Effect of pullet body weight and hen dietary amino acid treatments on their progeny fed high and low amino acid diets

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ABSTRACT Four studies were conducted on Cobb 700 broilers to evaluate the dietary protein and any maternal effects on live production and processing parameters. Day-old Cobb 700 broiler breeder pullets were reared to conform to 2 different BW curves (control BW and increased BW) with 8 replicate pens per treatment. Birds were fed common diets from 1 d of age until first egg (24 wk). At 24 wk, 12 pens of each pullet treatment were given different amino acid (**AA**) diets (low = 14% CP, high = 15% CP). The performance of female and male progeny from 32 and 45 wk hens were evaluated on low AA and high AA density diets. The 4 progeny trial designs were identical factorial 2 × 2 × 2 designs, with 2 pullet BW curves (control BW and increased BW), 2 dam CP diet levels (low and high), and 2 progeny CP diets (low and high), with 6 replicates each containing 18 birds, for a total of 108 broiler progeny per treatment. Broiler chickens on the higher AA density feed exhibited consistent improvement in mid-growth BW and FCR and white meat yield percentage. Some maternal effects were noted, including increased carcass yield in female broilers from 32 wk old hens. There were 3-way interactions of pullet BW × hen dietary AA × progeny dietary AA treatments for female progeny carcass yield (from 32-week-old hens) and male tender yield (from 45-week-old hens). There were 2-way interactions of pullet BW x hen dietary AA treatments effect on female and male progeny drumstick yield from 32-week-old hens, pullet BW × progeny dietary AA treatments effect on male 27 d BW from 32-week-old hens, and hen dietary AA × progeny dietary AA treatments effect on male thigh yield from 45-week-old hen. The epigenetic effects of maternal pullet BW and dietary AA treatments were seen in processing yields suggesting, the need of dietary CP changes of the progeny.

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INTRODUCTION

There is limited published information on the effects of broiler breeder treatment on their progeny, mainly because of the resources and time needed to perform the studies. Earlier work supports the view that there is effect of macronutrients and micronutrients in the maternal diet on the performance of progeny (as reviewed by: Kidd, 2003; Calini and Sirri, 2007). Amino acid (**AA**) availability to the dam influences the following in the progeny: chick weight (Spratt and Leeson 1987; Lopez and Leeson, 1994, 1995a), BW at differing ages (Spratt and Leeson, 1987; Brake, 2003), FCR (Proudfoot, 1985), and carcass protein (Spratt and Leeson, 1987). However, the effects are inconsistent with no effects in dam AA intake on progeny BW (Lopez and Leeson, 1995b), FCR (Pearson and Herron, 1981), and carcass weight (Lopez and Leeson, 1994). Therefore, there is much that is unknown about putative epigenetic effects on progeny of broiler breeders. Mejia et al. (2013) suggested the same conflicts in progeny BW within their work on breeders fed diets that differed in digestible Lys.

High-yielding broiler breeder progeny from hens with known residual feed intakes (**RFI**) were assigned to 1 of 3 maternal RFI categories (low, average, and high), where the hens residual maintenance need was also known (Romero et al., 2009). The progeny reflected greater chick BW from high RFI (residual feed intake) hens; however, the progeny from low RFI hens had

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higher 28 and 38 d BW (Romero et al., 2009). Three-way interaction between low RFI × high RFE × progeny sex produced progeny with increased 38 d BW (Romero et al., 2009). Feed efficiencies for low RFI hens was reflected upon their progeny, especially when the hens also had high RFE (Romero et al., 2009). Van Emous et al. (2015) studied a multipurpose broiler breeder strain for the effect of 2 pullet rearing BW curves (standard and high) fed different CP diets (low, medium, and high). Their study found no pullet growth rate x pullet dietary treatment interaction effects on the progeny (van Emous et al., 2015). Moraes et al. (2014) did work using a high-yielding broiler breeder strain on the 4-way interaction of pullet rearing dietary ME (low and high) × pullet rearing dietary CP (low and high) × prelaying dietary ME (low and high) × progeny sex. Increasing the energy to protein ratio from the rearing phase diet to the laying phase diets resulted in increased progeny BW (Moraes et al., 2014). Of most interest, they suggested that the increase in the progenies ability to deposit abdominal fat pad was more related to the pullet rearing dietary ME than the laying dietary ME treatments, suggesting an epigenetic effect from the pullets to their progeny of lipogenesis (Moraes et al., 2014). However, they found no maternal effect on the progeny for FCR (Moraes et al., 2014). These works suggest that there is an interaction of dietary CP and ME in the breeder pullet rearing phase that affects their broiler progeny.

The current knowledge of the high-yielding broiler breeders need of CP are those of recommendations of the primary breeding companies, of which vary and do not exist for progeny (Aviagen Group, 2016; Cobb-Vantress, Inc., 2018). Therefore, this study investigated whether progeny had a different need for CP because of an interactive effect from their dams rearing body weight and/or CP intake during egg production.

MATERIALS AND METHODS

Pullet Rearing Phase

Cobb 700 broiler breeder chicks day 1 posthatch were placed randomly into 16 pens (290 females per pen) at the University of Arkansas Broiler Research Farm managed by Cobb-Vantress, Inc. (Fayetteville, Arkansas). The pens measured 5.49 × 5.52 m (9.57 females/m^2). Eight pens were assigned each of the pullet BW treatments from 1 to 147 d of age: control (C) which was set at Cobb 700 Breeder Management Guide weight standards or an increased body weight curve (I). Body weight of the I pullet treatment were increased compared with the C treatment by: 8.6% at 4 wk, 9.6% at 8 wk, 9.7% at 12 wk, 11.3% at 16 wk, 6.3% at 20 wk, and 4.1% at 24 wk of age. A common chick starter diet was fed to both treatments ad libitum from 0 to 28 d of age (Table 1). The pullets were then fed a common pullet and prelaying diets on a 5 d "On"/2 d "Off" feeding program from 28 to 154 d of age (Table 1). Each batch of feed was monitored to ensure feeds were within specifications of diets macronutrients. Pullets photoperiod was 5 lux for 24 h the first 3 d (24L:0D), from 4 d to 14 d 5 lux for 16L:8D, at 14 to 154 d 5 lux for 8L:16D. On hatch day, all breeder chicks were weighed in groups of 100 chicks. Each wk from 1 to 20 wk, body weight was obtained from 30 random pullets per pen. Daily feed, water consumption, and mortality were recorded by pen. On 147 d of age, BW, leg shank length, keel length, breast width, abdominal fat, liver, spleen, and bursa weight of 2 pullets per pen were taken.

