Evaluating the Response of Cobb MV × Cobb 500 Broilers to Varying Amino Acid Density Regimens for a Small Bird Program

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Primary Audience: Production Managers, Nutritionists, Primary Breeders

SUMMARY

Primary breeder companies are continuously striving to improve existing commercial broiler crosses to increase performance and reduce cost. The objective of this study was to evaluate the response of a new commercial broiler cross (Cobb MV × Cobb 500) under 4 different amino acid density (AAD) regimens on live performance and carcass yield during a 36 d grow-out period with 2 processings to collect data at 32 and 35 d. Two basal diets were formulated to low AAD (LAAD, digestible lysine, dLys 1.08, 0.95, and 0.87% for starter, grower, and finisher) and very high AAD (VHAAD, dLys 1.39, 1.26, and 1.12%). Medium and high AAD (MAAD and HAAD) diets were created by mixing the LAAD and VHAAD diets at ratios of 66.6:33.3 and 33.3:66.6, respectively. This was a randomized complete block design with 12 replications/treatment (16 birds/pen, 0.07 m^2/bird). Feed intake/bird was reduced ($P < 0.05$) when birds were fed the VHAAD diet at 0–32 and 0–35 d. As AAD increased, FCR decreased significantly in a stepwise manner by approximately 4 points at each AAD level ($P < 0.05$). Feeding higher levels of AAD improved broiler live performance and carcass yields. At 33 d, birds fed the HAAD diet had the highest potential gross profit/bird, and at 36 d, birds fed the VHAAD diet had the highest potential gross profit/bird. Further research should evaluate the effects of feeding increased AAD diets to male and female Cobb MV × Cobb 500 separately, as well as in different feeding phases and longer grow-out periods.

Key words: amino acid density, lysine, live performance, processing yield

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DESCRIPTION OF PROBLEM

The majority of broiler production costs are due to feed and feed manufacture. To reduce these production costs and optimize performance, primary breeder companies are continuously striving to improve nutrient utilization of new commercial broiler crosses. Selection for growth performance characteristics for breeder offspring is counterproductive to reproduction efficiency [1]. The Cobb 500 female line is reported to efficiently grow on least cost diets, while also having a low FCR and good hatchability (85.6%) [2]. The Cobb MX male is reported to have improved fertility from the previous male line, as well as increased yield and average daily gain at the broiler level [3]. In effort to further improve the male line performance, a

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new broiler breeder product was developed, the Cobb MV male; this line has been reported to demonstrate improvements in FCR at the broiler level, while maintaining fertility and hatchability from the previous Cobb MX line [4]. This has led to the production of a new commercial broiler cross, the Cobb MV × Cobb 500; therefore, research is needed to evaluate the response of this new commercial broiler cross to different nutritional specifications in order to maximize performance.

There are many feeding strategies that have been studied to optimize broiler performance; one strategy represents feeding increased amino acid density (**AAD**) diets [5–7]. Previous research has demonstrated positive broiler performance responses to increased dietary AAD regimens, depending upon strain [5, 6, 8, 9]. However, in general, feeding high AAD diets to broilers improves FCR and meat yield, which could potentially increase the economic return [5, 7].

Currently, there is no published literature regarding the effects of AAD regimens on the growth performance and carcass yield of this new commercial broiler cross (Cobb MV × Cobb 500). Additionally, the target weight of broilers can vary from 1.5 to 3 kg or more depending on the market demand across the United States and different parts of world [10]. Therefore, the objective of this study was to evaluate the response of Cobb MV × Cobb 500 broilers to 4 AAD regimes to maximize 32 and 35 d performance of this new broiler cross, ultimately improving potential profit for poultry producers.

MATERIALS AND METHODS

Egg Management

A total of 1,431 fertilized eggs (Cobb MV × Cobb 500) from a 37-wk-old breeder flock were obtained from a commercial hatchery [11]. All eggs were stored at 18°C for 3 d prior to incubation. On day 0, all eggs were individually weighed and labeled; they were then put into labeled flats (30 eggs/flat) and equally distributed in 3 Natureform single-stage setters [12].

On day 11, all eggs were candled and candle residue was performed to remove infertile and contaminated eggs, as well as early dead embryos. On day 18, all eggs were in ovo [13] vaccinated for Marek's disease (Hvt/Sb1 full dose) [14]. Immediately following vaccination, eggs were transferred to labeled hatching baskets and set into the hatchers. Then, on day of hatch, chicks were wing banded and individually weighed prior to placement in the grow-out facility.

Candle and Hatch Residue Analysis Candle residue was performed on day 11 of incubation, whereas all infertile egg, early, and mid dead were removed from the incubator [12]. On day 21 of incubation, hatch residue was performed in which all contaminated, cracked, or pipped egg, abnormal embryo, and late dead were counted. Hatchability was calculated taking into consideration the total number of incubated fertilized eggs on day 0 of incubation and total number of eggs and embryos removed after candle and hatch-residue analyses. Descriptive data demonstrated a high hatchability (89.8%) due to the low % infertile eggs (1.96%).

Broiler Management

A total of 16 chicks (straight run) were assigned to each of 48 floor pens (0.07 m^2/bird). To avoid incubation effects (different hatcher and basket/position in the hatcher), all hatched chicks from a common basket (top or bottom) and hatcher (1, 2, or 3) were placed in a common block. There were 2 replications (2 blocks) per hatcher.

Water and feed were offered ad libitum throughout the study, and all pens contained used litter (top dressed with fresh shavings), a hanging feeder, and 3 nipple drinkers. Birds were placed in a solid-walled facility with forced-air heating and evaporative cooling cells. To obtain cross-ventilation, negative air pressure was used.

On day 0 (day of chick placement), the house temperature was 32.2°C and it was gradually decreased until reaching 18.3°C at the end of the study on day 36 [15]. Birds received light for 24 h from day 0 to 7, and 4 h of dark from day 7 to the end of this study (day 36). The light intensity was 26.9 lux during the first 10 d. The lighting intensity was decreased on day 10 until reaching 2.7 lux on day 21 and remained so until day 35 [15].

Treatment Outline

The AAD regimes used in this study were as follows: low AAD (**LAAD** = starter dLys 1.08%, grower dLys 0.95%, and finisher dLys 0.87%); medium AAD (**MAAD** = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%); high AAD (**HAAD** = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%); and very high AAD (**VHAAD** = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%). The starter phase was considered to be from day 0–11, the grower phase from day 11–21, and the finisher phase from day 21–35.

Experimental Diet Preparations

Diet Formulation Two basal diets were formulated to LAAD (starter dLys 1.08%, grower dLys 0.95%, and finisher dLys 0.87%) and VHAAD (starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%; Table 1). Prior to batching, corn, soybean meal, distillers dried grains and solubles, as well as meat and bone meal were scanned into the near infrared spectroscopy [16] at Mississippi State University. This was done to obtain available nutrient values in order to formulate diets to make them as close as possible to target nutrients, including AAD.

Batching All basal diets were batched at the Poultry Research Unit, Mississippi State University; any ingredient with the inclusion under 0.5% of diet was included in a premix (e.g., synthetic amino acids, minerals, and vitamins; Table 1). Premixes were made by mixing the designated ingredients in a small mixer (capacity of approximately 11 kg) for 5 min. All macro ingredients (e.g., corn, soybean meal, distiller's dried grains with solubles) as well as the appropriate premixes were mixed in a vertical screw mixer (with capacity of 0.907 tonne) [17] for 5 min dry. Next, diets were mixed for 10 min post fat addition and then equally/randomly allocated to a treatment, prior to pelleting. MAAD and HAAD diets were created by mixing the LAAD and VHAAD diets at ratios of 66.5:33.5 and 33.5:66.5, respectively. It is important to note that the goal AAD for MAAD blended diets was to be based on broiler recommendations for the Cobb 500 [18].

Feed Manufacture All diets were pelleted at the Poultry Research Unit, U.S. Department of Agriculture (Starkville, MS), in order of increasing AAD. Diets were steam conditioned at 81°C (10 s) with a 262 kPa incoming steam pressure. For diet analysis, feed samples of LAAD and VHAAD from all feeding phases (starter, grower, and finisher) were collected before and after pelleting and sent to commercial laboratory [19] for AA analysis [20] (Table 2). The starter diet was fed from day 0 to 11 as crumbles; the grower diet was presented as crumbles from day 11 to 15 and as pellets during day 15 to 21; and the finisher was fed from day 21 to 35 as pellets.

