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Dietary supplementation with standard ileum digestible lysine in starter period improves male broiler growth weight

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ABSTRACT

This research evaluates standard ileum digestible (SID) lysine density in starter period in Ross 308 male broilers to better understand the impact of increase dietary SID lysine density in live weight performance. Six diets (6 replicates) in starter period with different levels of SID lysine density, 1.411% (150% NRC), 1.321% (140% NRC), 1.215% (130% NRC), 1.126% (120% NRC), 1.035% (110% NRC) and 0.945 (100% NRC, 1994) were used in a completely randomized experimental design. All diets were iso-caloric and iso-nitrogenous. As a result of this study, Broilers fed 1.321% SID lysine level diet, body weight in 21 d was increased by 90 g compared with standard group (P<0.05). Levels of SID lysine density had a significant effect on body weight in weeks 1, 2 and 3. Feeding broilers with 1.321% SID lysine in starter diet was significant highest in body weight at 7, 14 and 21 days of age. Treatment 1.321% SID lysine was significant highest body weight gain from 0 to 7, 0 to 14 and 0 to 21 days of age and treatment 1.413% was significant highest body weight gain from 8 to 14 days of age compared with standard treatment (P<0.05). The results of this study suggest that 1.321% SID lysine density (140% NRC) in starter period diet optimized live weight and growth of Ross 308 male broiler and increasing SID lysine level from 0.945 to 1.413%, improved live weight in quadratic model.

Key words: Body weight, Digestible lysine, Gain, Starter period

Modern chicken broilers have been submitted to continuous genetic improvement, and therefore, their amino acids specially lysine requirements must be constantly updated to ensure their performance (Nasr and Kheiri 2012, Bernal *et al.* 2014). Genetic selection by primary breeding companies has resulted in vastly improved growth rate, feed conversion, and breast meat yield of broiler chickens compared with broilers of the previous decade (Dozier *et al.* 2012, Bernal *et al.* 2014). As a result, modern broilers require higher dietary amino acid concentrations to optimize performance and breast meat yield compared with the broilers of past years (Dozier *et al.* 2012, Ayasan and Okan 2010, Bernal *et al.* 2014). Part of the increased lysine requirement was achieved by reduced feed intake per unit of growth rate.

Lysine one the key AA for protein synthesis and muscle deposition has also been demonstrated to be involved in the synthesis of cytokines, proliferation of lymphocytes and thus in the optimum functioning of immune system in response to infection. The objective of the nutritionists has long been to optimize growth and tissue accretion by increasing nutrient density such as AA. The question remains about the potential benefits of AA beyond the protein synthesis for muscle developments. Essential amino acid recommendations for broilers by the NRC (1994) are largely based on experimentation conducted several decades ago. Therefore the objective of the present study was to determine the nutritional requirements of digestible lysine in starter period, with same crude protein, energy and other AA requirements recommended by NRC (1994) effects on the body weight and growth of male broilers.

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MATERIALS AND METHODS

An experiment with Ross 308 broilers was conducted from 1 to 3 weeks of age. Day-old (42±2g) commercial broiler chicks (720) were placed in 36 floor pens (20 chicks per pen and 0.11m^2 floor space/chick). Water and feed were also supplied *ad lib*. The lighting regimen was continuous, with 24 h of light daily in first days and then was standard 23L:1D, until the end of trail. The basic chemical composition of the feed materials was determined according to AOAC (2006). The total amino acid values of the ingredients were assayed by high-pressure liquid chromatography analysis. SID amino acid values were determined from digestible coefficients and analyzed total amino acid content of the ingredients.

Six diets (6 replicates) in starter period with different levels of SID lysine density, 1.411% (150%NRC), 1.321% (140%NRC), 1.215% (130%NRC), 1.126% (120%NRC),