Breeder Phase

At 154 d of age, 2,040 pullets per BW treatment (4,080 total females) were moved to the breeder house randomly into 24 pens per treatment (48 total pens). Twelve random pens of each pullet treatment were assigned to either the low AA breeder diets (**L**) or the high AA breeder diets (**H**) resulting in the following treatment combination: control BW pullets fed low AA breeder diets (**CL**), control BW pullets fed high AA breeder diets (**CH**), increased BW pullets fed low AA breeder diets (**IL**), and increased BW pullets fed high AA breeder diets (**IH**). Hens were fed a common prelaying diet from 154 d to 168 d (Table 1). First egg occurred at 168 d of age. After first egg, the hens were fed treatment respective diets of low or high AA that were 1% different in CP until 315 d of age. A difference of 1% in CP was chosen because of this amount of CP being considered different within the chicken industry to influence breeders egg production and economics of feeding. At 316 d of age, the hens were fed their treatment respective low or high AA breeder 2 diet (Table 2). The breeder 2 diets were 1.5% different in CP to increase the difference between the 4 groups considering the body weight difference of the 4 groups at 315 d. Each batch of feed was monitored to ensure feeds were within specifications of diets macronutrients. Hens photoperiod was 12L:12D from 154 to 168 d of age, 13L:11D from 169 to 182 d of age, 14L:8D from 183 to 169 d, and 16L:8D from 170 to 448 d; at an intensity of 10 lux. Daily feed and water consumption, egg production, and mortality were recorded by pen.

Seven Cobb MV males were placed in each breeder pen to provide male fertility and respective progeny at 154 d. Males were reared in the same facility as pullets in 1 pen and managed to adhere to the Cobb MV management guide weight curve (Cobb-Vantress, Inc., 2017) using the same diets fed to the pullets (Table 1). The male effect was not considered in the experiments because of the lack of replication.

Progeny Phase

The eggs were incubated at the University of Arkansas Agriculture Experimental Station Poultry Farm Hatchery in Fayetteville, Arkansas. The chicks were reared in a broiler house at the University of Arkansas Agriculture Experimental Station Poultry Farm in Fayetteville, Arkansas. The dimensions of each pen were

Table 1. Diets fed to Cobb 700 broiler breeder pullets before egg production of progeny chicks.

Ingredients	Chick starter	Pullet grower	Prelay
Ages fed	0–4 wk	5–18 wk	19 wk–1st Egg
Ingredient, % of diet			
Corn	61.17	21.76	59.59
Soybean meal 48%	30.50	12.37	15.32
Wheat middlings	5.05	27.81	19.88
Distillers dried grains	-	4.49	2.29
Phosphate, defluorinated	1.85	1.43	1.50
Trace mineral premix[1]	0.10	0.10	0.10
Vitamin premix[2]	0.05	0.06	0.06
Limestone	0.62	1.11	0.93
Salt	0.14	0.17	0.15
Lysine	-	0.01	-
L-Threonine 98%	0.06	0.01	0.02
Poultry fat	0.25	0.50	-
MHA Liquid[3]	0.15	0.11	0.09
Choline	0.09	0.07	0.08

Nutrient, % of diet	Formulated	Analyzed[4]	Formulated	Analyzed	Formulated	Analyzed
ME, kcal/kg	2,846		2,648		2,747	
CP	19.50	20.04	14.50	15.22	15.00	15.51
Calcium	0.90	1.17	0.95	1.21	0.95	1.12
Sodium	0.21	0.20	0.15	0.14	0.15	0.16
Total phosphate	0.73	0.80	0.76	0.75	0.73	0.78
Crude fat	2.11	2.77	2.92	3.83	2.58	3.14

[1]Mineral premix contained in diets: Manganese 120 ppm, Zinc 110 ppm, Selenium 0.30 ppm, Iron 45 ppm, Iodine 3.5 ppm, Copper 125 ppm.

[2]Vitamin premix contained per metric ton: Vitamin A 13,343 IU, Vitamin D3 5,810 IU, Vitamin E 119 IU, Vitamin K 6.52 g, Thiamine 5.34 g, Riboflavin 15.27 g, Niacin 54.69 g, Pantothenic acid 32.90 g, Pyridoxine 7.08 g, Biotin 0.43 g, Folic acid 4.49 g, Vitamin B12 0.076 g.

[3]MHA is the trademark name for granular DL-Methionine manufactured by Novus International, Saint Charles, Missouri.

[4]Analyzed values are averages of all batches of feed for the diets fed. For example, there were 2 deliveries of chick starter. The 2 analyzes are reported as an average.

1.07 × 1.83 m, allowing 0.11 meters2/bird of floor space. Pens contained 1 to 14.5 kg capacity hanging feeder. During the brooding phase 1, supplemental feeder lid was utilized until 10 d of age. Individual pen nipple water lines were used with 5 nipples per waterline resulting in 3.6 birds per water nipple. The pens had built up litter and top dressed in pine wood shavings at a depth of no less than 10 cm. Chicks were on continuous light (24L:0D) during day 1 to 3. At 4 d, the photoperiod was reduced to 20L:4D, and at 7 d, the photoperiod was reduced to 19L:5D for the remained of the 8 wk brooding period. There were 4 separate experiments conducted with progeny. The first 2 experiments were conducted concurrently in mid-Winter to early-Spring with male and female progeny from 32-week-old Cobb 700 broiler breeder hens. Similarly, 2 additional experiments were performed concurrently in late-Spring through mid-Summer using male and female progeny from 45-week-old Cobb 700 broiler breeder hens. Eggs (164) were collected from each breeder pen and identified by pen. The eggs were set on E0 and identified by pen. At E18, the eggs were candled to remove any infertile eggs or unviable embryos. The remaining viable E18 embryos were placed into hatcher baskets with dividers separating the eggs by hen pen and therefore maternal treatment. At day of hatch, the chicks were kept separate by breeder pen and sexed into 2 boxes per breeder pen. The chicks were placed into their respective broiler pens that corresponded to the breeder pen they were sourced from, that is pen 1 male broiler and pen 49 female broilers were sourced from pen 1 Cobb 700 broiler breeders from the previously mentioned pullet and hen treatments. Thus, it allowed for progeny pen to be monitored for epigenetic effects.