Measured Variables

Live Performance On day 7, 11, 21, 32, and 35, all broiler tag numbers and corresponding individual weights were obtained. Feed intake per bird (**FI**), FCR (corrected for mortality), body weight gain (**BWG**), average BW, and coefficient of variation (**CV**) of BW were calculated from day 0 to 7, 0 to 11, 0 to 21, 0 to 32, and 0 to 35. Total lysine intake (g/bird) was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during each respective feeding period. For all mortality throughout the experiment, sex and cause of death was observed via necropsy. Additionally, sex was determined based on phenotypic characteristics at day 32 and 35 to analyze the sex effect and uniformity of this new commercial broiler cross. Mississippi State University Institutional Animal Care and Use Committee guidelines in agreement with the Guide for the Care and Use of Agricultural Animals Research and Teaching [21] were followed for this experiment. All live performance variables are displayed in Tables 3–11.

Processing Measurements Processing was conducted at the Mississippi State University Poultry Processing Plant on day 33 (target weight was 1.8 kg) and day 35 (target weight was 2.3 kg), as they are common target weights for a small bird program in the United States and different parts of the world. Both processings followed the same procedure in which 2 males and 2 females were selected per pen (±100 g avg. BW of each sex/pen; total of 192 birds/processing), weighed,

Table 1. Diet Formulations for Starter, Grower, and Finisher Phases.[1]

	Starter (day 0–11)		Grower (day 11–21)		Finisher (day 21–35)	
Ingredient name	Low AAD Inclusion %	Very high AAD Inclusion %	Low AAD Inclusion %	Very high AAD Inclusion %	Low AAD Inclusion %	Very high AAD Inclusion %
Corn	66.88	51.75	71.30	55.49	65.81	61.73
Soybean meal (48% CP)	21.46	35.45	17.45	31.82	17.81	25.36
DDGS[2]	3.00	3.00	4.00	4.00	5.00	5.00
Defluorinated phosphate	0.976	0.964	0.865	0.854	0.904	0.884
Calcium carbonate	0.514	0.447	0.510	0.441	0.537	0.511
Salt, NaCl	0.102	0.120	0.111	0.132	0.175	0.155
Meat and bone meal	4.00	4.00	3.00	3.00	2.58	2.58
Poultry fat	0.500	2.69	0.500	2.88	3.14	2.53
DL-Methionine	0.290	0.394	0.242	0.343	0.206	0.312
Sand	1.12	–	0.969	–	3.00	–
Sodium S-Carb	0.314	0.295	0.248	0.223	0.157	0.184
Vitamin-trace mineral	0.250	0.250	0.250	0.250	0.250	0.250
L-Lysine HCl	0.375	0.336	0.350	0.300	0.253	0.327
L-Threonine	0.079	0.180	0.081	0.147	0.079	0.091
Selenium premix 0.06%	0.024	0.024	0.024	0.024	–	–
Phytase[3]	0.011	0.011	0.011	0.011	0.011	0.011
Antibiotic[4]	0.050	0.050	0.050	0.050	0.050	0.050
Nicarbazin	0.040	0.040	0.030	0.030	0.030	0.030
L-Valine	0.014	0.012	0.011	0.003	–	–
Nutrient name			Calculated Nutrients[5] (%)			
Crude protein (%)	19.55	25.40	17.53	23.48	17.20	20.77
AME (kcal/kg)	3,024.17	3,024.17	3,074.16	3,074.16	3,124.15	3,124.15
dLys (%)	1.08	1.39	0.950	1.26	0.870	1.12
dThr (%)	0.680	0.960	0.610	0.860	0.610	0.730
dMet (%)	0.553	0.717	0.487	0.650	0.448	0.592
dCys (%)	0.257	0.313	0.243	0.299	0.232	0.268
dMet+Cys (%)	0.810	1.03	0.730	0.950	0.680	0.860
dArg (%)	1.11	1.51	0.970	1.38	0.960	1.19
dIle (%)	0.726	0.966	0.637	0.883	0.639	0.780
dLeu (%)	1.56	1.89	1.44	1.77	1.43	1.64
dVal (%)	0.820	1.04	0.730	0.950	0.717	0.851
dTrp (%)	0.194	0.271	0.168	0.247	0.170	0.214
dPhe (%)	0.838	1.09	0.750	1.01	0.747	0.898
Calcium (%)	0.940	0.940	0.870	0.870	0.820	0.820
aP (%)	0.470	0.470	0.435	0.435	0.410	0.410
Sodium (%)	0.230	0.230	0.200	0.200	0.200	0.200
Chloride (%)	0.200	0.200	0.200	0.200	0.215	0.215

[1]Low AAD (amino acid density); very high AAD; medium AAD (amino acid density) diet was composed of 66.5% low AAD and 33.5% very high AAD; and high AAD diet was composed of 33.5% low AAD and 66.5% very high AAD.

[2]Corn distillers dried grains with solubles.

[3]Quantum Blue AB Vista.

[4]BMD-50.

[5]Values are calculated based on the near infrared results of the AA composition of corn, soybean meal, DDGs, and animal by-product blend.

and tagged. Selected broilers were hung by their feet in shackles (on automated processing line) and were stunned by electrical stunning (an electric current running through a water bath). After stunning, broilers were exsanguinated using a knife to cut their necks. Next, broilers were submerged in hot water (52–66°C) to facilitate the feather removal by an automated plucking machine equipped with rubber fingers. Following, feet were manually removed at the hock joint, and carcasses were hung on a second automated line, where heads and necks were mechanically removed, and evisceration occurred. Abdominal fat pads of each carcass were

Table 2. Analyzed and Total AA Profile for Starter, Grower, and Finisher Feed Samples.[1]

	Starter (day 0–11)				Grower (crumble; day 11–12)				Grower (pellet; day 15–21)				Finisher (day 21–35)			
	Low AAD		Very high AAD		Low AAD		Very high AAD		Low AAD		Very high AAD		Low AAD		Very high AAD	
Amino acid	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]	Analyzed[2]	Total[3]
Lysine	1.27	1.22	1.48	1.57	1.20	1.08	1.31	1.43	1.13	1.08	1.47	1.43	0.98	1.00	1.15	1.27
Methionine	0.68	0.58	0.79	0.75	0.51	0.51	0.59	0.68	0.50	0.51	0.73	0.68	0.52	0.45	0.60	0.62
Cysteine	0.37	0.33	0.44	0.40	0.35	0.19	0.41	0.28	0.34	0.19	0.41	0.28	0.32	0.30	0.45	0.34
Tryptophan	0.22	0.22	0.29	0.31	0.18	0.19	0.24	0.28	0.19	0.19	0.25	0.28	0.18	0.20	0.20	0.24
Threonine	0.80	0.81	1.02	1.12	0.70	0.72	0.97	1.00	0.74	0.72	1.08	1.00	0.70	0.72	0.80	0.86
Isoleucine	0.79	0.82	0.99	1.09	0.67	0.72	0.86	1.00	0.69	0.72	0.98	1.00	0.70	0.72	0.79	0.88
Valine	0.89	0.97	1.05	1.23	0.79	0.86	0.92	1.12	0.80	0.86	1.06	1.12	0.80	0.84	0.86	1.00
Arginine	1.26	1.22	1.52	1.65	1.10	1.06	1.34	1.50	1.14	1.06	1.56	1.50	1.13	1.05	1.22	1.30
Leucine	1.58	1.72	1.88	2.09	1.44	1.58	1.74	1.96	1.45	1.58	1.84	1.96	1.51	1.57	1.64	1.81
Phenylalanine	0.92	–	1.10	–	0.79	–	0.99	–	0.82	–	1.11	–	0.84	–	0.91	–

[1]Feed samples were analyzed in duplicate at ATC Scientific labs (North Little Rock, AR).

[2]Analyzed values.

[3]Total values according to the diet formulation (Table 1).