Table 1. Composition of experimental diets in starter (0–21 day) period

Lysine requirement levels	100%	110%	120%	130%	140%	150%
Item/Treatment	1	2	3	4	5	6
Corn, grain	59.5	59.5	59.5	59.5	59.5	59.5
Soybean meal 48%	28.5	28.5	28.5	28.5	28.5	28.5
Gluten meal 62%	4.77	4.66	4.53	4.41	4.26	4.14
Soybean oil	2.50	2.50	2.50	2.50	2.50	2.50
Fish meal 52%	1.00	1.00	1.00	1.00	1.00	1.00
Oyster shells	1.83	1.83	1.83	1.83	1.83	1.83
Dical. Phos.	1.00	1.00	1.00	1.00	1.00	1.00
Common salt	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin premix *	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix *	0.25	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.20	0.20	0.20	0.20	0.20	0.20
L-Lysine HCl	0.00	0.11	0.24	0.36	0.51	0.63
Nutrients contents (calculated)						
ME (Mcal/kg)	3.11	3.11	3.11	3.11	3.11	3.11
Protein (%)	21.73	21.73	21.73	21.72	21.74	21.75
Ether extract (%)	4.90	4.90	4.89	4.89	4.88	4.88
Linoleic acid (%)	2.70	2.70	2.70	2.70	2.70	2.70
Crude fiber (%)	4.21	4.21	4.20	4.20	4.21	4.20
Calcium (%)	1.16	1.16	1.16	1.16	1.16	1.16
Avail. phosphorus (%)	0.58	0.58	0.577	0.576	0.575	0.57
Sodium (%)	0.16	0.16	0.16	0.16	0.16	0.16
Amino acids analyzed						
SID** ARG (%)	1.172	1.172	1.171	1.171	1.171	1.171
SID GLY (%)	0.651	0.651	0.651	0.651	0.651	0.651
SID SER (%)	0.834	0.834	0.834	0.834	0.834	0.834
Lysine (%)	1.114	1.223	1.334	1.439	1.553	1.663
SID LYS (%)	0.945	1.035	1.126	1.219	1.318	1.411
SID MET (%)	0.479	0.479	0.479	0.479	0.479	0.479
SID TSAA (%)	0.755	0.755	0.755	0.755	0.755	0.755
SID TYR (%)	0.677	0.677	0.677	0.677	0.677	0.677
SID THR (%)	0.630	0.630	0.630	0.629	0.629	0.629
SID TRP (%)	0.222	0.222	0.222	0.222	0.222	0.222
SID VAL (%)	0.774	0.773	0.773	0.773	0.773	0.773

*Vitamin and mineral premix includes the following per kilogram of diet. vitamin A (vitamin A acetate), 4,960 IU; vitamin D (cholecalciferol), 1,653 IU; vitamin E (dl-a tocopherol acetate), 27 IU; menadione (menadione sodium bisulfate complex), 0.99 mg; vitamin B12 (cyanocobalamin), 0.015 mg; folic (folic acid), 0.8 mg; d-pantothenic acid (calcium pantothenate), 15 mg; riboflavin (riboflavin), 5.4 mg; niacin (niacinamide), 45 mg; thiamin (thiamin mononitrate), 2.7 mg; d-biotin (biotin), 0.07 mg; pyridoxine (pyridoxine hydrochloride), 5.3 mg; manganese (manganous oxide), 90 mg; zinc (zinc oxide), 83 mg; iron (iron sulfate monohydrate), 121 mg; copper (copper sulfate pentahydrate), 12 mg; iodine (calcium iodate), 0.5 mg; selenium (sodium selenite), 0.3 mg. ** Standard ileum digestible.

1.035% (110%NRC) and 0.945 (100%NRC, 1994) were used in a completely randomized experimental design. All diets were isocaloric and isonitrogenous (Table 1). Data were analyzed by GLM procedure, An ANOVA of SAS Institute and using REG Linear and quadratic response (SAS Institute 2004) where significance occurred, means were compared with the Duncan multiple range tests. Output data were expressed as means with SEM.

RESULTS AND DISCUSSION

The results of body weight and daily body weight gain in starter period (0– 21 day) are given in Tables 2,3. Increasing lysine density significantly improves body weight at 7, 14 and 21 days of age. Broiler BW (7, 14 and 21 d) was lowest in birds fed 1.114% diet and best in birds fed 1.553% diet compared to other treatments ($P<0.05$), indicating the importance of high lysine density in the starter diet optimize BW (Table 2) this result is similar to Kidd *et al.* (2004), Corzo *et al.* (2005) and Bernal *et al.* (2014). There was a significantly higher in body weight in broiler fed 1.553% lysine diet in weeks 2 and 3 than compared to 1.114% lysine diet (Table 2). Increasing level of lysine density significantly increased body weight gain from 8 to 14 day of age ($P<0.05$). Maximum weight gain occurred at 1.553% dietary lysine from 0 to 21 day of age. Increasing dietary lysine without an increase in methionine and threonine (other essential amino acids) may limit protein synthesis, hence not allowing for maximum gain and meat accretion.