Each of the broiler pens that corresponded to the breeder treatment were randomly assigned to either the low AA diet or the high AA diet (Table 3). The low AA diets were formulated to be 5% lower in CP, and the high AA diets to be 5% higher in CP compared with the Cobb 700 Broiler Performance & Nutrition Supplement. Each batch of feed was monitored to ensure feeds were within specifications of diets for macro nutrients. The progeny were fed ad libitum. Treatments were the following: control BW pullets (**C**), increased BW pullets (**I**), low AA diet containing 14% CP fed hens (**L**), high AA diet containing 15% CP fed hens (**H**), low AA diets containing 5% less dLys compared with Cobb 700 broiler recommendations fed progeny (L), and high AA diets containing 5% more dLys compared with Cobb 700 broiler recommendations fed progeny (**H**) resulting in treatment combinations of CLL, CLH, CHL, CHH, ILL, ILH, IHL, and IHH. Each combined pullet BW x hen AA density diets x progeny AA diets had 6 replicate pens for a total of 48

Table 2. Ingredients and nutrients of diets fed to Cobb 700 parent breeder hens from first egg to 45 wk and 45 to 64 wk of age responsible for the progeny produced for broiler progeny trials.

	Breeder 1 diets		Breeder 2 diets	
Ingredients	Low amino acid	High amino acid	Low amino acid	High amino acid
Ages fed	1st egg–45 wk		45 wk–64 wk	
Ingredients, % of diet				
Corn	65.70	66.50	65.10	65.10
Soybean meal	14.70	20.10	11.00	17.60
Wheat middlings	5.80	5.30	1.80	-
Distillers dried grains	5.60	-	13.40	8.60
Limestone	5.50	5.30	6.80	6.60
Phosphate	1.70	1.82	1.30	1.40
Fat, poultry	0.25	0.25	-	-
Salt 96+%	0.19	0.20	0.15	0.16
Alimet[1]	0.09	0.16	0.08	0.14
Trace mineral premix[2]	0.10	0.10	0.10	0.10
Choline Cl-70%	0.10	0.10	0.09	0.08
Vitamin premix[3]	0.07	0.07	0.07	0.07
S-Carb[4]	0.05	0.05	0.05	0.05
Larvadex[5]	0.05	0.05	-	-
Threonine 98%	-	0.03	-	0.02
L-Lysine HCl	-	0.02	0.10	0.08

Nutrients, % of diet	Formulated	Analyzed[6]	Formulated	Analyzed	Formulated	Analyzed	Formulated	Analyzed
ME, kcal/kg	2,797		2,797		2,797		2,797	
Crude protein	14.00	14.79	15.00	16.12	14.00	15.07	15.50	16.69
Crude fat	2.90	3.21	2.66	2.98	2.77	3.29	2.54	3.52
Calcium	2.89	2.93	2.89	2.82	3.25	2.98	3.25	2.65
Total phosphorus	0.70	0.69	0.70	0.73	0.63	0.65	0.63	0.57
Available phosphorus	0.43		0.43		0.38		0.38	
Sodium	0.20	0.18	0.20	0.20	0.18	0.18	0.18	0.15
Potassium	0.61	0.71	0.65	0.79	0.66	0.77	0.73	0.69
Chloride	0.18	0.18	0.18	0.18	0.18	0.20	0.18	0.19
Na + K-Cl, mEq/kg	192		201		196		215	
Arginine, total	0.85		0.97		0.77		0.92	
Arginine, digestible	0.79		0.90		0.70		0.85	
Lys, total	0.68		0.81		0.68		0.82	
Lys, digestible	0.59		0.72		0.59		0.72	
Met, total	0.32		0.39		0.32		0.39	
Met, digestible	0.30		0.37		0.30		0.37	
Met + Cys, total	0.59		0.67		0.60		0.67	
Met + Cys, digestible	0.53		0.60		0.53		0.61	
Trp, total	0.16		0.18		0.15		0.18	
Trp, digestible	0.14		0.15		0.13		0.15	
Thr, total	0.52		0.59		0.52		0.60	
Thr, digestible	0.44		0.51		0.43		0.51	
Ile, digestible	0.51		0.57		0.50		0.59	
Val, digestible	0.60		0.65		0.60		0.68	
Choline	1,498		1,498		1,498		1,498	

[1]Alimet is the tradename for liquid methionine produced by Novus International, Saint Charles, Missouri.
[2]Mineral premix contained in diets: Manganese 120 ppm, Zinc 110 ppm, Selenium 0.30 ppm, Iron 45 ppm, Iodine 3.5 ppm, Copper 125 ppm.
[3]Vitamin premix contained per metric ton: Vitamin A 13,343 IU, Vitamin D3 5,810 IU, Vitamin E 119 IU, Vitamin K 6.52 g, Thiamine 5.34 g, Riboflavin 15.27 g, Niacin 54.69 g, Pantothenic acid 32.90 g, Pyridoxine 7.08 g, Biotin 0.43 g, Folic acid 4.49 g, Vitamin B12 0.076 g.
[4]S-carb is the tradename for sodium bicarbonate manufactured by Genesis Energy, LP; Houston, Texas.
[5]Larvadex is the tradename for cyromazine manufactured by Elanco, Greenfield, Indiana.
[6]Analyzed values are the average for the nutrient of all feed loads fed to the treatments.

female pens in experiments 1 and 3 and 48 male pens in experiments 2 and 4.

Chicks were bulk weighed by pen to obtain the mean chick BW. Mortality and mortality BW were recorded daily by pen. At the beginning of each phase, the amount of treatment specific feed assigned to the pen was weighed and recorded by pen. Feed intake by pen was determined for each growth phase. Mean BW per pen were measured at the end of each growth phase. Feed conversion ratio (**FCR**) for the pen was calculated for each phase (FCR = feed intake for the pen/BW for the pen). Feed conversion ratio was also calculated for the entire experiment period. At 55 d of age, 5 birds were randomly

Table 3. Diets with low amino acid content and high amino acid content fed to Cobb 700 broiler progeny from breeders fed low and high amino acid diets.