Table 3. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Day 0 to 7 Cobb Broiler Performance.[1]

Amino acid density (AAD)[2]	Day 0–7 Avg[3] FI/bird[4] (kg)	Day 0–7 total lysine intake (g)/bird[5]	Day 0–7 percent mortality[6]	Day 0–7 mortality-corrected FCR[7]	Day 0–7 BWG[8] (kg)
Low	0.159[a]	2.003[b]	3.646	1.124[a]	0.139
Medium	0.153[b]	2.046[b]	4.688	1.102[a,b]	0.135
High	0.152[b]	2.147[a]	3.125	1.094[b]	0.141
Very high	0.147[c]	2.164[a]	3.125	1.048[c]	0.140
Fisher's LSD[9]	0.0082	0.0520	–	0.0294	–
P-value[10]	<0.0001	<0.0001	0.7859	<0.0001	0.2337
SEM[11]	0.0013	0.0180	1.2365	0.0102	0.0019

[1]For FI, FCR, and BWG, a RCBD with 4 AAD diets and 12 replicated floor pens per each treatment utilized.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average.
[4]Feed intake/bird (kg).
[5]Total lysine intake (g)/bird was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during the feeding period on a per bird basis.
[6]Percent mortality is based on a beginning pen number of 16 birds.
[7]Feed conversion ratio (feed: gain) was adjusted with mortality weight.
[8]Body weight gain (kg).
[9]Fisher's least significant difference.
[10]Alpha set at $P \leq 0.05$.
[11]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[a-c]Values within columns with different superscripts differ significantly ($P < 0.05$).

removed and kept for weight recording. Then, hot carcasses were removed from the automated line and weighed. After recording the weights of hot carcasses and abdominal fat pad, all carcasses were cooled for 3 h in an ice bath. Next, all carcasses were deboned and the following weights were obtained: boneless skinless breast (pectoralis major), tender (pectoralis minor), total breast (pectoralis major and minor), thigh, drumstick, and wing. Processing yield data was calculated relative to live BW (Tables 7–12).

Economic Analysis To evaluate the profitability of each AAD diet, the diet cost, the production costs per bird (in cents and dollar; from day 0 to 32 and from day 0 to 35), the potential gross chicken part value, and the potential cost savings/potential profit for each AAD (in cents and dollars) were calculated based on ingredient prices from Feedstuffs and USDA [22, 23] and chicken part values in the market ([24]; see equations below). These data are shown in Tables 16 and 17.

$$\text{Potential gross chicken part values} = \text{Processing data (chicken parts wt in kg)} * \text{Chicken part value in the market (cents)}$$

$$\text{Total potential gross chicken part value/bird (cents)} = \text{sum of all potential gross chicken part values/bird}$$

$$\text{Total feed cost/bird (cents)} = \text{Average feed intake (kg)} * \text{Feed cost (cents/kg)}$$

$$\text{Total feed cost/bird (dollars)} = \text{Total feed cost/bird (cents)}/100$$

$$\text{Gross bird profit (cents)} = \text{Total potential gross profit/bird (cents)} - \text{Total feed cost/bird (cents)}$$

$$\text{Gross bird profit (dollars; in kg)} = \text{Gross bird profit (cents)}/100$$

Table 4. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Day 0 to 11 Cobb Broiler Performance.[1]

Amino acid density (AAD)[2]	Day 0–11 Avg[3] FI/bird[4] (kg)	Day 0–11 total lysine intake (g)/bird[5]	Day 0–11 percent mortality[6]	Day 0–11 mortality-corrected FCR[7]	Day 0–11 BWG[8] (kg)
Low	0.370[a]	3.195	5.208	1.282[a]	0.284
Medium	0.359[a,b]	3.197	5.729	1.237[b]	0.289
High	0.352[b]	3.290	3.125	1.193[c]	0.292
Very high	0.340[c]	3.246	4.688	1.155[d]	0.291
Fisher's LSD[9]	0.0231	–	–	0.0242	–
P-value[10]	<0.0001	0.3090	0.6273	<0.0001	0.3650
SEM[11]	0.0036	0.0385	1.4675	0.0084	0.0030

[1]For FI, FCR, and BWG, a RCBD with 4 AAD diets and 12 replicated floor pens per each treatment utilized.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average.
[4]Feed intake/bird (kg).
[5]Total lysine intake (g)/bird was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during the feeding period on a per bird basis.
[6]Percent mortality is based on a beginning pen number of 16 birds.
[7]Feed conversion ratio (feed: gain) was adjusted with mortality weight.
[8]Body weight gain (kg).
[9]Fisher's least significant difference.
[10]Alpha set at $P \leq 0.05$.
[11]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[a–d]Values within columns with different superscripts differ significantly ($P < 0.05$).

Statistical Analysis

This study utilized a randomized complete block design (**RCBD**) with 4 AAD diets and 12 replicated floor pens per each treatment (12 blocks; designated by location) for FI, FCR, and BWG. One floor pen with 16 birds (0.07 m^2/bird) was considered as the experimental unit; the experimental period was from day 0–35. For BW, CV of BW, and processing, a RCBD with split plot was utilized, in which whole plots were AAD diets, and sex served as the split plot.

All measured variables were analyzed by the GLM procedure in SAS [25]. In addition, PROC CORR was used for correlation analysis between total lysine intake (g/bird) and BWG, as well as FCR. Also, PROC REG was utilized for regression analyses between dlys and FCR, as well as average FI/bird. A *P*-value of ≤0.05 was considered significant, and significant differences were further explored by Fisher's least significant difference.

RESULTS AND DISCUSSION

Feed Analysis

Formulated diets were analyzed for total analyzed AA composition and are displayed in Table 2. The analyzed and calculated values were similar across diets tested.

Broiler Performance

Feed Intake Results for days 0–7, 0–11, and 0–21 demonstrated that the birds fed the VHAAD diet had the lowest FI, while birds fed the LAAD diet had the highest FI ($P < 0.05$; Tables 3–5). These results are in agreement with a previous study with Cobb × Cobb 500 straight-run birds in which a decreased FI was observed when fed diets formulated to increased AAD at days 0–28 [10]. In addition, day 0–32 data showed that birds fed LAAD, MAAD, and HAAD diets had similar and higher FI when compared with birds fed VHAAD

Table 5. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Day 0 to 21 Cobb Broiler Performance.[1]

Amino acid density (AAD)[2]	Day 0–21 Avg[3] FI/bird[4] (kg)	Day 0–21 total lysine intake (g)/bird[5]	Day 0–21 percent mortality[6]	Day 0–21 mortality-corrected FCR[7]	Day 0–21 BWG[8] (kg)
Low	1.260[a]	13.337[c]	8.333	1.438[a]	0.876[b]
Medium	1.224[b]	13.935[b]	5.729	1.363[b]	0.896[a,b]
High	1.214[b]	14.628[a]	5.208	1.314[c]	0.915[a]
Very high	1.141[c]	14.676[a]	5.208	1.269[d]	0.909[a]
Fisher's LSD[9]	0.0672	0.3868	–	0.0202	0.0496
P-value[10]	<0.0001	<0.0001	0.6330	<0.0001	0.0179
SEM[11]	0.0106	0.1339	1.9661	0.0070	0.0078

[1]For FI, FCR, and BWG, a RCBD with 4 AAD diets and 12 replicated floor pens per each treatment utilized.

[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].

[3]Average.

[4]Feed intake/bird (kg).

[5]Total lysine intake (g)/bird was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during the feeding period on a per bird basis.

[6]Percent mortality is based on a beginning pen number of 16 birds.

[7]Feed conversion ratio (feed: gain) was adjusted with mortality weight.

[8]Body weight gain (kg).

[9]Fisher's least significant difference.

[10]Alpha set at $P \leq 0.05$.

[11]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.

[a–d]Values within columns with different superscripts differ significantly ($P < 0.05$).

diets ($P < 0.05$; Table 6). Additionally, day 0–35 data showed that birds fed LAAD had higher FI when compared with birds fed HAAD and VHAAD, with MAAD performing similar. In contrast, birds fed MAAD and HAAD had similar FI, and feeding VHAAD resulted in birds with lower FI than those fed LAAD and MAAD ($P < 0.05$; Table 7). Similarly, a previous study evaluating Ross × Ross 508 (male and female) found that feeding high AAD diet decreased feed consumption from 18 to 35 d of age [9].

Lysine Intake Birds fed HAAD and VHAAD diets had higher day 0–7 lysine intake as compared to birds fed LAAD and MAAD demonstrating similar lysine intake ($P < 0.05$; Table 3). However, no significant difference was observed for day 0–11 lysine intake ($P > 0.05$; Table 4). Furthermore, it was observed for days 0–21, 0–32, and 0–35 that birds fed HAAD and VHAAD diets had higher lysine intake when compared with those fed LAAD and MAAD diets, with those fed LAAD having the lowest lysine intake ($P < 0.05$; Tables 5–7).

Mortality Though mortality in the current study was high, mortality was not affected by the dietary treatment during the rearing period ($P > 0.05$; Tables 3–7). Previously, mortality was unaffected by different AAD diets throughout all phases [26]. All mortality in the current study was necropsied, and the main reason was due to *Escherichia coli* infection. Research has suggested that the amino acid requirement for birds that are immunosuppressed may be reduced [27, 28]; therefore, the performance of birds in the current study may be understated. Though, once again, it is important to note that there was no significance difference in mortality ($P > 0.05$; Table 3–7).