Daily body weight gain from 15 to 21 days of age unaffected by lysine levels but significant in 0–7, 8–14, 0–14, and 0–21 days of age (g/day). Daily body weight gain in 0–7, 0–14, and 0–21 day of age was significantly higher in 1.553% lysine diet than compared to 1.114% lysine diet by 1.8, 3.2 and 4.3 g/day, respectively, and daily body weight gain in 7–14 day of age was significantly higher in 1.663% lysine diet than compared to 1.114% SID Lysine (Lys) diet by 5.2 g/day (Table 3). The higher Lys requirement probably relates to increased growth rate and genetics potential of broiler chicks. Maximum weight gain occurred at 1.553% dietary SID Lysine from 0 to 21 day of age. These results indicated that the lysine requirement of male broilers for maximum body weight and gain were higher than those of values reported in NRC, 1994 recommended. The results of previous experiments by Vazquez and Pesti (1997) indicated that the lysine requirements of broilers to achieve maximum body weight gain in the starter period were 1.21% but in this study showed that the lysine requirements of male broilers to achieve maximum body weight gain in the starter period were 1.553%.

This study diets were formulated in the same amino acids (iso-nitrogenous) and energy requirements (iso-energetic) but were different only in lysine requirement level. Postnatal protein accretion results from an increase in protein synthesis or a decrease in protein degradation. Diets containing low lysine can limit meat formation early in development by reducing protein accretion from protein

Table 2. Effects of SID lysine levels in starter period (0–21 days) on male broiler live weight (g).

SID Lysine levels (%)	Body weight At 7 day	Body weight At 14 day	Body weight At 21 day
0.945	127.5[b]	373.1[b]	644.9[b]
1.035	134.6[ab]	376.9[b]	671.6[ab]
1.126	139.3[a]	394.0[ab]	703.3[ab]
1.215	138.9[a]	411.8[a]	716.6[ab]
1.321	139.9[a]	418.6[a]	734.9[a]
1.411	135.9[a]	415.8[a]	716.6[ab]
SEM	2.92	9.64	25.9
		Probability Value	
GLM	0.035	0.004	0.043
Linear response	0.1	0.000	0.011
Quadratic response	0.003	0.000	0.02

[a–c] Means followed by different superscript letters are significantly different (P< 0.05).

Table 3. Effects of SID lysine levels in starter period (0–21 days) on daily body weight gain (g/day)

SID Lysine levels (%)	0–7 days	8–14 days	14 days	15–21 days	21 days
0.945	11.8[b]	35.1[c]	23.5[b]	38.8	28.6[b]
1.035	12.8[ab]	34.6[c]	23.7[b]	42.1	29.9[ab]
1.126	13.6[a]	36.3[bc]	24.9[ab]	44.2	31.4[ab]
1.215	13.5[a]	39.0[ab]	26.2[a]	43.5	32.0[ab]
1.321	13.6[a]	39.8[ab]	26.7[a]	45.2	32.9[a]
1.411	12.7[ab]	40.3[a]	26.5[a]	43.0	32.0[ab]
SEM	0.41	1.17	0.69	3.25	1.23
			Probability value		
GLM	0.035	0.004	0.005	0.801	0.031
Linear response	0.1	0.000	0.000	0.269	0.01
Quadratic response	0.002	0.000	0.000	0.326	0.02

[a–c] Means followed by different superscript letters are significantly different (P< 0.05).

synthesis and RNA content (Tesseraud *et al.* 1996). The results confirmed the previous studies which demonstrated that Lys requirement for chicks is higher than that of NRC (1994) recommendation, which is supplemented on the diet for maximal growth. It is also confirmed that increasing dietary lysine level increases growth weight.

This study showed the higher efficiency of these diets (above NRC) as they allow a better transformation of AA intake into tissue synthesis and accretion. This is possibly related to a higher AA availability to synthesize muscle. Diets formulated with high lysine level (above 110% NRC) promoted a better conversion of amino acids into body gain. This suggested that the excess of AA intake caused by the diet with high lysine level, it was also verified that the high lysine diet promoted better conversion of lysine into growth weight (Tables 2, 3). Feeding high lysine density diet to broilers increases body weight gain. Lysine has largely demonstrated effects beyond their roles of building blocks of the protein accretion: from a better gut functioning to an enhanced immune system. More research is necessary to determine the optimal requirements of AA balance and lysine level to improve not only muscle development but also meat quality (Eits *et al.* 2003, Dozier *et al.* 2009, Ayasan and Okan 2010).

