DETERMINATION OF OPTIMAL RATIO FOR TOTAL DIGESTIBLE SULFUR-CONTAINING AMINO ACIDS TO LYSINE IN ROSS 308 BROILERS FROM 1 TO 14 DAYS OF AGE

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ABSTRACT

The objective of the study was to determine the effect of increasing the ratio of SID TSAA to Lys in broiler chicks diets for 1 to 14 d of age on growth performance, efficiency of Lys utilization, caloric efficiency and carcass characteristics. In this study, 400 day-old straight-run Ross 308 broiler chicks sourced from a commercial hatchery were randomly allotted into 5 treatments following a Randomized Complete Block Design (RCBD). The treatments used were five ratios of standardized ileal digestible (SID) total sulfur-containing amino acids (TSAA) to Lysine (Lys) in diet of 0.62, 0.68, 0.74, 0.80 and 0.86. There were 8 replicates per treatment with 10 birds in each cage. Result showed that increasing SID TSAA to Lys ratio improved (quadratic, P<0.05) day 14 BW, BWG, ADG, and FCR. Broilers fed the diet containing SID TSAA to Lys ratio of 0.80 had greater (P<0.01) BW, BWG, and ADG compared with those fed diets containing SID TSAA to Lys ratio of 0.62 and 0.86. Increasing SID TSAA to Lys ratio in the diets did not affect (P> 0.05) livability. No (P>0.05) significant differences were observed in blood urea nitrogen (BUN) concentrations across varying levels of SID TSAA to Lys ratios. Overall (day 1 to 33), BWG and ADG tended (quadratic, P=0.06) to be increased with increasing SID TSAA to Lys ratio in diets fed from day 1 to 14 of age. There were no (P>0.05) differences in FCR, livability across the levels of SID TSAA to Lys ratios. Carcass characteristics at day 34 of age did not (P>0.05) differ among the treatments regardless of the SID TSAA to Lys ratio in the booster diet.

Keywords: *SID TSAA, SID Lys, Broiler, Ross 308, booster diets*

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 et al., 2016). Poultry production of Vietnam is projected to expand at a rate of 10.10% per annum in the last 4 years with about 533 million of heads (GSO, 2021). The meat of poultry was obtained as the second largest meat sector with 1700 thousand metric tons (GSO, 2021; 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; LászlóSzőllősi 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; Tallentire 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). Sulfur amino acids are used for lean tissue accretion, feather formation, and methyl groupdonation (D'Mello, 2003; Lewiss, 2003; Bequette, 2003). Methionine is the first-limiting amino acid for broilers fed corn-soybean meal diets. Total sulfur amino acid (TSAA) 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) TSAA to Lys ratio of modern broilers strain such as Ross 308 during the booster period (0 to 14 days).

MATERIALS AND METHODS

Location and time

The experiment was conducted in the 2K farm of Thai Nguyen city, 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 2021 to January 2022.

Experimental design

For this feeding trial, a total of 400 straight - run day old chicks of Ross 308 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 TSAA to Lys ratio (0.62, 0.68, 0.74, 0.80 and 0.86). The recommended ratio of SID TSAA to Lys ratio was 0,74 by Ross - Aviagen (2018).

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 Ross 308 broilers (Ross, 2018) from 1 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 SID TSAA to Lys ratios in the diet from 1 to 14 days of age. From 15 to 33 days of age fed with commercial feed.

The measurements taken

The diet samples were analyzed in triplicates for dry matter (DM) (method 930.15; AOAC, 2007), Crude protein (CP) (method 990.03; AOAC, 2007), ether extract (EE) (method 920.39; AOAC, 2007), crude fiber (CF) (method 978.10; AOAC, 2007), ash (method 942.05; AOAC, 2007), ADF (method 973.18; AOAC, 2007) and neutral detergent fiber(NDF) (method Holst, 1973), Calcium (Ca) (TCVN 11678:2016), Phosphorus (P) (TCVN 11678:2016) followed the procedure of AOAC (1990) inIntistute of life science – Thai Nguyen Universitywhile ME was calculated according to (Rostagno et al., 2011).

Body weight (BW). 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 TSAA to Lys 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, Jane M Hochholzer, 1971) were determined using an auto chemistry analyzer.