Feed Conversion Ratio Birds fed the VHAAD diet had the lowest day 0–7 mortality-corrected FCR compared to birds fed the other treatments ($P < 0.05$; Table 3). Similar to this study, previous research has found a benefit in corrected FCR at days 14, 28, 42, and 56, when feeding increased AAD diets to broilers from 3 different strains; however, this study [6] was

Table 6. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Day 0 to 32 Cobb Broiler Performance.[1]

Amino acid Density (AAD)[2]	Day 0–32 Avg[3] FI/bird[4] (kg)	Day 0–32 total lysine intake (g)/bird[5]	Day 0–32 percent mortality[6]	Day 0–32 mortality-corrected FCR[7]	Day 0–32 BWG[8] (kg)
Low	2.923[a]	29.402[c]	9.375	1.554[a]	1.870
Medium	2.877[a]	31.073[b]	5.729	1.498[b]	1.919
High	2.847[a]	32.404[a]	5.729	1.469[c]	1.928
Very high	2.756[b]	33.011[a]	6.250	1.425[d]	1.928
Fisher's LSD[9]	0.1792	0.8367	–	0.0196	–
P-value[10]	0.0041	<0.0001	0.5158	<0.0001	0.1081
SEM[11]	0.0282	0.2893	1.9905	0.0068	0.0169

[1]For FI, FCR, and BWG, a RCBD with 4 AAD diets and 12 replicated floor pens per each treatment utilized.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average.
[4]Feed intake/bird (kg).
[5]Total lysine intake (g)/bird was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during the feeding period on a per bird basis.
[6]Percent mortality is based on a beginning pen number of 16 birds.
[7]Feed conversion ratio (feed: gain) was adjusted with mortality weight.
[8]Body weight gain (kg).
[9]Fisher's least significant difference.
[10]Alpha set at $P \leq 0.05$.
[11]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[a–d]Values within columns with different superscripts differ significantly ($P < 0.05$).

published in 2005 and the highest AAD fed was comparable to the MAAD in the current study.

Additionally, results demonstrated that mortality-corrected FCR (days 0–11, 0–21, 0–32, and 0–35) incrementally decreased in a stepwise manner (the differences ranged from 4 to 9 points, i.e., 1.277 vs. 1.237) when birds were fed diets increasing in AAD ($P < 0.05$; Tables 4–7). In agreement, Taschetto et al. [10] reported a decrease in FCR (corrected for mortality) when Cobb × Cobb 500 straight-run birds were fed higher AAD diets, which were similar to higher AAD diets in the current study, as compared to those fed the low AAD diet at days 0–28 and 0–40. Also, based on this current study, this new broiler cross had a better mortality-corrected FCR (when feeding HAAD and VHAAD diets at day 32, and all AAD diets at day 35) than the reported FCR in the broiler performance manual (1.48 at day 32, and 1.53 at day 35) [18].

Body Weight Gain Previous research reported that BWG was not affected by varying AAD during days 1–19 [29]. Similar to this study, BWG was not affected by the dietary treatments during days 0–7, 0–11, 0–32, and 0–35 ($P > 0.05$; Tables 3, 4, 6, 7). However, day 0–21 data demonstrated that birds fed HAAD and VHAAD diets had higher BWG than those fed the LAAD diet, and birds receiving MAAD diets had intermediate BWG ($P < 0.05$; Table 5).

Body Weight A significant interaction of AAD × sex was observed for day 32 BW, in which females had the lowest BW regardless of AAD. For males, an improvement in BW was observed as AAD level increased, with males fed VHAAD diet having the highest BW, which was similar to those fed HAAD diet. Among AAD, male broilers fed LAAD diet had the lowest BW, followed by those that were provided MAAD diets, which performed similar to those fed HAAD diet.

For the main effect of AAD, BW was lower in birds fed the LAAD diet from day 21 when compared to those fed MAAD, HAAD, and VHAAD diets ($P < 0.05$; Table 8). However, no significant difference was observed for BW at days 7,

Table 7. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Day 0 to 35 Cobb Broiler Performance.[1]

Amino acid density (AAD)[2]	Day 0–35 Avg[3] FI/bird[4] (kg)	Day 0–35 total lysine intake (g)/bird[5]	Day 0–35 percent mortality[6]	Day 0–35 mortality-corrected FCR[7]	Day 0–35 BWG[8] (kg)
Low	3.183[a]	31.951[c]	9.375	1.519[a]	2.104
Medium	3.157[a,b]	33.981[b]	5.729	1.465[b]	2.172
High	3.082[b,c]	35.283[a]	5.729	1.430[c]	2.166
Very high	3.037[c]	36.231[a]	6.250	1.394[d]	2.175
Fisher's LSD[9]	0.0855	1.0144	–	0.0156	–
***P*-value**[10]	0.0048	<0.0001	0.5158	<0.0001	0.0837
SEM[11]	0.0329	0.3512	1.9905	0.0054	0.0220

[1]For FI, FCR, and BWG, a RCBD with 4 AAD diets and 12 replicated floor pens per each treatment utilized.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average.
[4]Feed intake/bird (kg).
[5]Total lysine intake (g)/bird was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during the feeding period on a per bird basis.
[6]Percent mortality is based on a beginning pen number of 16 birds.
[7]Feed conversion ratio (feed: gain) was adjusted with mortality weight.
[8]Body weight gain (kg).
[9]Fisher's least significant difference.
[10]Alpha set at $P \leq 0.05$.
[11]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[a-d]Values within columns with different superscripts differ significantly ($P < 0.05$).

11, and 35, as well as CV of BW ($P > 0.05$; Table 8). These results are inconsistent with a previous study in which Ross × Ross 508 males and females were fed increased AAD diets, resulting in improved BW at days 14, 28, 35, and 49 [5]. However, it should be noted that their highest AAD diet was similar to the MAAD in the current study; a longer grow-out and a different strain were utilized [5].

For the main effect of sex, significant differences were found for BW at day 11, 21, and 35, as well as CV of BW at day 7 ($P < 0.05$; Table 8), in which male broilers had higher BW than females in all cases; these differences were in agreement with those previously reported [30, 31]. On the other hand, no significant differences were observed for BW day 7, and CV of BW at days 11, 21, 32, and 35 ($P > 0.05$; Table 8); this was partially similar to a study conducted by Lopez et al. [32], in which no significant difference was found for CV of BW due to sex or strain. Additionally, the current study's broiler cross demonstrated a higher BW when compared to current broiler performance standards (regardless of AAD or sex at day 32 and for male broilers at day 35) [18].

Processing (days 33 and 36) No significant AAD × sex interaction was observed for any measured variable at days 33 and 35 ($P > 0.05$; Tables 12–15). For the main of AAD, results of day 33 processing demonstrated no significant difference for carcass, tender, drumstick, wing, and thigh yields (relative to live weight at day 32), as well as thigh and wing weights ($P > 0.05$; Tables 12 and 13). Processing data (day 36) demonstrated no significant difference for carcass, drumstick, thigh, and wing (relative to day 35 live weight), as well as drumstick, thigh, and wing weights ($P > 0.05$; Tables 14 and 15).

An improvement in breast and tender weight at day 33 was observed when birds were fed MAAD, HAAD, and VHAAD diets, when compared to those fed the LAAD diet ($P < 0.05$, Table 13). Similarly, Taschetto et al. [10] concluded that feeding increased AAD diets

Table 8. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Day 0, 7, 11, 21, 32, and 35 Body Weight, and Coefficient of Variation of Body Weight.[1]

