, g/kg	Total Low	Total High	Digestible Low	Digestible High
Corn	593	526	584	514
Soybean meal, 48%	112	167.8	119	178
DDGS	100	100	100	100
Pork MBM	60	60	60	60
Soybean oil	29.5	40	31	42
L-Lysine HCl	0.39	0.77	0.54	0.81
L-Threonine	0	0.38	0.09	0.41
DL-Methionine	1.01	1.52	1.08	1.56
Limestone (38% Ca)	99	98.1	99	98
Sodium chloride	2.0	2.0	2.0	2.0
Vitamin and mineral premix (A)	3.5	3.5	3.5	3.5
Total	1000	1000.01	1000.01	999.98
Calculated nutrient and energy composition (g/kg)				
MET	3.54	4.29	3.21	3.93
CYS	2.63	2.87	1.75	1.95
M+C	5.16	5.63	3.90	4.33
LYS	7.37	9.11	6.17	7.75
THR	5.54	6.71	3.87	4.90
ARG	9.41	10.98	8.06	9.60
ILE	5.53	6.44	4.33	5.17
LEU	14.02	15.34	11.60	12.79
VAL	7.00	7.92	5.18	6.02
CP	173	196	176	200
ME (kcal/kg)	2883	2884	2883	2885
Ca	44	44	44	44
P	6.1	6.3	6.2	6.3
Non-phytate P	4.2	4.2	4.2	4.3
Na	1.9	1.9	1.9	1.9

[1]Respective medium and medium-high diets were made by blending 2/3rd of low and 1/3rd of high or 1/3rd of low and 2/3rd of high diets, respectively

Table 3. Analyzed amino acid contents of experimental diet[1], (%)

	Total		Digestible	
	Low	High	Low	High
Taurine	0.05	0.05	0.05	0.05
Hydroxyproline	0.19	0.24	0.23	0.22
Aspartic Acid	1.20	1.56	1.36	1.55
Threonine	0.51	0.67	0.57	0.67
Serine	0.58	0.73	0.65	0.73
Glutamic Acid	2.38	2.97	2.66	2.93
Proline	1.07	1.27	1.20	1.24
Lanthionine	0.00	0.00	0.00	0.00
Glycine	0.91	1.14	1.06	1.08
Alanine	0.91	1.09	1.02	1.06
Cysteine	0.23	0.26	0.26	0.26
Valine	0.66	0.81	0.74	0.80
Methionine	0.36	0.51	0.46	0.57
Isoleucine	0.54	0.68	0.61	0.68
Leucine	1.33	1.59	1.47	1.57
Tyrosine	0.45	0.56	0.51	0.57
Phenylalanine	0.67	0.83	0.75	0.83
Hydroxylysine	0.02	0.01	0.02	0.04
Ornithine	0.01	0.01	0.01	0.01
Lysine	0.72	0.95	0.83	0.96
Histidine	0.36	0.45	0.41	0.45
Arginine	0.87	1.13	1.01	1.13
Tryptophan	0.15	0.19	0.17	0.19
Total	14.17	17.70	16.05	17.59

[1]Respective medium and medium-high diets were made by blending 2/3rd of low and 1/3rd of high or 1/3rd of low and 2/3rd of high diets, respectively

Table 4. Feed intake per period

Treatment[1]	30-34	34-38	38-42	42-46	30-46
	Fed intake/bird/d				
Low	86.25	101.50	94.11	91.73	93.32
Medium	86.94	102.94	90.29	90.51	92.52
Medium-high	88.84	103.17	93.26	90.59	93.84
High	87.24	101.52	90.80	89.78	92.21
SEM	0.670	0.904	1.636	1.414	0.955
Diet formulation[2]	0.32	0.22	0.08	0.26	0.19
Trt	0.06	0.40	0.28	0.81	0.61
Diet formulation*Trt	0.21	0.66	0.83	0.65	0.88

[1]Treatment – High, low, medium, or medium high
[2]Diet formulation – Total or digestible

