DETERMINATION OF OPTIMAL STANDARDIZED ILEAL DIGESTIBLE LYSINE TO METABOLIZABLE ENERGY RATIOS IN DIET FOR COBB 500 BROILERS FROM 1 TO 14 DAYS OF AGE

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ABSTRACT

In this study, 400 day-old straight-run Cobb 500 broiler chicks sourced from a commercial hatchery were randomly allotted to treatment following a Randomized Complete Block Design (RCBD). The treatments used were fivve ratios of SID Lysine (Lys) to metabilizable energy (ME) in diet of 3.61, 3.89, 4.17, 4.45, or 4.73 g SID Lys/Mcal ME. There were 8 replicates per treatment with 10 birds in each cage. Result showed that increasing SID Lys to ME ratio improved (quadratic, P<0.01) day 14 body weigh (BW), body weigh gain (BWG), average daily gain (ADG), Feed conversion ratio (FCR) of broiler chicks from 1 to 14 day of age. No (P>0.05) significant differences were observed foraverage daily feed intake (ADFI) across the treatments. Broilers fed the diet containing 4.45 g SID Lys/Mcal ME had the greatest (P<0.01) BW, BWG, ADG, and FCR among all the treatments. Increasing SID Lys to ME ratio in diets did not affect (P>0.05) livability. Overall (day 1 to 33), a tendency for increased (quadratic, P=0.08) ADG and improved (quadratic, P=0.02) FCR in broilers were observed with increasing levels of SID Lys to ME ratios during the booster phase. At day 33 of age there were only numerical differences in BW across the treatments.

Keywords: *SID Lysine, Broiler, Cobb 500, booster diets, metabolizable energy.*

INTRODUCTION

Broiler contribution in meat production has increased markedly in the last few decades, and this is mainly due to improved genetic and management practices (Tallentire et al., 2016). Due to its low fat and high protein content, broiler meat is considered as a high-quality food by consumers (Adeyemo, G.O. et al., 2016). Poultry production of Vietnam is projected to expand at a rate of 10.10 % per annum in the last 4 year with about 512,7 million of heads (GSO, 2020). The meat of poultry was obtained as the second largest meat sector with 1504.9 thousand metric tons (GSO, 2020; Mottet and Tempio, 2017). Significant developments in genetics, management, health and nutrition are largely responsible for the rapid growth experienced today in the broiler industry (Gillespie et al., 2017; Saleeva, I. et al., 2020; László Szőllősi et al., 2021). For example, in 1990, broilers at 42 days old weighed on average about 1.82 kg with a feed conversion ratio (FCR) of 1.95; whereas today, broilers reach the same weight at 33 days old with an FCR of 1.58 (Van et al., 2015; Utnik-Bana’s K et al., 2018). Percent breast meat yield (BMY) of broilers at 42 days old was also projected to increase to about 27% of live weight, which was 125% greater than the BMY in the 1980’s (Thruvenkadan et al., 2011; Van Horne, 2018). Thus, with the greater genetic potential of current broiler chicken strains, optimum dietary amino acid (AA) levels for maximizing performance or optimizing profitability might be higher than currently assumed (Wijtten et al., 2004; Martins et al., 2016; Tallentire, C.W. et al., 2016).

Broiler responses of economic interest, such as body weight (BW) gain, FCR and BMY can be optimized by increasing AA concentrations, improving the AA balance, or both (Vieira et al., 2012). Amino acid requirements increase proportionately faster than energy requirements; thus, a higher AA-to-energy ratio may be required in faster growing strains of broilers (Gous, 2010). Previous researches have been conducted to estimate digestible Lys requirement for maximizing breast muscle size and optimizing FCR and BW gain of high-yield broilers (Acar et al., 1991;

Nasr and Kheiri, 2012). However, there is limited research that estimated the optimal ratio of digestible Lys, and consequently balanced protein, with ME in broiler chicks raised under tropical environments.

Lysine amino acid (Lys) requirements of broilers have been estimated from 0 to 3 weeks of age on a total basis (NRC, 1994; Kalinowski et al., 2003) and on a digestible basis (Garcia et al., 2007; Lumpkins et al., 2007), but information is limited for standardized ileal digestible (SID) Lys to ME ratio of modern broilers strain such as Cobb 500 during the booster period (0 to 14 days). Therefore, the objective of this study was first to determine the optimal Lys to ME ratios for Cobb 500 chicken based on growth performance from 1 to 14 days of age and second, further investigate the influence of body weigh at day 14 on growth performance and carcass traits of 33 days of age.