	Low amino acid diets				High amino acid diets			
Ingredients	Starter	Grower	Finisher	Withdraw	Starter	Grower	Finisher	Withdraw
Ages fed	0–13 d	13–27 d	27–39 d	39–55 d	0–13 d	13–7 d	27–39 d	39–55 d
Ingredients, % of diet								
Corn	65.2	69.3	70.4	73.7	59.4	66.9	64.9	67.8
Soybean meal	25.7	20.8	19.1	15.9	29.8	24.8	23.4	21.3
Pro-Plus 57[1]	6.4	6.7	6.5	7.0	7.5	7.5	7.0	6.5
Phosphate, defluorinated	0.99	0.80	0.62	0.75	0.78	0.69	0.51	0.61
Fat, poultry	0.50	1.19	2.36	1.76	1.37	2.01	3.24	2.82
Methionine, DL	0.23	0.1886	0.15	0.13	0.27	0.22	0.18	0.17
Limestone	0.20	0.177	0.16	0.01	0.15	0.10	0.14	0.16
L-Lysine HCl	0.16	0.157	0.07	0.10	0.15	0.13	0.04	0.06
Choline Cl-60%	0.15	0.173	0.18	0.19	0.14	0.16	0.17	0.17
Salt 96+%	0.14	0.1672	0.20	0.17	0.16	0.18	0.21	0.20
Mineral premix[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sodium bicarbonate	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Threonine 98%	0.10	0.08		0.01	0.10	0.08		
Vitamin premix[3]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Selenium	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02

Nutrient, % of diet																
ME, kcal/kg	2,996		3,084		3,084		3,084		2,996		3,084		3,084		3,084	
CP	20.90	23.62	19.07	19.85	18.05	17.91	17.10	16.64	23.10	24.36	21.00	22.95	19.95	21.65	18.90	19.30
Crude fat	3.83	3.27	4.58	4.28	5.72	4.09	5.22	4.83	4.65	4.99	5.34	6.20	6.51	4.88	6.11	5.51
Calcium	0.90	0.69	0.84	0.79	0.76	0.74	0.76	0.69	0.90	0.88	0.84	0.93	0.76	0.90	0.76	1.05
Phosphorus, total	0.68	0.55	0.63	0.61	0.59	0.57	0.61	0.53	0.69	0.58	0.65	0.64	0.59	0.65	0.59	0.67
Phosphorus, available	0.45		0.42		0.38		0.41		0.45		0.43		0.38		0.38	
Sodium	0.18	0.17	0.18	0.18	0.18	0.16	0.18	0.19	0.18	0.17	0.18	0.18	0.18	0.18	0.18	0.18
Potassium	0.81	0.84	0.71	0.85	0.67	0.73	0.60	0.77	0.89	0.67	0.79	0.84	0.75	0.65	0.71	0.78
Chloride	0.22	0.18	0.24	0.20	0.24	0.17	0.24	0.21	0.23	0.21	0.24	0.22	0.24	0.22	0.24	0.22
Na + K-Cl	225		191		182		165		242		212		204		193	
Arg, total	1.36		1.22		1.15		1.08		1.52		1.37		1.30		1.22	
Arg, digestible	1.24		1.11		1.05		0.98		1.39		1.25		1.19		1.12	
Lys, total	1.27		1.14		1.02		0.97		1.41		1.25		1.13		1.07	
Lys, digestible	1.14		1.02		0.90		0.86		1.26		1.12		1.00		0.95	
Met, total	0.58		0.51		0.46		0.44		0.65		0.57		0.52		0.49	
Met, digestible	0.55		0.49		0.43		0.41		0.61		0.54		0.49		0.46	
Met + Cys, total	0.95		0.87		0.80		0.77		1.05		0.95		0.89		0.84	
Met + Cys, digestible	0.84		0.77		0.70		0.67		0.93		0.84		0.78		0.74	
Trp, total	0.25		0.21		0.20		0.18		0.28		0.24		0.23		0.22	
Trp, digestible	0.21		0.18		0.17		0.15		0.24		0.21		0.20		0.18	
Thr, total	0.86		0.77		0.66		0.63		0.95		0.85		0.73		0.70	
Thr, digestible	0.74		0.66		0.56		0.53		0.82		0.73		0.62		0.59	
Ile, digestible	0.76		0.68		0.65		0.60		0.85		0.76		0.73		0.69	
Val, digestible	0.88		0.81		0.77		0.73		0.98		0.89		0.85		0.81	
Choline, mg/kg	1,872		1,872		1,872		1,872		1,872		1,872		1,872		1,872	
Fe, ppm	141		127		119		115		140		128		121		121	
Mn, ppm	138		135		134		133		138		136		135		135	
Cu, ppm	130		129		129		129		130		129		129		129	
Zn, ppm	131		129		129		128		132		130		130		129	

[1]Pro-Plus 57 is a trademark name of a protein concentrate manufactured at 57% CP by H. J. Baker and Bro., LLC., Shelton, Connecticut.

[2]Mineral premix contained per kilogram of all diets (minimum): Ca, 48.8 mg; Mn, 80 mg; Mg, 21.6 mg; Zn, 80 mg; Fe, 40 mg; Cu, 8 mg; I, 0.8 mg.

[3]Vitamin premix contained per kilogram of all diets (minimum): vitamin A, 3,083,700 IU; vitamin D3, 22,026,432 ICU; vitamin E, 22,026 IU; vitamin B12, 53 mg; menadione, 6,000 mg; riboflavin, 26,432 mg; d-pantothenic acid, 39,648 mg; thiamine, 6,167 mg; niacin, 154,185 mg; pyridoxine, 11,013 mg; folic acid, 3,524 mg; biotin, 330 mg.

selected and tagged in each pen. The tag numbers corresponded to the pen and treatment. On day 56, the birds were processed for yield at the University of Arkansas' Pilot Processing Plant. The following weights were recorded by bird tag number: live BW, carcass weight, breast fillet, breast tenders, drumsticks, thighs, wings, and abdominal fat. Each part weight was calculated as a percent of live BW. Breast fillets were scored for woody breast and white stripping on a 0 to 3 scale, in which 0 was no incidence, 1 mild incidence, 2 moderate incidence, and 3 severe incidence.