A summary of the SID Lys requirement estimates are given in Table 4. Significant quadratic responses (P<0.05) were observed for BW at 7, 14 and 21 d with broilers fed progressive additions of Dig Lys. The SID Lys requirement was estimated at 1.234, 1.364 and 1.324%, respectively, for BW at 7, 14 and 21 d based on quadratic regression equations (Table 4). The higher Lys requirement reported by the current research, Garcia *et al.* (2006), Dozier *et al.* (2009), Nasr and Kheiri (2011), and Bernal *et al.* (2014), probably relates to increased genetic growth rate of the modern broiler and strain. Ross 308 male broilers fed gradient concentrations of SID Lys displayed significant quadratic responses for DBWG (g/d) from 0 to 7, 0 to 14, 8 to 14 and 0 to 21 days of age (P<0.05). The SID Lys requirement was estimated at 1.234, 1.364, 1.513 and 1.324, respectively, for DBWG from 0 to 7, 0 to 14, 8 to 14 and 0 to 21 days of age based on quadratic regression equations (Table 4).

Table 4. Standard ileum digestible lysine requirement of male broilers based on quadratic regression analysis for BW and gain

Response criteria	Equation*	R^2	SE**	R***	P-value
BW, g (7 d)	-95.7 + 382.324 (SIDLys) – 154.909 (SIDLys × SIDLys)	0.98	5.361	1.234	0.000
BW gain, g/d (0–7 d)	–20.068 + 54.636 (SIDLys) – 22.138 (SIDLys × SIDLys)	0.98	0.765	1.234	0.000
BW gain, g/d (8–14 d)	–3.976 + 58.696 (SIDLys) – 19.389 (SIDLys × SIDLys)	0.87	2.241	1.513	0.000
BW, g (14 d)	–123.783 + 793.629 (SIDLys) – 290.822 (SIDLys × SIDLys)	0.92	18.36	1.364	0.000
BW gain, g/d (0–14 d)	–12.0996 + 56.802 (SIDLys) – 20.822 (SIDLys × SIDLys)	0.92	1.312	1.364	0.000
BW gain, g/d (15–21 d)	–24.954 + 107.524 (SIDLys) – 41.869 (SIDLys × SIDLys)	0.84	7.884	1.284	0.468
BW, g (21 d)	–298.761 + 1546.834 (SIDLys) – 584.134 (SIDLys × SIDLys)	0.96	60.43	1.324	0.023
BW gain, g/d (0–21 d)	–16.323 + 73.607 (SIDLys) – 27.796 (SIDLys × SIDLys)	0.96	2.878	1.324	0.02

*, Prediction equation based on formulated SID lysine for optimum response. **, Standard error. ***, Requirement.

Standard ileum digestible Lys requirements were from 0 to 7 and 11 to 24 d of age for Ross 308 manual (2009) 1.27 and 1.1%. The present research resulted in a only 2.8% lower SID Lys requirement (1.234%) from 0 to 7 d of age to Ross Manual (2009). The higher SID Lys requirement (1.324%) was estimated in current research from 0 to 21 days of age than NRC, 1994. Our results indicated that optimum SID Lys level for BW was in the range of 1.234–1.513% based on quadratic regression method for broilers in the different weeks of starter period. the SID Lys requirements from 0 to 21 d of age for male broiler for DBWG was estimated at 1.324%, using quadratic regression ($P<0.05$). In this study showed that male broilers fed the standard Lys diet resulted in reduced growth when compared with the addition of standard Lys to the dose-response diets, providing evidence that the standard Lys diet was deficient from 0 to 21 days of age ($P<0.05$).

Male broilers fed the standard Lys diet (NRC recommended) resulted in reduced growth when compared with the addition of standard Lys to the dose-response diets in the different weeks of starter period. Feeding broilers high lysine density about 140% NRC diet increased body weight at 21 day of age by 13.95% more than broilers fed standard lysine density diets (NRC recommended). These data suggested a lower SID Lys requirement (1.234%) of male broilers from 0 to 7 days of age and higher SID Lys requirement (1.324%) from 0 to 21 days of age than Ross 308 manual (2009). Significant quadratic regression response was observed for body weight in starter period with broilers fed progressive additions of SID Lys.

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