MATERIALS AND METHODS

Location and time

The experiment was conducted in the 2K farm of Thai Nguyen city of Thai Nguyen Province, while the feed samples were sent and chemically analyzed by the Laboratory of Animal Science and Veterinary Medicine, Thai Nguyen University of Agriculture and Forestry. It was implemented from September 2019 to Jan 2020.

Experimental design

For this feeding trial, a total of 400 straight - run day old chicks of Cobb 500 were randomly allotted to treatments following a Randomized Complete Block Design. There were 8 replicates per treatment with 10 birds (5 males and 5 females) in each cage. The treatments used were five ratios of SID Lysine (Lys) to ME ratio 3.61, 3.89, 4.17, 4.45, or 4.73 g SID Lys/Mcal ME. The recommended ratio of SID Lysine (Lys) to ME was 4.17 by Cobb-vantress (2012).

Feeds and Feeding

The experimental diets were formulated based on Brill feed formulation program. The experimental birds were fed with self-formulated feeds booster rations. The diets were formulated on an ideal protein basis to ensure adequacy of all other indispensable amino acids. All other nutrients were formulated to meet or exceed nutrient recommendations for Cobb 500 broilers (Cobb, 2012) from1 to 14 days of age. The birds were fed *ad-libitum*. The amount of feeds given and left over were measured and recorded. Experimental chickens were fed with different energy to protein ratios in the rations from 1 to 14 days of age. From 15 to 33 days of age fed with commercial feed.

Table 1. Ingredients of nutritional value for chicken experiments period 1 to 14 days of age

Item	Lys to ME ratios				
	3.61	***3.89***	***4.17***	***4.45***	***4.73***
Ingredient, %					
Corn, yellow	61.790	62.000	62.240	62.340	62.410
Soybean meal	24.100	23.770	23.380	23.030	22.680
Soybean Protein Concentrate	6.000	6.000	6.000	6.000	6.000
Coconut oil	2.340	2.260	2.170	2.130	2.100

Item	Lys to ME ratios				
	3.61	***3.89***	***4.17***	***4.45***	***4.73***
Monodicalcium phosphate 21%	1.610	1.620	1.620	1.620	1.630
Blood cells, spray-dried	1.500	1.500	1.500	1.500	1.500
Limestone	1.400	1.400	1.400	1.400	1.400
Salt	0.470	0.470	0.470	0.470	0.470
Choline chloride 60%	0.250	0.250	0.250	0.250	0.250
DL - Methionine	0.240	0.300	0.380	0.440	0.510
L - Lysine HCL	0.020	0.110	0.210	0.300	0.400
L - Threonine	-	0.040	0.090	0.160	0.210
L - Valine	-	-	0.010	0.080	0.160
Vitamin premix[1/]	0.130	0.130	0.130	0.130	0.130
Mineral premix[2/]	0.100	0.100	0.100	0.100	0.100
Coccidiostat	0.050	0.050	0.050	0.050	0.050
Total	100.000	100.000	100.000	100.000	100.000
Calculated composition					
ME, kcal/kg	3,035	3,035	3,035	3,035	3,035
SID Lys:ME, g/Mcal	3.61	3.89	4.17	4.45	4.73
CP (N × 6.25), %	21.000	21.000	21.000	21.000	21.000
Crude fat, %	5.020	4.939	4.853	4.813	4.778
Ash, %	2.247	2.231	2.211	2.192	2.172
NDF, %	10.694	10.675	10.648	10.611	10.572
ADF, %	4.396	4.377	4.353	4.329	4.303
Ca, %	0.900	0.900	0.900	0.900	0.900
Available P, %	0.450	0.450	0.450	0.450	0.450
Standardized ileal digestible (SID) AA					
SID Lys, %	1.100	1.180	1.270	1.350	1.440
Met:Lys	48	50	52	54	55
Met + Cys:Lys	74	74	74	74	74
Thr:Lys	67	65	65	65	65
Trp:Lys	22	20	18	17	16
Val:Lys	86	80	75	75	75
Linoleic acid, %	1.429	1.429	1.429	1.427	1.425