Table 4. Effects of dietary amino acid and maternal treatment of production parameters in Cobb 700 female broilers. The birds were progeny from 32-week-old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Parameters	13 d BW g	27 d BW g	39 d BW g	55 d BW g	0–13 d FCR[5]	0–27 d FCR	0–39 d FCR	0–55 d FCR	0–55 d mortality, %	Total protein g[6]
Progeny (B)										
Low AA[7]	328	1,129[b]	2,218[b]	3,668	1.195	1.277[a]	1.446[a]	1.654[a]	1.16	3,844[b]
High AA[8]	331	1,258[a]	2,283[a]	3,709	1.187	1.231[b]	1.395[b]	1.612[b]	1.62	3,942[a]
SEM	4.2	12.1	24.4	28.2	0.0062	0.0057	0.0067	0.0077	0.624	17.3
Maternal (H)										
Low AA	332	1,255	2,261	3,700	1.190	1.248	1.422	1.622[b]	1.45	3,838[b]
High AA	328	1,225	2,243	3,680	1.191	1.258	1.420	1.644[a]	1.33	3,943[a]
SEM	3.9	11	23.3	29.1	0.0067	0.0074	0.0093	0.0085	0.581	17.0
Pullet BW (P)										
Control	332	1,234	2252	3,689	1.192	1.262[a]	1.422	1.638	0.70	3,851[b]
Increased	327	1,244	2251	3,689	1.190	1.244[b]	1.419	1.628	2.01	3,935[a]
SEM	4	11.7	24	25.3	0.0069	0.0072	0.0086	0.0098	0.653	18.2
P × H × B interaction										
Control × Low × Low										3,742[e]
Control × Low × High										3,844[c,d]
Control × High × Low										3,836[d]
Control × High × High										3,966[a,b]
Increased × Low × Low										3,821[d,e]
Increased × Low × High										3,930[b,c]
Increased × High × Low										3,961[a,b]
Increased × High × High										4,027[a]
SEM										18.9
P-value										
P × H x B	0.4123	0.2483	0.4231	0.6591	0.0602	0.1600	0.2705	0.2510	0.2252	<0.0001
H × B	0.4712	0.7233	0.3538	0.6064	0.3666	0.8705	0.8370	0.0880	0.6003	<0.0001
P × B	0.7786	0.2761	0.5226	0.7580	0.7817	0.7626	0.7937	0.1517	0.9540	<0.0001
P × H	0.9826	0.6366	0.8997	0.7412	0.4726	0.5565	0.8939	0.5412	0.5230	<0.0001
B	0.6046	0.0192	0.0270	0.2826	0.4476	<0.0001	<0.0001	<0.0001	0.6010	0.0003
H	0.5466	0.0700	0.6002	0.6027	0.8314	0.4447	0.8124	0.0388	0.9531	<0.0001
P	0.3072	0.5521	0.9591	0.9738	0.9250	0.0292	0.5757	0.3361	0.0969	0.0021

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2,797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]FCR is adjusted for mortality.
[6]Total protein equals total protein fed to pullets, hens to 32 wk of age, and the broiler.
[7]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[8]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

Table 5. Effects of dietary amino acid and maternal treatment of processing yield parameters in Cobb 700 female broilers. The birds were progeny from 32-week-old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Parameters	Carcass, %	Fillet, %	Tender, %	Total white, %	Drum, %	Thigh, %	Wing, %	Abdominal fat, %
Progeny (B)								
Low AA[5]	77.9[b]	24.3[b]	4.6[b]	28.9[b]	8.4	13.1[a]	6.9	1.6[a]
High AA[6]	78.4[a]	25.4[a]	4.8[a]	30.1[a]	8.4	17.8[b]	6.9	1.5[b]
SEM	0.14	2.09	0.03	0.17	0.05	0.08	0.03	0.05
Maternal (H)								
Low AA	78.1	24.7	4.7	29.4	8.4	12.9	6.9	1.5
High AA	78.2	24.9	4.7	29.6	8.4	12.9	6.9	1.6
SEM	0.14	2.04	0.03	0.26	0.05	0.08	0.03	0.05
Pullet BW (P)								
Control	77.9[b]	24.7	4.7	29.4	8.4	12.9	6.9	1.5
Increased	78.4[a]	25.0	4.7	29.7	8.4	13.0	6.9	1.6
SEM	0.13	1.93	0.03	0.17	0.05	0.08	0.03	0.06
P x H × B interaction								
Control × Low × Low	77.7[b]							
Control × Low × High	78.0[a,b]							
Control × High × Low	77.8[b]							
Control × High × High	78.3[a,b]							
Increased × Low × Low	77.7[b]							
Increased × Low × High	78.9[a]							
Increased × High × Low	78.5[a,b]							
Increased × High × High	78.3[a,b]							
SEM	0.28							
P × H interaction[7]								
Control × low					8.3			
Control × high					8.4			
Increased × low					8.5			
Increased × high					8.5			
SEM					0.7			
P-values								
P × H × B	0.0263	0.1471	0.4141	0.1195	0.8228	0.5021	0.9989	0.2420
H × B	0.0933	0.2013	0.9870	0.2128	0.2469	0.4839	0.0957	0.3054
P × B	0.9069	0.4384	0.0790	0.6627	0.3607	0.2617	0.5398	0.2620
P × H	0.8967	0.7222	0.8878	0.7487	0.0347	0.1611	0.6631	0.3301
B	0.0148	<0.0001	0.0041	<0.0001	0.8005	0.0177	0.5994	0.0255
H	0.4723	0.2795	0.4132	0.7486	0.3320	0.8692	0.8390	0.2029
P	0.0247	0.2459	0.9126	0.2508	0.2595	0.2014	0.2624	0.6482

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2,797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[6]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.
[7]Tukey's HSD with contrast plot indicates that the control BW pullet x high amino acid broiler breeder is causing absence of mean separation, all other interactions are.

Animal Wellbeing

The birds were monitored and cared for within the guidelines of the University of Arkansas IACUC protocol number 18107.

Statistical Analysis

The experimental design was a randomized complete design with a 2 × 2 × 2 factorial arrangement (2 pullet body weight curves × 2 hen dietary AA densities × 2 broiler dietary AA densities). The experimental unit was progeny at the pen level. There were 8 replicates in the pullet rearing phase, 12 replicates in the breeder phase, and 6 replicates in the progeny phase. One-way analysis of variance was performed using JMP 14 software (SAS Institute, Cary, NC), and means were separated by Student *t* test for main effects and Tukey–Kramer HSD for combined effects with *P*-value <0.05 considered significant.

RESULTS

32-Week Hatch: Female Progeny Responses

Effects of dietary AA and dam treatment are summarized in Table 4 for female broiler performance, in Table 5 for carcass yield, and Table 6 for meat quality. There were no main effects of pullet, hen, or progeny treatments on 13 d BW, 55 d BW, 0 to 13 d FCR, 0 to 55 d mortality, wing yield, white stripping scores of 0, 1, 2, or 3, and wooden breast scores of 0.5, 1.5, 2, or 2.5 ($P > 0.05$). The main effect of pullet BW on 0 to 27 d FCR resulted in lower ($P = 0.0292$) FCR for progeny from I BW pullets. The main effect of hen dietary AA treatments on 0 to 55 d FCR resulted in lower ($P = 0.0388$) FCR for progeny from hens fed L AA diets. Progeny main effect of dietary AA treatments on 27 and 39 d BW, fillet yield, tender yield, total white meat yield, and wooden breast scores of 1 and 3 were higher

Table 6. Effects of dietary amino acid and maternal treatment of white stripping score[1] percentages[2] of breast fillets in Cobb 700 female broilers. The birds were progeny from 32-week-old broiler breeder hens fed either low[3] or high[4] amino acid diets and that were reared on either control[5] or increased[6] BW.