Amino acid density (AAD)[2]	Sex	Day 0 BW[3] (kg)	CV[4] day 0 BW (%)	Day 7 BW[3] (kg)	CV[4] day 7 BW (%)	Day 11 BW[3] (kg)	CV[4] day 11 BW (%)	Day 21 BW[3] (kg)	CV[4] day 21 BW (%)	Day 32 BW[3] (kg)	CV[4] day 32 BW (%)	Day 35 BW[3] (kg)	CV[4] day 35 BW (%)
Low	Female	0.044	5.933	0.184	7.794	0.328	7.833	0.885	8.993	1.828[d]	9.675	2.021	11.221
Medium		0.043	7.817	0.181	6.920	0.332	5.735	0.906	7.083	1.850[d]	8.551	2.038	1.627
High		0.043	7.924	0.182	6.496	0.332	5.992	0.913	6.735	1.858[d]	7.381	2.037	7.007
Very high		0.043	7.350	0.182	7.396	0.330	7.418	0.897	10.475	1.866[d]	8.189	2.053	9.087
Low	Male	0.044	6.634	0.184	7.681	0.333	6.731	0.932	7.473	1.982[c]	8.487	2.284	9.287
Medium		0.044	8.652	0.177	11.045	0.342	7.709	0.970	8.564	2.062[b]	8.374	2.397	7.235
High		0.043	7.101	0.185	8.281	0.331	7.851	1.004	8.480	2.091[ab]	8.707	2.400	9.258
Very high		0.044	8.099	0.183	8.537	0.338	9.108	0.992	9.040	2.132[a]	8.407	2.440	9.245
Fisher's LSD[5]		–	–	–	–	–	–	–	–	0.0051	–	–	–
SEM[6]		0.0005	0.6168	0.0021	1.1039	0.0033	0.9287	0.0112	1.3153	0.0190	1.1099	0.0265	1.6639
Main effect of AAD													
Low		0.044	6.283	0.184	7.737	0.331	7.282	0.909[b]	8.233	1.906	9.081	2.153	10.254
Medium		0.043	8.235	0.179	8.982	0.332	6.722	0.938[a]	7.824	1.957	8.462	2.218	8.589
High		0.043	7.512	0.183	7.389	0.337	6.921	0.959[a]	7.608	1.975	8.044	2.218	8.133
Very high		0.043	7.724	0.182	7.966	0.334	8.263	0.945[a]	9.757	1.999	8.298	2.240	9.166
SEM[6]		0.0003	0.5199	0.0021	1.0409	0.0029	0.6768	0.0098	1.0498	0.0199	0.6322	0.0266	0.9001
Main effect of sex													
Female		0.043	7.256	0.182	7.151[b]	0.330[b]	6.745	0.900[b]	8.322	1.850	8.449	2.037[b]	9.315
Male		0.044	7.621	0.182	8.886[a]	0.336[a]	7.850	0.974[a]	8.389	2.067	8.494	2.380[a]	8.715
SEM[6]		0.0002	0.3084	0.0011	0.5519	0.0016	0.4643	0.0056	0.6577	0.0095	0.5549	0.0187	0.8332
P-values													
AAD[7]		0.5052	0.0737	0.2629	0.7308	0.4513	0.3949	0.0089	0.4747	0.0151	0.6932	0.1030	0.3694
Sex[8]		0.1200	0.4066	0.8550	0.0315	0.0193	0.0995	<0.0001	0.9424	<0.0001	0.9549	<0.0001	0.6381
AAD x sex[9]		0.6609	0.4854	0.4349	0.2875	0.3419	0.2987	0.1166	0.4372	0.0391	0.7267	0.1091	0.4327

[1]For BW and coefficient of variation of BW, a RCBD with split plot was utilized, in which whole plots were AAD diets, and sex served as the split plot.

[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].

[3]Body weight (kg).

[4]Coefficient of variation of BW.

[5]Fisher's least significant difference.

[6]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.

[7]*P*-values for AAD main effect; alpha set at $P \leq 0.05$.

[8]*P*-values for sex main effect; alpha set at $P \leq 0.05$.

[9]*P*-values for AAD x sex interaction; alpha set at $P \leq 0.05$.

[a,b]Values within columns with different superscripts differ significantly ($P < 0.05$).

Table 9. Correlations Between Total Lysine (Lys) Intake and Body Weight Gain, as Well as Total Lysine Intake and Feed Conversion Ratio (Day 0–7, 0–11, 0–21, 0–32, and 0–35).

Total Lysine (Lys) intake[1] and BWG[2]	Day 0–7 Lys intake/bird[3] and BWG	Day 0–11 Lys intake/bird[4] and BWG	Day 0–21 Lys intake/bird[5] and BWG	Day 0–32 Lys intake/bird[6] and BWG	Day 0–35 Lys intake/bird[7] and BWG
R	0.4645	0.7137	0.7488	0.7595	0.7081
P-values	0.0011	<0.0001	<0.0001	<0.0001	<0.0001
Lys intake[1] and FCR[8]	Day 0–7 Lys intake/bird[3] and FCR	Day 0–11 Lys intake/bird[4] and FCR	Day 0–21 Lys intake/bird[5] and FCR	Day 0–32 Lys intake/bird[6] and FCR	Day 0–35 Lys intake/bird[7] and FCR
R	–0.0251	0.0719	–0.6829	–0.6674	–0.6414
P-values	0.8669	0.6309	<0.0001	<0.0001	<0.0001

[1]Total lysine intake (g)/bird was calculated utilizing the analyzed total lysine of the diet (Table 2) fed during the feeding period and multiplying it by the intake during the feeding period on a per bird basis.
[2]Body weight gain (kg).
[3]Lys intake/bird on day 0–7 (g), which was calculated using day 0–7 feed intake/bird and analyzed Lys/diet.
[4]Lys intake/bird on day 0–11 (g), which was calculated using day 0–11 feed intake/bird and analyzed Lys/diet.
[5]Lys intake/bird on day 0–21 (g), which was calculated using day 0–21 feed intake/bird and analyzed Lys/diet.
[6]Lys intake/bird on day 0–32 (g), which was calculated using day 0–32 feed intake/bird and analyzed Lys/diet.
[7]Lys intake/bird on day 0–35 (g), which was calculated using day 0–35 feed intake/bird and analyzed Lys/diet.
[8]Feed conversion ratio (corrected for mortality).

Table 10. Regression Analysis for Feed Conversion Ratio and Digestible Lysine (dLys) (Through Treatment Means).

		Linear model			Quadratic model			
Days of grow-out	Relationship between FCR[1] and dLys[2]	Model *P*-value	Linear slope *P*-value	R^2 value	Model *P*-value	Linear slope *P*-value	Quadratic slope *P*-value	R^2 value
Day 0–7	Linear[3]	0.0474	0.0474	0.9075	0.2098	0.5411	0.4846	–
Day 0–11	Linear[4]	0.0030	0.0030	0.9941	0.0545	0.8097	0.5017	–
Day 0–21	Quadratic[5]	<0.0001	<0.0001	–	<0.0001	0.0296	0.1115	0.8652
Day 0–32	Quadratic[6]	<0.0001	<0.0001	–	<0.0001	0.0933	0.2297	0.8010
Day 0–35	Quadratic[7]	<0.0001	<0.0001	–	<0.0001	0.0604	0.1605	0.8018

[1]Feed conversion ratio (corrected for mortality).
[2]Digestible lysine (%).
[3]Calculated values were derived using the regression equation: $y = –0.2303x + 1.37636$, where y = FCR and x = dLys.
[4]Calculated values were derived using the regression equation: $y = –0.38571x + 1.69463$; where y = FCR and x = dLys.
[5]Calculated values were derived using the regression equation: $y = 0.54948x^2–1.88405x + 2.82574$, where y = FCR and x = dLys.
[6]Calculated values were derived using the regression equation: $y = 0.40038x^2–1.39726x + 2.59440$, where y = FCR and x = dLys.
[7]Calculated values were derived using the regression equation: $y = 0.46467x^2–1.55290x + 2.65590$, where y = FCR and x = dLys.

maximized breast meat yields. In contrast, previous research feeding similar AAD regimes demonstrated no AAD effect on carcass yield and breast weight [8, 26].

Based on this study, birds fed HAAD and VHAAD diets had greater tender yield (relative to day 35 live weight) when compared to birds fed the LAAD diet ($P < 0.05$). Tender weight increased when birds were fed the VHAAD diet as compared to those fed the LAAD diet, with birds receiving MAAD and HAAD diets performing similar ($P < 0.05$; Tables 14 and 15). In agreement, Corzo et al. [6] reported higher tender yields (relative to live weight) at day 42 and 56 (which were longer than the processing periods for the current study), when birds were

Table 11. Regression Analysis for Average Feed Intake and Digestible Lysine (Through Treatment Means).

		Linear model			Quadratic model			
Days of grow-out	Relationship between FI[1] and dLys[2]	Model *P*-value	Linear slope *P*-value	R^2 value	Model *P*-value	Linear slope *P*-value	Quadratic slope *P*-value	R^2 value
Day 0–7	Linear[3]	0.0434	0.0434	0.9151	0.2869	0.9671	0.8885	–
Day 0–11	Quadratic[4]	0.0270	0.0270	–	0.0412	0.1142	0.1356	0.9983
Day 0–21	–	0.0523	0.0523	–	0.2166	0.5273	0.4747	–
Day 0–32	Linear[5]	0.0215	0.0215	0.9574	0.1321	0.5262	0.4424	–
Day 0–35	Linear[6]	0.0258	0.0258	0.9491	0.0850	0.2918	0.2460	–

[1]Feed Intake (g).
[2]Digestible lysine (%).
[3]Calculated values were derived using the regression equation: $y = -33.53789x + 193.79047$,where y = FI and x = dLys.
[4]Calculated values were derived using the regression equation: $y = -215.59794x^2 + 446.82935x + 133.34985$, where y = FI and x = dLys.
[5]Calculated values were derived using the regression equation: $y = —491.88979x + 3463.37089$, where y = FI and x = dLys.
[6]Calculated values were derived using the regression equation: $y = -665.57029x + 4986.99938$, where y = FI and x = dLys.

fed the high AAD diet as compared to those fed the low AAD diet; however, their high AAD diet was equivalent to the MAAD diet in the current study.