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

ITEM	**TSAA TO LYS**				
	0.62	0.68	0.74	0.80	0.86
Ingredient, %					
Corn, yellow	61.87	61.93	62.00	62.06	62.13
Soybean meal	24.00	23.89	23.77	23.66	23.55
Soybean protein concentrate	6.00	6.00	6.00	6.00	6.00
Coconut oil	2.32	2.29	2.26	2.23	2.19
Monodicalcium phosphate	1.62	1.62	1.62	1.62	1.62
Blood cells, spray-dried	1.50	1.50	1.50	1.50	1.50
Limestone	1.40	1.40	1.40	1.40	1.40
Salt	0.47	0.47	0.47	0.47	0.47
Choline 60%	0.25	0.25	0.25	0.25	0.25
DL - Methionine	0.16	0.23	0.31	0.38	0.45
Vitamin premix[1/]	0.13	0.13	0.13	0.13	0.13
Mineral Premix[2/]	0.10	0.10	0.10	0.10	0.10
Coccidiosta	0.05	0.05	0.05	0.05	0.05
L - Lysine HCL 98%	0.11	0.11	0.11	0.11	0.12
L - Threonine 99%	0.03	0.03	0.03	0.04	0.04
Total	100.00	100.00	100.00	100.00	100.00
Calculated composition					
ME, kcal/kg	3,035	3,035	3,035	3,035	3,035
CP, %	21.000	21.000	21.000	21.000	21.000
Crude fat, %	4.999	4.970	4.940	4.910	4.880
Ash, %	2.243	2.237	2.231	2.226	2.220
NDF, %	10.691	10.683	10.675	0.667	10.659
ADF, %	4.392	4.385	4.378	4.371	4.364
Ca, %	0.900	0.900	0.900	0.900	0.900
Available P, %	0.450	0.450	0.450	0.450	0.450

ITEM	TSAA TO LYS				
	0.62	0.68	0.74	0.80	0.86
Standardized ileal digestible (SID) AA					
SID Lys, %	1.180	1.180	1.180	1.180	1.180
Met:Lys	38.00	44.00	50.00	56.00	62.00
Met + Cys:Lys	62.00	68.00	74.00	80.00	86.00
Thr:Lys	65.00	65.00	65.00	65.00	65.00
Trp:Lys	20.00	20.00	20.00	20.00	20.00
Val:Lys	80.00	80.00	80.00	80.00	80.00
Linoleic Acid, %	1.430	1.429	1.429	1.429	1.429

Note: 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.

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 (ADFI) 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 (DWG) 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 TSAA to Lys 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 TSAA to Lys 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 TSAA to Lys ratio.

RESULTS AND DISCUSSION

Growth Performance

The growth performances of the experimental birds are shown in Table 2. Broilers fed increasing SID TSAA to Lys ratio improved (quadratic, P<0.05) day 14 BW, BWG, average daily gain (ADG) and FCR. Broilers fed the diet containing SID TSAA to Lys ratio of 0.80 had greater (P<0.01) BW, BWG, and ADG compared with those fed diets containing SID TSAA to Lys ratio of 0.62 and 0.86. Increasing SID TSAA to Lys ratio in the diets did not affect (P> 0.05) livability.

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

ITEM	SID TSAA TO LYS RATIO					SEM	*P*- VALUE	
							Contrasts	
	0.62	0.68	0.74	0.80	0.86		Lin	Quad
BW, g								
Day 1	46	46	46	46	46	0.52	0.44	0.52
Day 14	385[b]	395[ab]	408[ab]	420[a]	386[b]	5.19	0.22	<0.01
Day 1 to 1 4								
BWG, g	339.5[b]	348.7[ab]	362.4[ab]	374.6[a]	340.1[b]	5.33	0.22	<0.01
ADG, g	24.1[b]	24.7[ab]	25.8[ab]	26.7[a]	24.2[b]	0.37	0.22	<0.01
ADFI, g	31.8	31.2	31.6	30.4	30.9	0.44	0.14	0.72
FCR	1.33[a]	1.27[ab]	1.23[bc]	1.15[c]	1.29[ab]	0.03	<0.01	<0.01
Livability, %	98.75	98.75	98.75	98.12	98.12	0.69	0.55	0.87

Note: [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)

Previous researchs indicated that BW and BWG of broilers Cobb 500 increased with increasing SID TSAA to Lys ratios (Mohamed and Talha, 2011; Gaulart et al., 2011). Yan et al. (2010) and Dozier and Mercier (2013) also observed improvements in F/G with increasing SID TSAA to Lys ratios from 1 to 14 day of age. Mohamed and Talha (2011) determined that an SID TSAA to Lys ratio of 0.72 was optimum for BW and BWG. However, Dozier and Mercier (2013) reported that BW, BWG, and ADG of Ross × Ross 708 were not affected by increasing SID TSAA to Lys ratios in the diet. These differences may be due to genetic differences, ingredients, time of experimentation, and experimental conditions.