	White stripping, %					Wooden breast, %						
	0	0.5	1	2	3	0.0	0.5	1	1.5	2	2.5	3
Progeny (B)												
Low AA[7]	5.08	26.27[a]	61.02[b]	7.63	0.00	26.27[a]	47.46	17.80[b]	2.54	5.93	0.00	0.00[b]
High AA[8]	1.70	11.86[b]	73.73[a]	11.86	0.85	15.25[b]	40.68	30.51[a]	2.54	6.78	0.85	3.39[a]
SEM	1.67	3.57	4.29	2.74	0.60	3.72	4.58	3.91	1.46	2.26	0.60	1.18
Maternal (H)												
Low AA	4.46	21.43	65.18	8.93	0.00	22.32	44.64	25.00	2.78	5.36	0.00	0.00
High AA	2.42	16.94	69.36	10.48	0.81	19.36	43.55	23.39	2.42	7.26	0.81	3.23
SEM	1.72	3.72	4.45	2.81	0.62	3.85	4.71	4.06	1.49	2.31	0.62	1.22
Pullet BW (P)												
Control	3.39	19.49	65.25	11.86	0.00	21.19	44.07	2.54	2.54	5.09	0.85	0.85
Increased	3.39	18.64	69.49	7.63	0.85	20.34	44.07	2.29	2.54	7.62	0.00	2.54
SEM	1.67	3.63	4.33	2.74	0.60	3.75	4.59	3.96	1.46	2.25	0.60	1.19
P × H × B interaction												
Control × low AA × low AA		12.00[a,b]										0.00[b]
Control × low AA × high AA		24.14[a,b]										0.00[b]
Control × high AA × low AA		32.35[a,b]										0.00[b]
Control × high AA × high AA		6.67[a,b]										3.33[a,b]
Increased × low AA × low AA		34.45[a]										0.00[b]
Increased × low AA × high AA		13.79[a,b]										0.00[b]
Increased × high AA × low AA		23.33[a,b]										0.00[b]
Increased x high AA x high AA		3.33[b]										10.0[a]
SEM		7.01										2.35
P-values												
P × H × B	0.5006	0.0094	0.0793	0.5624	0.4462	0.1466	0.9755	0.2414	0.3600	0.9874	0.4462	0.0241
H x B	0.2976	0.0070	0.0825	0.6422	0.4041	0.1918	0.7072	0.0833	0.9052	0.9005	0.4041	0.0072
P x H	0.7716	0.5132	0.8085	0.2186	0.4041	0.4668	0.9985	0.9154	0.0851	0.7895	0.4446	0.1188
B	0.1515	0.0047	0.0374	0.2744	0.3183	0.0371	0.2962	0.0225	1.0000	0.7907	0.3183	0.0439
H	0.3882	0.3824	0.4965	0.6890	0.3430	0.5767	0.8664	0.7737	0.9000	0.5520	0.3430	0.0556
P	1.0000	0.8691	0.6920	0.2744	0.3183	0.8732	1.0000	0.6499	1.0000	0.4256	0.3183	0.3152

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).

[1]Myopathy scores were assigned to the breast fillets as: 0 = no incidence, 0.5 = slight incidence, 1.0 = low incidence, 1.5 = mild incidence, 2.0 = moderate incidence, 3.0 = severe incidence.

[2]Myopathy percentages were figured as counts by score/total fillets counted by pen.

[3]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2,797 kcal/kg ME.

[4]High amino acid breeder diets were 15% crude protein.

[5]Control pullet BW represents the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.

[6]Increased pullet BW was achieved each week through regulated feed intake higher than those on the control body weight curve.

[7]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.

[8]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

($P < 0.05$) when the progeny were fed H AA diets. Progeny dietary treatments had a main effect having lower ($P < 0.05$) thigh yield and abdominal fat yield of progeny fed L AA diets. Conversely, progeny AA diet effects on 0 to 27 d, 0 to 39 d, and 0 to 55 d FCR, white stripping scores of 0.5, and wooden breast scores of 0.0 was lower ($P < 0.0001$) when progeny were fed H AA diets. The 3-way interactions between the pullet BW, hen dietary AA, and progeny AA treatments were for carcass yield ($P < 0.05$), resulting in ILH having the greatest response, and breast fillets scoring 0.5 ($P < 0.05$) resulting in ILL having the greatest response.

32-Week Hatch: Male Progeny Responses

Effects of pullet BW, hen dietary AA, and progeny dietary AA treatments on male broiler progeny can be found in Tables 7–9. There were no main effects on 13 d BW, 55 d BW, 0 to 55 d mortality, wing yield, and white stripping scores ($P > 0.05$). Main effect of progeny dietary AA treatments on 39 and 55 d BW and yields of carcass, fillet, tender and total white meat yield delivered ($P < 0.05$) resulting in progeny fed H AA diets having greater responses. Main effects of progeny dietary AA treatments on 0 to 27 d, 0 to 39 d, and 0 to 55 d FCR, yields of drumstick, thigh, and abdominal fat, and wooden breast scores of 2.5 were lowest ($P < 0.0001$) for progeny fed H AA diets. There was a 2-way interaction on 27 d BW ($P = 0.0338$), resulting in progeny from the I BW pullet treatment x H progeny treatment being highest. A 3-way interaction effect on drumstick yield ($P = 0.0363$) delivered resulting in CHH and IHL having the highest yields and lowest for IHH and CLH; and all other means being intermediate.

45-Week Hatch: Female Progeny Responses

Effects of pullet BW, hen dietary AA, and female progeny dietary AA treatments on live production and carcass yields can be found in Tables 10 and 11. There were no main effects on 0 to 55 d mortality, white stripping scores, or wooden breast scores ($P > 0.05$).