Breast yield relative to day 32 live weight resulted in an improvement when birds were fed diets formulated to either MAAD, HAAD, or VHAAD as compared to those fed the LAAD diet ($P < 0.05$; Table 12). This result is in agreement with previous findings [5, 7, 8, 26], in which breast meat yield was shown to be affected by dietary AAD; feeding higher AAD diets exhibited an increase in breast meat yield on broilers when compared to feeding the LAAD diet. In addition, day 36 processing demonstrated that birds fed MAAD and VHAAD had greater breast yield (relative to day 35 live weight) and weight when compared to birds fed the LAAD diet ($P < 0.05$; Tables 14 and 15). Additionally, day 33 processing resulted in birds fed HAAD and VHAAD diets having greater day 32 live weight and drumstick weight when compared to birds fed the LAAD diet ($P < 0.05$; Tables 12 and 13).

Lastly, it was observed that on days 33 and 36 processing that feeding the VHAAD diet decreased fat pad yield (relative to days 32 and 35 live weight) and weight of broilers, with birds receiving the HAAD diet performing similar ($P < 0.05$; Tables 12–15). Unlike the present study, it was previously found that abdominal fat weight was not affected when feeding different AAD diets [7]. However, the current study is in agreement with previous studies, in which abdominal fat pad yield and weight were reported to be affected by different AAD diets [5, 6, 8, 9]. Providing higher AAD diets to broilers has been shown to decrease abdominal pad fat yield and weight in comparison to feeding the LAAD diet [7, 26].

For the main of sex, as expected, some benefits in processing characteristics were found when comparing male to female broilers, such as a greater average live weight at days 32 and 35, drumstick yield (relative to days 32 and d 35 live weight), drumstick and wing weights at days 33 and 36, as well as breast and thigh weights at day 36 ($P < 0.05$; Tables 12–15). This was somewhat in agreement with previous work that observed that males had higher carcass and breast weight compared with females [32, 33].

Additionally, the current study found that females had greater tender and fat pad yield (relative to days 32 and 35 live weight) as well as fat pad weight at day 33 when compared to males ($P < 0.05$; Tables 9–11). These results are in partial agreement with a study conducted by Kidd et al. [31], in which females were reported to have a lower tender yield when compared with males. It was previously reported that females had a higher abdominal fat pad than males, which might be due to differences between sex and their

Table 12. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Processing Characteristics (Day 33) Reported as Average Yield Relative to Day 32 Live Weight.[1]

			Yield relative to day 32 live weight[4] (%)						
Amino acid density (AAD)[2]	Sex	Avg[3] day 32 BW (kg)	Carcass	Breast[5]	Tender[6]	Drumstick	Thigh	Wing	Fat pad
Low	Female	1.894	65.863	15.525	3.657	8.704	11.736	7.996	1.588
Medium		1.937	66.652	16.566	3.803	8.736	12.085	7.828	1.282
High		1.961	66.736	16.857	3.922	8.729	11.791	7.765	1.287
Very high		1.942	67.011	17.205	3.889	8.622	11.863	7.835	1.079
Low	Male	1.928	65.924	15.835	3.611	8.824	11.817	7.905	1.175
Medium		1.966	66.898	16.635	3.708	8.971	11.779	8.072	1.099
High		2.015	66.723	16.954	3.609	9.048	11.622	7.929	0.909
Very high		2.025	66.428	16.528	3.659	9.071	12.045	7.869	0.834
Fisher's LSD[7]		–	–	–	–	–	–	–	–
SEM[8]		0.0185	0.3364	0.2655	0.0750	0.1472	0.1430	0.0861	0.0804
			Main effect of AAD						
Low		1.911[b]	65.894	15.680[b]	3.634	8.764	11.776	7.951	1.381[a]
Medium		1.952[ab]	66.775	16.600[a]	3.756	8.854	11.932	7.950	1.190[b]
High		1.988[a]	66.730	16.905[a]	3.765	8.889	11.707	7.847	1.098[b,c]
Very high		1.984[a]	66.719	16.866[a]	3.774	8.847	11.954	7.852	0.966[c]
SEM[8]		0.0192	0.3272	0.1928	0.0512	0.0911	0.1298	0.0609	0.0586
			Main effect of sex						
Female		1.934[b]	66.565	16.538	3.818[a]	8.698[b]	11.869	7.856	1.309[a]
Male		1.984[a]	66.493	16.488	3.647[b]	8.978[a]	11.815	7.944	1.010[b]
SEM[8]		0.0092	0.3364	0.2655	0.0750	0.1472	0.1430	0.0861	0.0414
			P-values						
AAD[9]		0.0271	0.1894	0.0002	0.1968	0.7995	0.4738	0.4444	0.0002
Sex[10]		0.0004	0.7638	0.7904	0.0024	0.0100	0.6000	0.1574	<0.0001
AAD × Sex[11]		0.4557	0.6416	0.2790	0.2768	0.7225	0.3113	0.2367	0.4449

[1]For BW and coefficient of variation of BW, a RCBD with split plot was utilized, in which whole plots were AAD diets, and sex served as the split plot.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that medium AAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average.
[4]Yield relative to live body weight (%).
[5]Breast refers to the pectoralis major.
[6]Tender refers to the pectoralis minor.
[7]Fisher's least significant difference.
[8]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[9]*P*-values for AAD main effect; alpha set at $P \leq 0.05$.
[10]*P*-values for sex main effect; alpha set at $P \leq 0.05$.
[11]*P*-values for AAD x sex interaction; alpha set at $P \leq 0.05$.
[a–c]Values within columns with different superscripts differ significantly ($P < 0.05$).

body metabolism, fat accumulation, and nutritional requirement [6, 34].

Correlation Analysis Significant correlations were observed for total lysine intake and BWG at day 0–7 ($P = 0.0011$; R = 0.4645); day 0–11 ($P < 0.0001$; R = 0.7137); day 0–21 ($P < 0.0001$; R = 0.7488); day 0–32 ($P < 0.0001$; R = 0.7595); and day 0–35 ($P < 0.0001$; R = 0.7081; Table 9). No correlations ($P > 0.05$) were observed for total lysine intake and FCR at day 0–7 or day 0–11. On the other hand, strong correlations were observed for total lysine

Table 13. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Processing Characteristics (Day 33) Reported as Average Weight.[1]

		Avg weight[3] (kg)					
Amino acid density (AAD)[2]	Sex	Breast[4]	Tender[5]	Drumstick	Thigh	Wing	Fat pad
Low	Female	0.294	0.069	0.165	0.222	0.151	0.030
Medium		0.321	0.074	0.169	0.235	0.152	0.025
High		0.331	0.077	0.171	0.231	0.152	0.025
Very high		0.334	0.076	0.168	0.231	0.152	0.021
Low	Male	0.305	0.070	0.170	0.228	0.152	0.023
Medium		0.328	0.073	0.176	0.232	0.159	0.022
High		0.342	0.073	0.182	0.234	0.160	0.018
Very high		0.335	0.074	0.184	0.244	0.159	0.017
Fisher's LSD[6]		–	–	–	–	–	–
SEM[7]		0.0057	0.0014	0.0032	0.0035	0.0019	0.0016
		Main effect of AAD					
Low		0.299[b]	0.069[b]	0.167[b]	0.225	0.151	0.026[a]
Medium		0.324[a]	0.073[a]	0.173[a,b]	0.233	0.155	0.023[a,b]
High		0.336[a]	0.075[a]	0.177[a]	0.233	0.156	0.022[b,c]
Very high		0.335[a]	0.075[a]	0.176[a]	0.237	0.156	0.019[c]
SEM[7]		0.0051	0.0013	0.0022	0.0037	0.0017	0.0012
		Main effect of sex					
Female		0.320	0.074	1.168[b]	0.230	0.152[b]	0.025[a]
Male		0.327	0.072	0.178[a]	0.234	0.157[a]	0.020[b]
SEM[7]		0.0027	0.0007	0.0016	0.0018	0.0010	0.0009
		P-values					
AAD[8]		<0.0001	0.0224	0.0193	0.1472	0.2220	0.0017
Sex[9]		0.0683	0.1628	<0.0001	0.0576	0.0002	<0.0001
AAD × sex[10]		0.7759	0.4322	0.3791	0.1330	0.2644	0.4628

[1]For BW and coefficient of variation of BW, a RCBD with split plot was utilized, in which whole plots were AAD diets, and sex served as the split plot.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that medium AAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average weight (kg).
[4]Breast refers to the pectoralis major.
[5]Tender refers to the pectoralis minor.
[6]Fisher's least significant difference.
[7]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[8]*P*-values for AAD main effect; alpha set at $P \leq 0.05$.
[9]*P*-values for Sex main effect; alpha set at $P \leq 0.05$.
[10]*P*-values for AAD x sex interaction; alpha set at $P \leq 0.05$.
[a–c]Values within columns with different superscripts differ significantly ($P < 0.05$).

intake and FCR at day 0–21 ($P < 0.0001$; R = –0.6829); day 0–32 ($P < 0.0001$; R = –0.6674); and day 0–35 ($P < 0.0001$; R = –0.6414; Table 9).