Table 5. Effect of amino acid density on hen body weight

Treatment[1]	Body weight, g	
	Start	End
Low	3086.5	2837.3b
Medium	3089.6	2953.6a
Medium-high	3104.7	3005.8a
High	3079.7	3011.6a
SEM	25.10	20.60
Diet Formulation[2]	0.58	0.38
Trt	0.91	<0.0001
Diet formulation*Trt	0.72	0.078

[1]Treatment – High, low, medium, or medium high
[2]Diet formulation – Total or digestible

Table 6. Effects of amino acid density and method of diet formulation on egg production

Diet formulation[1]	Treatment[2]	Age, wk				
		30-34	34-38	38-42	42-46	30-46
		Egg number/bird/period				
Digestible	Low	23.9^{ab}	23.2^{b}	25.0^{b}	23.1^{bde}	95.1^{b}
Digestible	Medium	24.6^{ab}	24.4^{a}	26.2^{abc}	24.5^{a}	99.6^{ac}
Digestible	Medium-high	24.4^{ab}	24.2^{a}	27.1^{a}	24.4^{ac}	100.2^{ac}
Digestible	High	24.4^{ab}	24.6^{a}	26.8^{abc}	24.4^{ac}	100.1^{ac}
Total	Low	24.2^{ab}	23.8^{ab}	25.0^{bc}	23.2^{de}	96.1^{bc}
Total	Medium	23.6^{b}	23.8^{ab}	25.3^{abc}	23.6^{ace}	96.3^{bc}
Total	Medium-high	24.9^{a}	24.5^{a}	26.9^{a}	24.9^{ac}	101.2^{a}
Total	High	25.6^{ab}	24.8^{a}	26.5^{abc}	24.5^{ac}	100.3^{ac}
	SEM	2.30	1.83	3.41	2.33	7.70
	Diet formulation	0.91	0.46	0.24	0.80	0.70
	Trt	0.082	<0.0001	<0.0001	<0.0001	<0.0001
	Diet formulation*Trt	0.057	0.099	0.73	0.11	0.083

[1]Diet formulation – Total or digestible
[2]Treatment – High, low, medium, or medium high

Table 7. Effect of amino acid density on egg weight

	Age, wk				
	30-34	34-38	38-42	42-46	30-46
Treatment[1]	Egg weight, g/egg				
Low	60.53	61.86c	65.29	63.67bc	62.84
Medium	61.31	62.25cb	63.52	64.30ac	62.85
Medium-high	63.31	63.39ab	64.44	65.03a	64.04
High	61.48	63.56a	64.38	64.95a	63.60
SEM	0.856	0.340	1.034	0.315	0.415
Diet formulation[2]	0.86	0.026	0.83	0.001	0.38
Trt	0.14	0.001	0.69	0.01	0.12
Diet formulation*Trt	0.54	0.22	0.76	0.11	0.93

[1]Treatment – High, low, medium, or medium high
[2]Diet formulation – Total or digestible

Table 8. Effect of method of diet formulation on egg mass

Diet formulation[1]	Treatment[2]	Age, wk 30-34	34-38	38-42	42-46	30-46
		Egg mass, g/period/bird				
Digestible	Low	1453.6^{bc}	1445.9^{b}	1603.4^{ab}	1476.3^{bc}	5979.1^{b}
Digestible	Medium	1513.8^{abc}	1515.5^{ab}	1673.0^{ab}	1591.0^{ad}	6293.1^{abc}
Digestible	Medium-high	1518.9^{ab}	1557.9^{ac}	1756.0^{ab}	1613.4^{a}	6446.0^{a}
Digestible	High	1501.2^{ac}	1563.6^{a}	1720.6^{ab}	1585.9^{a}	6371.9^{ac}
Total	Low	1456.8^{abc}	1457.8^{bcd}	1649.0^{b}	1466.0^{bd}	6029.4^{bc}
Total	Medium	1438.3^{c}	1482.6^{bcd}	1593.8^{ab}	1503.9^{bcd}	6018.5^{b}
Total	Medium-high	1609.1^{a}	1527.5^{acd}	1722.9^{ab}	1589.3^{ad}	6448.8^{a}
Total	High	1506.8^{abc}	1570.4^{a}	1711.3^{ab}	1590.3^{a}	6378.6^{a}
	SEM	280.8	144.0	320.2	160.1	607.6
	Diet formulation	0.82	0.38	0.50	0.042	0.32
	Trt	0.016	<0.0001	0.009	<0.0001	<0.0001
	Diet formulation*Trt	0.14	0.46	0.48	0.12	0.13