From day 15 to 24 and day 25 to 33, no (P>0.05) significant differences in growth performance were observed regardless of the SID TSAA to Lys ratio in the diet fed at day 1 to 14 of age (Table 3). However, broilers fed diets with increasing levels of SID TSAA to Lys ratio at day 1 to 14 of age tended to improve (quadratic, P<0.07) day 24 and day 33 BW.

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

ITEM	SID TSAA: LYS RATIO					SEM	*P-* VALUE	
							Contrasts	
	0.62	0.68	0.74	0.80	0.86		Lin	Quad
BW, g								
Day 14	385[b]	395[ab]	408[ab]	420[a]	386[b]	5.19	0.22	<0.01
Day 24	1,124	1,139	1,171	1,142	1,114	13.81	0.82	0.07
Day 33	1,983	2,023	2,027	2,032	1,962	19.38	0.72	0.06
Day 15 to 2 4								
BWG, g	738.2	744.0	763.1	721.8	728.2	11.93	0.48	0.40
ADG, g	73.9	74.2	75.9	73.8	72.1	1.47	0.39	0.18
ADFI, g	108.7	105.2	111.1	109.6	105.7	1.96	0.87	0.47
F/G	1.47	1.41	1.47	1.49	1.47	0.02	0.59	0.80
Day 25 to 33								
BWG, g	859.8	884.6	855.7	890.5	847.8	15.80	0.81	0.45
ADG, g	94.3	98.0	95.1	98.3	94.4	1.69	0.96	0.37
ADFI, g	171.0	176.3	172.1	163.8	163.9	3.06	0.08	0.43
FCR	1.81	1.80	1.82	1.68	1.76	0.03	0.13	0.93
Day 1 to 33								
BWG, g	1,937.5	1,977.3	1,981.1	1,986.9	1,916.1	19.39	0.73	0.06
ADG, g	58.7	59.9	60.0	60.2	58.1	0.58	0.72	0.06
ADFI, g	93.1	93.2	94.0	90.8	89.8	1.37	0.20	0.45
FCR	1.62	1.59	1.61	1.53	1.58	0.02	0.17	0.59
Livability, %	96.87	98.12	98.12	95.62	97.50	0.07	0.79	0.83

Note: [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)

This suggests that differences in BW of broilers at day 14 may influence BW at later stages. Leeson and Summers (2009) indicated that 1 g difference in day 7 BW of broiler Cobb 500 will be multiplied to 3 g at day 18 and 5 g at day 49. Overall (day 1 to 33), BWG and ADG tended (quadratic, P=0.06) to be increased with increasing SID TSAA to Lys ratio in diets fed from day 1 to 14 of age. However, there were no (P>0.05) differences in FCR and livability across the levels of SID TSAA to Lys ratios.

Efficiency of AA Utilization

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

ITEM	SID TSAA TO LYS RATIO					SEM	*P*- VALUE	
							Contrasts	
	0.62	0.68	0.74	0.80	0.86		Lin	Quad
TSAA intake, mg	233.2[a]	250.0[b]	276.2[b]	287.5[c]	314.1[c]	3.80	<0.01	0.80
TSAA/BWG, mg/g	9.7[a]	10.2[b]	10.7[b]	10.8[bc]	13.1[c]	0.22	<0.01	<0.01
BUN, mmol/L	1.24	1.03	1.19	1.19	0.93	0.07	0.21	0.58

Note: [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)

Progressive additions of SID TSAA to Lys ratio increased (linear, P<0.01) SID TSAA intake of broilers from 1 to 14 d of age (Table 4). Broilers consumed 233.2 to 314.1 mg of digestible TSAA from 1 to 14 day of age when SID TSAA to Lys ratios were increased from 0.62 to 0.86. Quadratic responses were significant (P<0.01) for SID TSAA:BW gain from 1 to 14 day of age. Increasing SID TSAA to Lys ratio to 0.86 resulted in poorer (P<0.01) efficiency of utilizing TSAA for BWG compared with those fed diets containing SID TSAA to Lys ratio of 0.62 to 0.80. No (P>0.05) significant differences were observed in BUN concentrations across varying levels of SID TSAA to Lys ratios.