Regression Analysis Based on this study, day 0–7 and 0–11 data demonstrated that FCR decreased linearly with increasing dLys levels ($P < 0.05$; Table 10). In addition, significant quadratic relationships between FCR and dLys were observed at days 0–21, 0–32, and 0–35 ($P < 0.0001$; Table 10). Lastly, based on days 0–7, 0–32, and 0–35 data, FI decreased linearly with increasing dLys levels, while day 0–11 data showed a significant quadratic relationship between FI and dLys ($P < 0.05$; Table 11).

Table 14. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Processing Characteristics (Day 36) Reported as Average Yield Relative to Day 35 Live Weight.[1]

Amino acid density (AAD)[2]	Sex	Avg[3] day 35 BW (kg)	Yield relative to day 35 live weight[4] (%) Carcass	Breast[5]	Tender[6]	Drumstick	Thigh	Wing	Fat pad
Low	Female	2.118	68.202	16.538	3.961	9.098	12.208	7.824	1.509
Medium		2.132	66.372	17.493	4.057	9.039	12.343	7.813	1.492
High		2.137	68.938	17.637	4.093	9.170	12.273	7.806	1.325
Very high		2.127	68.783	18.072	4.082	9.039	12.366	7.622	1.115
Low	Male	2.231	67.511	16.750	3.620	9.489	11.969	7.891	1.216
Medium		2.333	67.849	17.663	3.734	9.371	12.231	7.537	1.282
High		2.312	67.899	17.203	3.784	9.226	12.075	7.619	1.076
Very high		2.364	68.241	17.759	3.956	9.235	12.395	7.885	1.028
Fisher's LSD[7]		–	–	–	–	–	–	–	–
SEM[8]		0.0245	0.8033	0.3095	0.0755	0.0930	0.1688	0.154	0.0884
Main effect of AAD									
Low		2.175	67.856	16.644[b]	3.791[b]	9.293	12.089	7.858	1.363[a,b]
Medium		2.233	67.110	17.578[a]	3.900[a,b]	9.205	12.287	7.675	1.387[a]
High		2.224	68.419	17.420[a,b]	3.939[a]	9.198	12.174	7.713	1.201[b,c]
Very high		2.247	68.572	17.977[a]	4.026[a]	9.116	12.399	7.733	1.059[c]
SEM[8]		0.0304	0.6080	0.2785	0.0478	0.0926	0.1332	0.0990	0.0628
Main effect of sex									
Female		2.128[b]	68.074	17.435	4.051[a]	9.086[b]	12.298	7.766	1.360[a]
Male		2.312[a]	67.891	17.362	3.772[b]	9.324[a]	12.172	7.722	1.146[b]
SEM[8]		0.0215	0.4298	0.1969	0.0338	0.0655	0.0942	0.0700	0.0444
P-values									
AAD[9]		0.3945	0.3574	0.0218	0.0185	0.7047	0.4539	0.5937	0.0041
Sex[10]		<0.0001	0.7282	0.6793	<0.0001	0.0006	0.2818	0.7639	0.0017
AAD × sex[11]		0.0963	0.3935	0.6353	0.4648	0.2801	0.8688	0.3084	0.6959

[1]For BW and coefficient of variation of BW, a RCBD with split plot was utilized, in which whole plots were AAD diets, and sex served as the split plot.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that medium AAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average.
[4]Yield relative to live body weight (%).
[5]Breast refers to the pectoralis major.
[6]Tender refers to the pectoralis minor.
[7]Fisher's least significant difference.
[8]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[9]*P*-values for AAD main effect; alpha set at $P \leq 0.05$.
[10]*P*-values for sex main effect; alpha set at $P \leq 0.05$.
[11]*P*-values for AAD x sex interaction; alpha set at $P \leq 0.05$.
[a–c]Values within columns with different superscripts differ significantly ($P < 0.05$).

Economic Analysis (Days 33 and 35)

At 33 d of age, the potential cost saving/potential gross profit per bird was greater on birds fed the HAAD diet (Table 16). While at 36 d of age, the highest potential cost saving/potential gross profit per bird was observed on birds fed the VHAAD diet (Table 17). Based on economic return, the higher breast weight at day 32 for birds fed the HAAD diet provided an increase of $0.16 in potential gross chicken part value when compared to birds fed the LAAD diet. An increase of $0.18 in potential gross chicken part value for birds fed

Table 15. The Effect of Varying Amino Acid Density (Low, Medium, High, or Very High) on Processing Characteristics (Day 36) Reported as Average Weight.[1]

Amino acid density (AAD)[2]	Sex	Avg weight[3] (kg) Breast[4]	Tender[5]	Drumstick	Thigh	Wing	Fat pad
Low	Female	0.350	0.084	0.193	0.259	0.166	0.032
Medium		0.374	0.087	0.193	0.263	0.166	0.032
High		0.377	0.087	0.196	0.262	0.167	0.029
Very high		0.386	0.087	0.192	0.263	0.162	0.024
Low	Male	0.375	0.081	0.212	0.267	0.176	0.028
Medium		0.413	0.087	0.219	0.285	0.176	0.030
High		0.398	0.088	0.213	0.279	0.176	0.025
Very high		0.420	0.094	0.218	0.293	0.186	0.024
Fisher's LSD[6]		–	–	–	–	–	–
SEM[7]		0.0084	0.0019	0.0032	0.0050	0.0034	0.0021
		Main effect of AAD					
Low		0.363[b]	0.082[b]	0.202	0.263	0.171	0.030[a]
Medium		0.393[a]	0.087[a,b]	0.206	0.274	0.171	0.031[a]
High		0.387[a,b]	0.088[a,b]	0.205	0.271	0.171	0.027[a,b]
Very high		0.405[a]	0.091[a]	0.205	0.279	0.174	0.024[b]
SEM[7]		0.0100	0.019	0.0036	0.0048	0.0030	0.0015
		Main effect of sex					
Female		0.372[b]	0.0863	0.194[b]	0.262[b]	0.165[b]	0.029
Male		0.402[a]	0.0873	0.215[a]	0.282[a]	0.178[a]	0.027
SEM[7]		0.0071	0.0013	0.0026	0.0034	0.0021	0.0010
		P-values					
AAD[8]		0.0463	0.0504	0.9189	0.1612	0.8704	0.0118
Sex[9]		<0.0001	0.4408	<0.0001	<0.0001	<0.0001	0.1089
AAD × sex[10]		0.6858	0.1142	0.3702	0.2184	0.0953	0.6320

[1]For BW and coefficient of variation of BW, a RCBD with split plot was utilized, in which whole plots were AAD diets, and sex served as the split plot.
[2]Low AAD (amino acid density) = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%; medium AAD = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%; high AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%; and very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%. It is important to note that medium AAD was formulated based on breeder recommendation for Cobb 500 [18].
[3]Average weight (kg).
[4]Breast refers to the pectoralis major.
[5]Tender refers to the pectoralis minor.
[6]Fisher's least significant difference.
[7]Standard error of the mean, an estimate of the amount that an obtained mean may be expected to differ by chance from the true mean.
[8]*P*-values for AAD main effect; alpha set at $P \leq 0.05$.
[9]*P*-values for sex main effect; alpha set at $P \leq 0.05$.
[10]*P*-values for AAD x sex interaction; alpha set at $P \leq 0.05$.
[a–c]Values within columns with different superscripts differ significantly ($P < 0.05$).

VHAAD diet vs. LAAD diet at day 36 was also observed.