[1/]The vitamins- premix contained the following quantities of vitamins per kilogram of premix: Vitamin A, 11,000,000 IU/kg; Vitamin D, 5,000,000 IU/kg, Vitamin E, 50,000 mg/kg; Vitamin K, 3,000 mg/kg; thiamine, 2,000 mg/kg; riboflavin, 7,000 mg/kg; pyridoxine, 3,000 mg/kg; niacin, 40,000 mg/kg; pantothenic acid, 15,000 mg/kg; vitamin B12, 15 mg/kg; folic acid, 1,5000 mg/kg;

[2/] The micro minerals- premix contained the following quantities of micro minerals per kilogram of premix: Fe, 92,000 mg/kg; Cu, 7,500 mg/kg; Zn, 60,000 mg/kg;Mn, 50,000 mg/kg; I, 700 mg/kg; Se, 150 mg/kg.

The measurements taken

Feed, nutrient and ME intakes: dry matter (DM), organic matter (OM), ash, neutral detergent fiber (NDF), Chemical analyses of DM, OM, CP, EE, CF, NFE, NDF and ash followed the procedure of AOAC (1990) in Intistute of life sciences – Thai Nguyen University while ME was calculated according to (Rostagno et al., 2011).

Body weight. The initial weight, weight at day 14, 24 and final (33 days old) weight of the experimental birds was gathered using an appropriate weighing scale.

Blood urea nitrogen (BUN) was measured as response criteria for determining optimal SID Lys to ME ratio. On day 14, blood samples were collected from 8 birdsin the 8 replicate pens of each treatment (one bird/pen) via the ulnar vein directly into a heparinized (50 IU/mL) syringe. Samples from each bird were centrifuged at 2,000 g for five min and one mL of plasma was obtained and stored at -20°C for subsequent analysis. Plasma concentrations of blood urea nitrogen (Lowell B Foster and Jane M Hochholzer, 1971) were determined using an auto chemistry analyzer.

Carcass characteristics. At 34 days of age, one male and one female bird from each replication were randomly selected for carcass data collection. Birds were fasted for 8 h, then weighed and dressed. Birds were killed by cutting the jugular vein, scalded, plucked and eviscerated. The abdominal fat were removed from the abdomen and gizzard and weighed immediately after evisceration using a precision scale. From the eviscerated carcass, skinless and boneless wing, thigh and drumstick were obtained and all cuts was weighed on a precision scale. Carcass yield, commercial cuts, and the relative weight of the abdominal fat was calculated relative to the bird body weigh at slaughter and expressed as a percentage.

Feed intake. The daily feed intake of the experimental birds was monitored. This was done by weighing the leftover feeds in the trough at the end of the day and subtracting it from the total amount of feeds given for the day. This was done from beginning up to the end of the experiment.

Daily weight gain was measured by weighing the initial live weight and final live weight.

Feed conversion ratio (FCR) was calculated by the daily feed intake and daily gain

Statistical analysis

Homogeneity of variances and outliers were tested using the UNIVARIATE procedure of SAS (SAS Inst. Inc. Cary, NC). Data were analyzed using the MIXED procedure of SAS with cage as the experimental unit. The model included level of SID Lys to ME ratios as fixed effects and block as the random effect. Least square means were calculated for each independent variable. When diet is a significant source of variation, least square means were separated using the PDIFF option of SAS adjusted using a Tukey-Kramer test. Polynomial contrasts were performed to determine linear and quadratic effects of increasing SID Lys to ME ratios. The α-level used to determine significance and tendencies between means were 0.05 and 0.10, respectively. When significant quadratic effects are observed, broken line analysis using NLIN procedure of SAS was used to determine the optimal SID Lys to ME ratio.

RESULTS AND DISCUSSION

Growth performance

The growth performances of the experimental birds are shown in Table 2.