Table 7. Effects of dietary amino acid and maternal treatment of production parameters in Cobb 700 male broilers. The birds were progeny from 32-week-old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Treatment	13 d BW g	27 d BW g	39 d BW g	55 d BW g	0–13 d FCR[5]	0–27 d FCR	0–39 d FCR	0–55 d FCR	0–55 d mortality %	Total protein g[6]
Progeny (B)										
Low AA[7]	307	1,272	2,418[b]	4,133[b]	1.242	1.280[a]	1.449[a]	1.647[a]	2.7	3,975[b]
High AA[8]	306	1,306	2,528[a]	4,299[a]	1.230	1.234[b]	1.380[b]	1.583[b]	3	4,107[a]
SEM	4.4	13.4	18.8	25.1	0.0122	0.0054	0.0074	0.0064	0.85	16.5
Maternal (H)										
Low AA	305	1,296	2,487	4,226	1.223	1.250	1.411	1.613	2.8	3,994[b]
High AA	307	1,282	2,459	4,206	1.250	1.263	1.416	1.617	2.9	4,092[a]
SEM	4.5	14.2	24.8	28.7	0.0116	0.0073	0.0105	0.0096	0.85	18.7
Pullet BW (P)										
Control	308	1,295	2,495	4,239	1.233	1.261	1.415	1.622	2.6	3,996[b]
Increased	305	1,282	2,450	4,191	1.238	1.252	1.411	1.608	3.1	4,986[a]
SEM	4.6	13.5	22.3	31.6	0.0122	0.0069	0.0492	0.0093	0.84	19.2
P × B interactions										
Control × B low AA		1,291[a,b]								
Control × B high AA		1,293[a,b]								
Increased × B low AA		1,245[b]								
Increased × B high AA		1,319[a]								
SEM		17.8								
P × H × B interaction										
Control × Low × Low										3,907[e]
Control × Low × High										3,989[d]
Control × High × Low										3,992[d]
Control × High × High										4,112[b]
Increased × Low × Low										3,964[d]
Increased × Low × High										4,133[b]
Increased × High × Low										4,054[c]
Increased × High × High										4,195[a]
SEM										17.8
P-value										
P × H × B	0.1624	0.3839	0.3519	0.0525	0.3422	0.9649	0.5162	0.6057	0.9968	<0.0001
H × B	0.1664	0.1436	0.0971	0.2628	0.0889	0.5089	0.7950	0.5792	0.4985	<0.0001
P × B	0.2703	0.0481	0.4280	0.0957	0.2524	0.6318	0.1501	0.2165	0.8890	<0.0001
P × H	0.5291	0.4692	0.9789	0.6336	0.1757	0.2540	0.6590	0.2153	0.7395	<0.0001
B	0.7849	0.0338	<0.0001	<0.0001	0.4443	<0.0001	<0.0001	<0.0001	0.8890	<0.0001
H	0.6919	0.4378	0.1722	0.3040	0.0821	0.4447	0.4066	0.5780	0.7325	0.0007
P	0.5975	0.5904	0.1878	0.2531	0.8191	0.1726	0.6131	0.1575	0.3854	0.0019

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2,797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]FCR is adjusted for mortality.
[6]Total protein equals total protein fed to pullets, hens to 32 wk of age, and the broiler.
[7]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[8]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

Table 8. Effects of dietary amino acid and maternal treatment of processing yield parameters in Cobb 700 male broilers. The birds were progeny from 32-week-old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Effects	Carcass, %	Fillet, %	Tender, %	Total white, %	Drum, %	Thigh, %	Wing, %	Abdominal fat, %
Progeny (B)								
Low AA[5]	77.6[b]	22.3[b]	4.1[b]	26.4[b]	9.5[a]	14.3[a]	7.1	1.4[a]
High AA[6]	78.2[a]	23.6[a]	4.4[a]	28.0[a]	9.3[b]	13.9[b]	7.2	1.2[b]
SEM	1.64	1.90	0.03	0.21	0.05	0.09	0.05	0.05
Maternal (H)								
Low AA	77.7	22.9	4.3	27.2	9.3[b]	14.1	7.1	1.3
High AA	78.1	23.0	4.3	27.2	9.5[a]	14.1	7.2	1.2
SEM	1.49	0.18	0.03	0.17	0.06	0.09	0.05	0.04
Pullet BW (P)								
Control	77.8	22.9	4.3	27.2	9.4	14.1	7.2	1.3
Increased	78.0	23.0	4.3	27.2	9.4	14.1	7.2	1.2
SEM	0.14	0.18	0.04	0.17	0.06	0.09	0.04	0.05
P × H × B interaction								
Control × low AA × low AA					9.3[a,b]			
Control × low AA × high AA					9.3[b]			
Control × high AA × low AA					9.5[a,b]			
Control × high AA × high AA					9.6[a]			
Increased × low AA × low AA					9.5[a,b]			
Increased × low AA × high AA					9.4[a,b]			
Increased × high AA × low AA					9.6[a]			
Increased × high AA × high AA					9.1[b]			
SEM					0.06			
P-values								
P × H × B	0.4344	0.2404	0.1979	0.1845	0.0363	0.7660	0.6806	0.4076
H × B	0.2680	0.2945	0.6052	0.2868	0.6279	0.7669	0.0803	0.1881
P × B	0.7100	0.3035	0.9784	0.3184	0.0380	0.2061	0.7989	0.9826
P × H	0.0510	0.4928	0.4627	0.1504	0.0049	0.2133	0.1573	0.9244
B	0.0027	<0.0001	<0.0001	<0.0001	0.0233	0.0038	0.1164	0.0005
H	0.1098	0.8555	0.5144	0.9765	0.0422	0.5161	0.1760	0.2362
P	0.2796	0.7775	0.4490	0.88833	0.9474	0.8980	0.5929	0.5020

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2,797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[6]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

There was a main effect of hen dietary treatment on thigh yield being highest ($P = 0.0064$) when hens were fed H AA diets. There was a main effect of hen dietary AA treatment on thigh yield ($P < 0.01$) for progeny from hens fed H AA diets being highest. The main effect of progeny dietary AA on 13, 27, 39, and 55 d BW and yields of carcass, fillet, tender, total white, and wing being higher ($P < 0.05$) when progeny were fed H AA diets. Main effect of progeny dietary AA on 0 to 13 d, 0 to 27 d, 0 to 39 d, and 0 to 55 d FCR, and yields of drumsticks, wing, and abdominal fat were lowest ($P < 0.05$) for progeny fed H AA diets.