[1]Diet formulation – Total or digestible
[2]Treatment – High, low, medium, or medium high

Table 9. Effect of amino acid density on egg component (egg white as weight as a percent of egg weight)

Treatment[1]	Age, wk				
	30-34	34-38	38-42	42-46	30-46
	Egg white as a percent of egg weight, %				
Low	58.82	60.00	59.14	58.88	59.21
Medium	59.88	60.17	59.64	58.71	59.60
Medium-high	59.73	60.09	58.55	59.12	59.37
High	59.99	59.41	59.79	58.7	59.47
SEM	0.610	0.662	0.627	0.690	0.365
Diet formulation[2]	0.30	0.54	0.11	0.32	0.064
Trt	0.52	0.84	0.50	0.97	0.89
Diet formulation*Trt	0.17	0.85	0.71	0.46	0.58

[1]Treatment – High, low, medium, or medium high
[2]Diet formulation – Total or digestible

Table 10. Effect of amino acid density on egg component (egg yolk as a percent of egg weight)

Treatment[1]	Age, wk				
	30-34	34-38	38-42	42-46	30-46
	Egg yolk as a percent of egg weight, %				
Low	26.47	26.25	26.42	26.42	26.40
Medium	26.76	26.12	29.20	26.56	27.16
Medium-high	26.94	26.20	26.08	26.60	26.45
High	26.33	26.20	26.48	26.71	26.43
SEM	0.400	0.274	1.300	0.351	0.359
Diet formulation[2]	0.51	0.19	0.32	0.36	0.12
Trt	0.70	0.99	0.30	0.95	0.37
Diet formulation*Trt	0.39	0.86	0.54	0.53	0.63

[1]Treatment – High, low, medium, or medium high
[2]Diet formulation – Total or digestible

Table 11. Effect of method of diet formulation and amino acid concentration on egg component (egg shell weight as a percent of egg weight)

Diet formulation[1]	Trteatment[2]	Age, wk				
		30-34	34-38	38-42	42-46	30-46
		Egg shell weight as a percent of egg weight, %				
Digestible	Low	8.74[ab]	8.82[ab]	8.91	9.13	8.90
Digestible	Medium	8.87[ab]	8.83[ab]	8.78	9.00	8.87
Digestible	Medium-high	9.02[a]	8.58[ab]	8.60	10.6	9.20
Digestible	High	8.95[ab]	8.33[b]	8.84	9.18	8.83
Total	Low	8.56[ab]	9.02[a]	9.09	8.91	8.90
Total	Medium	8.40[b]	9.00[a]	9.03	9.12	8.89
Total	Medium-high	9.02[a]	8.83[ab]	8.85	9.03	8.93
Total	High	8.84[ab]	8.94[ab]	8.94	8.98	8.93
	SEM	0.152	0.164	0.141	0.633	0.164
	Diet formulation	0.086	0.01	0.049	0.30	0.75
	Trt	0.030	0.20	0.28	0.54	0.60
	Diet formulation*Trt	0.44	0.49	0.94	0.56	0.70

[1]Diet formulation – Total or digestible
[2]Treatment – High, low, medium, or medium high

Table 12. Effect of amino acid density on egg's specific gravity

Treatment[1]	Phase 1	Phase 2	Phase 3	Phase 4	Phase 1 to 4
	Specific gravity				
Low	1.071	1.077	1.063	1.078	1.072
Medium	1.075	1.055	1.088	1.092	1.077
Medium-high	1.072	1.176	1.089	1.078	1.104
High	1.077	1.076	1.073	1.081	1.077
SEM	0.003	0.051	0.012	0.007	0.013
Diet formulation[2]	0.73	0.42	0.63	0.53	0.57
Trt	0.45	0.35	0.33	0.51	0.33
Diet formulation*Trt	0.23	0.33	0.18	0.32	0.37

[1]Treatment – High, low, medium, or medium high
[2]Diet formulation – Total or digestible