Table 2. Effect of varying SID Lys to ME ratios on growth performance of broilers from day 1 to 14 of age[1]

Item	**SID Lys to ME ratio, g/mcal**					**SEM**	***P*- value**	
							Contrasts	
	3.61	***3.89***	***4.17***	***4.45***	***4.73***		*Lin*	*Quad*
BW, g								
Day 1	44	44	44	44	44	0.40	0.38	0.38
Day 14	274[b]	286[b]	294[b]	325[a]	286[b]	7.96	<0.01	<0.01
Day 1 to 14								
BWG, g	230[b]	243[b]	250[b]	281[a]	242[b]	7.80	<0.01	<0.01
ADG, g	16.4[b]	17.2[b]	17.8[b]	20.1[a]	17.3[b]	0.56	<0.01	<0.01
ADFI, g	26	27	27	27	26	0.63	0.40	0.12
FCR	1.60[a]	1.54[a]	1.54[a]	1.36[b]	1.55[a]	0.04	0.02	0.01
Livability,%	98.12	98.75	98.75	97.50	99.37	1.04	0.69	0.71

[1/]Data are least square means of 8 replicate per treatment with 10 birds per replicate.

[a-b] Least square means with different superscripts in arrow differ (P<0.05)

Increasing SID Lys to ME ratio improved (quadratic, *P*<0.01) d 14 BW, BWG, ADG and FCR of broiler chicks from 1 to 14 day of age. No (*P*>0.05) significant differences were observed for ADFI across the treatments. Broilers fed the diet containing 4.45 g SID Lys/Mcal ME had the greatest (*P*<0.01) BW, BWG, ADG and FCR among all the treatments. Increasing SID Lys to ME ratio in diets did not affect (*P*>0.05) livability.

Dozier and Payne (2012) investigatedthe effect of SID Lys to ME ratios on BW of female broiler chicks (Ross × Ross 708) from 1 to 14 day of age and showed that a ratio of 4.11 g SID Lys/Mcal ME was the optimal ratio for both BW and BW gain. Progressive increase of the ratio quadratically altered BW. Similarly, Kidd and Fancher (2001) studied the effect of SID Lys to ME ratios on BW of male broilers (Ross × Ross 508) in the starter phase (day 0 to 18). Their results indicate that BW and BW gain of birds fed the diet containing 4.22 g SID Lys/Mcal ME were greater than those fed diets containing a ratio of 2.81, 3.16, 3.52, 3.87 and 4.57. Their result also showed a quadratic response fitted for BW gain as a response to increasing SID Lys to ME ratios.

Dozier and Payne (2012) also reported that the optimal SID Lys to ME ratio for maximum F/G of female Hubbard × Cobb 500 from 1 to 14 d of age was 4.14 g SID Lys/Mcal ME. In contrast, Kidd and Fancher (2001) indicated that the optimal SID Lys to ME ratio for F/G of broilers from 1 to 18 day of age was 3.87 g SID Lys/Mcal ME. The higher SID Lys to ME ratios requirement in current research compared with estimates from Dozier and Payne (2012) may be due to time and location of experimentation, environmental conditions.

Table 3. Overall growth performance of broilers fed with varying SID Lys to ME ratios from day 1 to 14 of age[1]

Item	SID Lys to ME ratio, g/Mcal					SEM	*P- value*	
							Contrasts	
	3.61	***3.89***	***4.17***	***4.45***	***4.73***		*Lin*	*Quad*
BW, g								
Day 14	274[b]	286[b]	294[b]	325[a]	286[b]	7.96	<0.01	<0.01
Day 24	734[b]	782[ab]	794[ab]	821[a]	775[ab]	21.01	0.07	0.02
Day 33	1,396	1,452	1,497	1,485	1,443	39.65	0.31	0.08
Day 15 to 24								
BWG, g	460	495	500	496	489	18.9	0.34	0.19
ADG, g	43.1	45.8	46.7	45.9	45.7	1.72	0.34	0.24
ADFI, g	76	75	75	75	79	2.32	0.35	0.21
F/G	1.82	1.66	1.65	1.67	1.73	0.07	0.49	0.10
Day 25 to 33								
BWG, g	663	671	696	667	668	29.70	0.95	0.53
ADG, g	73.6	74.5	77.1	74.1	73.3	3.24	0.91	0.46
ADFI, g	134	134	138	138	142	3.40	0.06	0.80
F/G	1.88	1.83	1.80	1.87	1.93	0.06	0.46	0.21
Day 1 to 33								
BWG, g	1,353	1,409	1,453	1,442	1,400	39.60	0.35	0.19
ADG, g	40.9	42.7	44.0	43.7	42.4	1.20	0.31	0.08
ADFI, g	71	71	72	72	74	1.52	0.08	0.60
FCR	1.73	1.67	1.65	1.64	1.75	0.04	0.97	0.02
Livability,%	98.12	98.75	98.75	7.50	99.37	0.79	0.61	0.69