Caloric Efficiency

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

ITEM	SID TSAA TO LYS RATIO					SEM	*P*- VALUE	
							Contrasts	
	0.62	0.68	0.74	0.80	0.86		Lin	Quad
ME intake, kcal/day	96.71	94.62	96.01	92.42	93.91	1.33	0.14	0.72
Caloric efficiency, kcal/kg gain	4,029[a]	3,846[ab]	3,731[bc]	3,475[c]	3,917[ab]	78	0.01	<0.01

Note: [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)

From day 1 to 14, daily ME intake was unchanged (P>0.05) regardless of the SID TSAA to Lys ratio (Table 5). Caloric efficiency was improved (quadratic, P<0.01) when broilers were fed diets containing SID TSAA to Lys ratio of 0.80. This indicates that the efficiency of ME utilization in broilers from 1 to 14 day of age was optimal when SID TSAA to Lys ratio was 0.80.

Dressing percentage and carcass yield

Carcass characteristics of broilers fed varying SID TSAA to Lys ratios were showed in Table 6. Carcass characteristics did not (P>0.05) differ among the treatments regardless of the SID TSAA to Lys ratio or the carbohydrate source in the diet. However, wing weight of broilers fed diets containing SID TSAA to Lys ratio of 0.62 were heavier (P=0.05) than those fed diets containing SID TSAA to Lys ratio of 0.86 from 1 to 14 day of age. Yan et al. (2010) reported that carcass composition of Cobb broilers at d 49 did not differ among broilers fed diets containing SID TSAA to Lys ratio of 0.70 and 0.73.

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

ITEM	SID TSAA TO LYS RATIO					SEM	*P*- VALUE	
							Contrasts	
	0.62	0.68	0.74	0.8	0.86		Lin	Quad
Live weight, g	1,984	1,967	1,947	2,006	1,986	15	0.56	0.40
Dressed weight, g								
Without giblets	1,584	1,581	1,566	1,617	1,588	13	0.51	0.85
With giblets	1,675	1,656	1,634	1,692	1,664	13	0.83	0.44
Dressed, %								
Without giblets	79.84	80.36	80.42	80.6	79.93	0.23	0.73	0.10
With giblets	84.42	84.16	83.94	84.37	83.76	0.23	0.33	0.98
Breast								
Breast weight, g	520.5	518.5	526.7	537.5	529.0	5.34	0.17	0.73
Breast, %	32.86	32.80	33.64	33.26	33.29	0.20	0.21	0.38
Breast muscle								
Breast muscle, g	379.5	379.2	377.1	382.0	384.1	4.80	0.62	0.68
Breast muscle, %	23.95	23.99	24.07	23.59	24.16	0.21	0.98	0.68
Leg quarters								
Leg weight, g	416.6	416.2	411.3	419.2	414.2	4.22	0.92	0.87
Leg, %	26.30	26.32	26.28	25.92	26.12	0.14	0.25	0.95
Wings								
Wing weights, g	187.0^{a}	184.5^{ab}	183.6^{ab}	193.4^{ab}	181.9^{b}	1.84	0.89	0.49
Wing, %	11.81	11.68	11.73	11.97	11.48	0.09	0.44	0.33
Abdominal fat								
Abdominal fat, g	19.9	19.6	19.6	19.7	21.0	0.75	0.54	0.42
Abdominal fat, %	1.26	1.24	1.25	1.22	1.32	0.04	0.63	0.45

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

CONCLUSIONS

Increasing SID TSAA to Lys ratio improved (quadratic, P<0.05) d 14 BW, BWG, ADG, and FCR. Broilers fed the diet containing SID TSAA to Lys ratio of 0.80 had greater (P<0.01) BW, BWG, and ADG compared with those fed diets containing SID TSAA to Lys ratio of 0.62 and 0.86. Increasing SID TSAA to Lys ratio in the diets did not affect (P>0.05) livability. BUN concentration did not (P>0.05) differ among the treatments regardless of the SID TSAA to Lys ratios. There were no (P>0.05) differences in FCR, livability across the levels of SID TSAA to Lys ratios. Carcass characteristics at day 34 of age did not (P>0.05) differ among the treatments regardless of the SID TSAA to Lys ratio in the booster diet. The optimal ratio for SID TSAA to Lys in Cobb 500 chicks from 1 to 14 d of age, raised under tropical environments was 0.80.

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