In addition, birds fed the LAAD diet demonstrated the lowest potential saving/potential gross profit per bird in both periods. However, it is important to point out that these potential gross savings or profits were calculated only during a specific period of time (a 32 and 35 d grow-out period in July 2017) [22, 23]. Therefore, it is essential to constantly reconsider the relationship between feed costs and processing yield, since feed ingredients and chicken part values have been instable and change periodically [26].

Table 16. Potential Gross Bird Profit or Potential Saving for Each Amino Acid Density Diet (Day 33).

Potential gross chicken part values[1] using processing data (chicken parts weight in kg) and chicken part values in the market (cents)[2]	Amino acid density (AAD)			
	Low[3]	Medium[4]	High[5]	Very high[6]
Breast	100.22	108.66	112.69	112.15
Wings	65.808	67.384	67.778	67.680
Tenders	30.621	32.323	32.923	32.923
Thighs	29.854	30.908	30.908	31.479
Drumsticks	19.313	19.942	20.386	20.256
Total potential gross chicken part values/bird (cents)[7]	245.82	259.22	264.68	264.49
Total feed costs/bird (cents)[8]	63.954	65.351	67.158	67.446
Total feed costs/bird (dollars)[9]	0.6395	0.6535	0.6716	0.6745
Gross bird profit (profit processing-feed costs/bird; cents)[10]	181.87	193.86	197.52	197.05
Gross bird profit (profit processing-feed costs/bird; dollars; kg)[11]	1.819	1.939	1.975	1.971

[1]Potential gross chicken part values = Processing data (chicken parts wt in kg) ∗ Chicken part value in the market (cents).
[2]Express Markets Incorporated (weekly report for July 7, 2017; 5-day average, Fort Wayne, IN. Chicken part prices (cents/kg): breast = 335.09; wings = 434.45; tenderloins = 441.31; thighs = 132.72; drumsticks = 115.41).
[3]Low AAD = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%.
[4]Medium AAD (MAAD) = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].
[5]High AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%.
[6]Very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%.
[7]Total potential gross chicken part value/bird (cents) = sum of the potential gross chicken part values (breast, wings, tenders, thighs, and drumsticks) per bird.
[8]Total feed cost/bird (cents) = Average feed intake (kg) ∗ Feed cost (cents/kg; ingredient prices were based from Feedstuffs—Ingredient Market Prices and USDA—Feedstuffs Reports. Ingredient prices ($/ton): Corn = $124.57; soybean meal = $328.28; corn distiller's dried grains with solubles = $104.45; meat and bone meal = $272.4; deflourinated phosphate = $1,520; calcium carbonate = $212; salt = $54; poultry fat = $23.63; sand = $150; sodium S-carb = $488; vitamin-trace mineral = $1,556; selenium premix = $386; DL-methionine = $2,880; L-lysine = $1,660; L-threonine = $1,940; L-valine = $9,900; phytase = $8,300; bacitracin = $7,500; nicarbazin = $898).
[9]Total feed cost/bird (dollars) = Total feed cost/bird (cents)/100.
[10]Gross bird profit (cents) = Total potential gross profit/bird (cents)—Total feed cost/bird (cents).
[11]Gross bird profit (dollars; in kg) = Gross bird profit (cents)/100.

SUMMARY AND FUTURE DIRECTION

This study emphasizes the importance of considering several factors (such as age and market) when evaluating the response of a new commercial broiler cross (Cobb MV × Cobb 500) to different AAD diets. Feeding increased AAD decreased FCR and FI, as well as improved BWG (day 21), BW (days 21 and 32), and some processing characteristics. Based on this, performance data demonstrated a better mortality-corrected FCR (HAAD and VHAAD diets at day 32; and all AAD diets at day 35) in comparison to what was previously found by Zhai et al. [26] (FCR = 1.58 when feeding MAAD diets at d 35). In addition, a greater BW was observed when feeding all diets at day d 35 in comparison to the BW reported by Zhai et al. (1.95 kg when feeding MAAD at d 35) [26]. Because it is also known that sex and age can affect nutrition requirements, further research is needed to evaluate the effects of feeding different AAD diets in male and female Cobb MV × Cobb 500 separately, as well as longer grow-out periods. Additionally, future small bird research should compare the economics of different commercial broiler crosses.

CONCLUSION AND APPLICATIONS

1. Feeding diets with higher levels of AAD improved live performance of the Cobb MV × Cobb 500 broiler cross. These data were supported by correlation and

Table 17. Potential Gross Bird Profit/Potential Saving for Each Amino Acid Density Diet (Day 36).

Potential gross chicken part values[1] using processing data (chicken part weight in kg) and chicken part values in the market (cents)[2]	Amino acid density (AAD)			
	Low[3]	Medium[4]	High[5]	Very high[6]
Breast	121.50	131.83	129.78	135.56
Wings	74.083	73.591	74.379	75.660
Tenders	36.426	38.327	38.627	39.928
Thighs	34.880	36.385	35.903	37.077
Drumsticks	23.344	23.736	23.605	23.684
Total potential gross chicken part values/bird (cents)[7]	290.23	303.87	302.30	311.91
Total feed costs/bird (cents)[8]	69.135	71.596	73.024	73.193
Total feed costs/bird (dollars)[9]	0.6913	0.7160	0.7302	0.7319
Gross bird profit (profit processing-feed costs/bird; cents)[10]	221.1	232.3	229.3	238.7
Gross bird profit (profit processing-feed costs/bird; dollars; kg)[11]	2.211	2.323	2.293	2.387

[1]Potential gross chicken part values = Processing data (chicken parts wt in kg) ∗ Chicken part value in the market (cents).
[2]Express Markets Incorporated (weekly report for July 7, 2017; 5-day average, Fort Wayne, IN. Chicken part prices (cents/kg): breast = 335.09; wings = 434.45; tenderloins = 441.31; thighs = 132.72; drumsticks = 115.41).
[3]Low AAD = starter dLys (digestible lysine) 1.08%, grower dLys 0.95%, and finisher dLys 0.87%.
[4]Medium AAD (MAAD) = starter dLys 1.18%, grower dLys 1.05%, and finisher dLys 0.95%. It is important to note that MAAD was formulated based on breeder recommendation for Cobb 500 [18].
[5]High AAD = starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%.
[6]Very high AAD = starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%.
[7]Total potential gross chicken part value/bird (cents) = sum of the potential gross chicken part values (breast, wings, tenders, thighs, and drumsticks) per bird.
[8]Total feed cost/bird (cents) = Average feed intake (kg) ∗ Feed cost (cents/kg; ingredient prices were based from Feedstuffs—Ingredient Market Prices and USDA—Feedstuffs Reports. Ingredient prices ($/ton): Corn = $124.57; soybean meal = $328.28; corn distiller's dried grains with solubles = $104.45; meat and bone meal = $272.4; deflourinated phosphate = $1,520; calcium carbonate = $212; salt = $54; poultry fat = $23.63; sand = $150; sodium S-carb = $488; vitamin-trace mineral = $1,556; selenium premix = $386; DL-methionine = $2,880; L-lysine = $1,660; L-threonine = $1,940; L-valine = $9,900; phytase = $8,300; bacitracin = $7,500; nicarbazin = $898).
[9]Total feed cost/bird (dollars) = Total feed cost/bird (cents)/100.
[10]Gross bird profit (cents) = Total potential gross profit/bird (cents)—Total feed cost/bird (cents).
[11]Gross bird profit (dollars; in kg) = Gross bird profit (cents)/100.

regression analyses. Perhaps most notable, these improvements were found with FCR (mortality corrected) at days 32 and 35 by approximately 4 and 6 points, respectively.

2. Interestingly, for day 32 BW, males were more sensitive to AAD of diets than females, whereas feeding VHAAD diets maximized BW for males. Females responded similarly at day 32 for BW, regardless of AAD.
3. Diet AAD elicited varied responses from Cobb MV × Cobb 500 broilers, depending upon age of processing:
   a. At day 33, feeding broilers MAAD or higher resulted in improved (but similar) breast yield (relative to live weight), as well as breast and tender weights, as compared to birds fed LAAD diets.
   b. At day 36, feeding broilers VHAAD diets consistently resulted in the highest numerical breast and tender yields (relative to live weight) and weights, respectively. While these birds at times performed similar to broilers fed MAAD and/or HAAD diets, birds fed MAAD and/or HAAD diets also on occasion performed similar to birds fed LAAD diets.
4. Based on our economic model, feeding broilers the HAAD diet (starter dLys 1.28%, grower dLys 1.15%, and finisher dLys 1.03%) was the most profitable at day 33, while feeding broilers the VHAAD (starter dLys 1.39%, grower dLys 1.26%, and finisher dLys 1.12%) diet was the most profitable at day 36.

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