[1]*Data are least square means of 8 replicate per treatment with 10 birds per replicate.*

[a-b]*Least square means with different superscripts in a row differ (P < 0.05)*

From day 15 to 24 and day 25 to 33, no significant differences (*P*>0.05) in BWG, ADG, ADFI and FCR were observed among all the treatments (Table 3). This was expected as all broilers were fed a common starter and finisher diet. However, increasing SID Lys to ME ratio during the booster phase also increased (quadratic, *P*=0.02) BW at d 24. The heaviest birds fed the diet containing 4.45 g SID Lys/Mcal ME had greater (*P*=0.05) d 24 BW than the lightest at d 14 (birds fed 3.61 g SID Lys/Mcal ME) with the other treatments being intermediate. Overall (day 1 to 33), a tendency for increased (quadratic, P=0.08) ADG wereimproved (quadratic, P=0.02). FCR in broilers were observed with increasing levels of SID Lys to ME ratios during the booster phase. At day 33 (end of the experiment), there were only numerical differences in BW across the treatments. These results indicate that growth performance in the early chick phase may influence overall production performance; however, the magnitude of the difference decreases with age.

Efficiency of AA Utilization

From 1 to 14 days of age, SID Lys intake of broilers increased (linear, $P<0.01$) with increasing SID Lys to ME ratio (Table 4). There was also a quadratic increase ($P<0.01$) in SID Lys:BW gain as SID Lys to ME ratio increased from 3.61 to 4.73 g/Mcal. There were no ($P>0.05$) significant differences in SID Lys:BW gain when birds were fed from 3.61 to 4.45 g SID Lys/Mcal ME; however, SID Lys:BW gain increased ($P<0.01$) when birds were fed 4.73 g SID Lys/Mcal ME. This suggests that this level is above the optimal requirement for SID Lys. However, there were no ($P>0.05$) significant differences in BUN concentration across the treatments. Likewise, there were no significant differences in SID Lys intake, SID Lys:BW gain, and BUN concentration between broilers fed diets containing yellow corn only and yellow corn with cassava meal. Blood urea N (BUN) may be used as an indicator of AA requirements in both swine and poultry (Donsbough et al., 2010). Changes in BUN concentrations indicate changes in efficiency of AA utilization (Waguespack et al., 2011). The fact that BUN concentration was unaffected within the range of AA used in the study may suggest that the amount of excess AA relative to their requirement was not significant to increase deamination and consequently BUN levels.

Table 4. Effect of varying SID Lys to ME ratios on SID lysine intake, efficiency of SID lysine utilization and blood urea nitrogen concentration in diets of broiler chicks from day 1 to 14 of age[1]

Item	SID Lys to ME ratio, g/Mcal					SEM	*P*- value	
							Contrasts	
	3.61	***3.89***	***4.17***	***4.45***	***4.73***		*Lin*	*Quad*
SID Lys intake, mg	286.6[d]	312.5[c]	343.1[b]	365.9[ab]	380.3[a]	7.90	<0.01	0.13
SID Lys/BWG, mg/g	17.6[b]	18.3[b]	19.5[b]	18.3[b]	22.3[a]	0.54	<0.01	0.01
BUN, mmol/L	1.85	1.93	1.95	1.94	1.79	0.11	0.78	0.25

[1] *Data are least square means of 8 replicates per treatment with 10 birds per replicate.*

[a,b]*Least square means with different superscripts differ (P < 0.05)*

Caloric Efficiency

From day 1 to 14, daily ME intake was unchanged regardless of the SID Lys to ME ratio (Table 5). Caloric efficiency was improved (quadratic, $P<0.01$) when broilers were fed diets containing 4.45 g SID Lys/Mcal ME. Caloric efficiencies were calculated using the total ME consumed and dividing it by the growth rate; therefore, a lower value equates to improved caloric efficiency. As a result, improving dietary caloric efficiency is an important tool to effectively reduce cost of production. This indicates that the optimal ratio for best caloric conversion is 4.45 g SID Lys/Mcal ME.

Dressing percentage and carcass yield

Carcass characteristics (Table 6) did not (*P*>0.05) differ among the treatments regardless of the SID Lys to ME ratio in the diet. Likewise, Kidd and Fancher (2001) evaluated growth performance of male (Ross × Ross 508) broilers fed varying levels of SID Lys to ME ratios from day 1 to 19 of age, and reported that Lys level in booster phase did not affect carcass composition of broilers at day 42. Kidd et al. (1998) also indicated that Lys level in the booster diet is independent of the breast muscle weight of broilers at day 50**.**

Table 5. Effect of varying SID Lys to ME ratios on daily ME intake and caloric efficiency in broiler chicks from day 1 to 14 of age[1]

Item	SID Lys to ME ratio, g/Mcal					SEM	*P*- value	
							Contrasts	
	3.61	***3.89***	***4.17***	***4.45***	***4.73***		*Lin*	*Quad*
ME intake, kcal/d	79.07	80.39	81.99	82.26	80.15	1.92	0.39	0.13
Caloric efficiency, kcal/kg gain	4,856[a]	4,673[a]	4,673[a]	4,127[b]	4,704[a]	123	0.02	0.01

[1/]*Data are least square means of 8 replicates per treatment with 10 birds per replicate.*

[a,b]*Least square means with different superscripts differ (P < 0.05)*

Table 6. Carcass characteristics of broilers fed varying SID Lys to ME ratios in diets from day 1 to 14 of age[1]

Item	SID Lys to ME ratio, g/Mcal					SEM	*P*- value	
							Contrasts	
	3.61	***3.89***	***4.17***	***4.45***	***4.73***		*Lin*	*Quad*
Live weight, g	1,539	1,566	1,572	1,573	1,560	25	0.43	0.24
Dressed weight, g								
Without giblets	1,167	1,183	1,194	1,194	1,182	21	0.47	0.29
With giblets	1,239	1,252	1,267	1,274	1,254	22	0.38	0.28
Dressed, %								
Without giblets	75.77	75.56	76.02	75.85	75.77	0.51	0.85	0.84
With giblets	80.43	79.96	80.59	80.95	80.40	0.58	0.60	0.80
Breast								
Breast weight, g	356.17	360.75	360.52	362.54	360.78	8.36	0.64	0.70
Breast, %	30.41	30.46	30.17	30.34	30.49	0.31	0.95	0.55

Item	SID Lys to ME ratio, g/Mcal					SEM	*P*- value	
							Contrasts	
	3.61	***3.89***	***4.17***	***4.45***	***4.73***		*Lin*	*Quad*
Breast muscle								
Breast muscle, g	254.48	257.75	257.91	261.87	255.23	6.31	0.78	0.47
Breast muscle, %	21.70	21.75	21.57	21.93	21.57	0.32	0.93	0.79
Leg quarters								
Leg weight, g	329.57	334.23	337.02	340.15	335.49	6.02	0.28	0.33
Leg, %	28.28	28.25	28.26	28.55	28.46	0.28	0.44	0.90
Wings								
Wing weights, g	145.47	147.97	151.37	151.87	148.18	2.45	0.17	0.05
Wing, %	12.52	12.53	12.69	12.76	12.59	0.15	0.43	0.40
Abdominal fat								
Abdominal fat, g	11.38	11.16	11.94	12.33	11.67	0.90	0.52	0.67
Abdominal fat, %	0.98	0.94	1.00	1.04	0.99	0.08	0.63	0.87

[1]*Data are least square means of 8 replicates per treatment with 10 birds per replicate.*

CONCLUSIONS

Increasing SID Lys to ME ratio improved (quadratic, P<0.01) BWat day 14, and BWG, ADG and FCR of broiler chicks from 1 to 14 d of age. No (P>0.05) significant differences were observed for ADFI across the treatments. Broilers fed the diet containing 4.45 g SID Lys/Mcal ME had the greatest (P<0.01) BW, BWG, ADG, and FCR among all the treatments. Increasing SID Lys to ME ratio in diets did not affect (P>0.05) livability. BUN concentration did not (*P>0.05*) differ among the treatments regardless of the SID Lys to ME ratio.

Overall day 1 to 33 a tendency for increased (quadratic, P=0.08) ADG and improved (quadratic, P=0.02) FCR in broilers were observed with increasing levels of SID Lys to ME ratios during the booster phase. At day 33 (end of the experiment), there were only numerical differences in BW across the treatments. Carcass characteristics at day 34 of age did not (*P*>0.05) differ among the treatments regardless of the SID Lys to ME ratio in the booster diet.

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