45-Week Hatch: Male Progeny Responses

Effects of pullet BW, hen dietary AA, and male progeny dietary AA treatments from the 45 wk hatch on production parameters can be found in Tables 12 and 13. No main effects were found for 13 and 55 d BW, 0 to 55 d mortality, drumstick, wing yields, white stripping scores, or wooden breast scores ($P > 0.05$). Main effects of pullet BW on 0 to 27 d FCR ($P < 0.05$) for progeny from I BW pullets having the lowest FCR. Main effects of progeny dietary AA on 27, 39, and 55 d BW and yields of carcass, fillet, tenders, and total white meat yield were highest ($P < 0.05$) for progeny fed H AA diets. There were main effects of progeny dietary AA treatments on 0 to 13 d, 0 to 27 d, 0 to 39 d, and 0 to 55 d FCR, and abdominal fat yield being lowest ($P < 0.05$) for progeny fed H AA diets. Two-way interaction of hen and progeny dietary AA treatments on thigh yield were highest ($P < 0.01$) for LL and HL means, lowest for LH, and intermediate for the HL treatments. Three-way interaction between pullet BW, hen dietary AA, and progeny AA treatments on tender yield was highest ($P < 0.05$) for treatments CLH and CHH, lowest for CLL and IHL, and CHL, ILL, ILH, and IHH had intermediate responses.

DISCUSSION

In all 4 of the experiments, most responses delivered was from the progeny dietary treatments, as would be expected. For these discussions, we will focus on the 3-way and 2-way interactions as well as the main effects of pullet BW and hen AA treatments.

Female progeny from 32-week-old high-yielding broiler breeders had a 3-way interaction between pullet BW × hen dietary AA × progeny dietary AA

Table 9. Effects of dietary amino acid and maternal treatment of white stripping score[1] percentages[2] of breast fillets in Cobb 700 male broilers. The birds were progeny from 32 week old broiler breeder hens fed either low[3] or high[4] amino acid diets and that were reared on either control[5] or increased[6] BW.

	White stripping, %				Wooden breast, %						
	0.5	1	2	3	0.0	0.5	1	1.5	2	2.5	3
Progeny (B)											
Low AA[7]	25.22	60.00	14.78	0.00	11.30	40.87	24.35	5.22	11.30	3.48[a]	3.48
High AA[8]	15.97	60.50	22.69	0.84	8.40	34.45	28.57	10.08	9.24	0.00[b]	9.24
SEM	3.76	4.58	3.64	0.61	2.79	4.53	4.13	2.49	5.71	1.20	2.28
Maternal (H)											
Low AA	21.95	62.60	15.45	0.00	8.94	40.65	25.20	8.13	10.57	1.80	4.88
High AA	18.92	57.66	22.52	0.90	10.81	34.23	27.93	7.21	9.91	1.63	8.11
SEM	3.85	4.66	3.71	0.62	2.84	4.61	4.21	2.54	2.89	1.24	2.33
Pullet BW (P)											
Control	20.34	61.86	17.80	0.00	12.71	36.44	29.66	5.93	7.63	1.70	5.93
Increased	20.69	58.62	19.83	0.86	6.90	38.79	23.28	9.48	12.93	1.72	6.90
SEM	3.77	4.56	3.64	0.61	2.76	4.52	4.10	2.48	2.82	1.21	2.28
P × H × B interaction											
Control × low AA × low AA											
Control × low AA × high AA											
Control × high AA × low AA											
Control × high AA × high AA											
Increased × low AA × low AA											
Increased × low AA × high AA											
Increased × high AA × low AA											
Increased × high AA × high AA											
SEM											
P-values											
P × H × B	0.2027	0.5688	0.5867	0.4635	0.5226	0.0941	0.7095	0.5612	0.7313	0.7447	0.2296
H × B	0.0302	0.1959	0.2434	0.3989	0.4902	0.1367	0.8563	0.5358	0.9512	0.2345	0.0640
P × H	0.8377	0.8231	0.3961	0.3883	0.2644	0.1735	0.4939	0.6212	0.6017	0.9992	0.7843
B	0.0804	0.9375	0.1228	0.3266	0.4583	0.3132	0.4664	0.1639	0.6053	0.0403	0.0724
H	0.5682	0.4425	0.1680	0.2935	0.6335	0.3137	0.6389	0.7924	0.8689	0.9179	0.3159
P	0.9473	0.6140	0.6925	0.3142	0.1363	0.7118	0.2704	0.3102	0.1827	09,863	0.7645

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Myopathy scores were assigned to the breast fillets as: 0 = no incidence, 0.5 = slight incidence, 1.0 = low incidence, 1.5 = mild incidence, 2.0 = moderate incidence, 3.0 = severe incidence.
[2]Myopathy percentages were figured as: counts by score/total fillets counted by pen.
[3]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2797 kcal/kg ME.
[4]High amino acid breeder diets were 15% crude protein.
[5]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[6]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[7]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[8]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

treatments for carcass yield as a percent of 56 d BW (Tables 5 and 12). The treatment with the highest carcass yield were the female broilers fed high AA diets from pullets on an increased BW curve and fed low AA diets during egg production. Further investigation into the 2-way and main effects (Tables 5, 6 and 12) suggests that either the female progeny fed high AA or those from pullets of increased BW have the highest ($P < 0.05$) carcass yields. This is also supported by the 3-way interaction for female progeny from 32-week-old breeders indicating that the ILL female progeny had the highest ($P < 0.05$) breast fillets that had scores of 0.5, and the IHH female progeny had the lowest ($P < 0.05$) breast fillets that had scores of 0.5. Suggesting that IHH female progeny had more breast fillets that were 1.0 or greater. The 3-way interaction of IHH having the highest ($P < 0.05$) wooden breast scores of 3.0 supports the interaction of hen partitioning of AA. Hen AA supply increasing progeny carcass yield and meat quality is in agreement with Spratt and Leeson (1987). Moreover, there may be an epigenetic effect of protein accretion of the pullet and that of the female progeny of young high-yielding breeder hens. There were no 3-way, or 2-way interactions found for the female progeny from 45-week-old high-yielding broiler breeders.

However, the male progeny from 45-week-old high-yielding broiler breeders had a 3-way interaction for tender yield (Tables 11 and 12). When the interactions are compared, the data are conflicted, but at the main effect level, the data would suggest that the 3-way interaction for increased ($P < 0.05$) tender yield of the male progeny was of those from the control BW pullets. There was also a 2-way interaction for thigh yield of the male progeny from 45-week-old high-yielding broiler breeders where the lowest ($P < 0.05$) thigh yield was found to be that of the male progeny fed high AA from hens fed low AA, and the main hen dietary treatment effect would agree that the highest ($P < 0.05$) thigh yield was that of progeny from hens fed high AA diets. Although there were no interactions found for the female progeny from 45-week-old high-yielding broiler breeders, the interactions found for the male progeny supports the findings

Table 10. Effects of dietary amino acid and maternal treatment of production parameters in Cobb 700 female broilers. The birds were progeny from 45 wk old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Treatment	13 d BW g	27 d BW g	39 d BW g	55 d BW g	0–13 d FCR[5]	0–27 d FCR	0–39 d FCR	0–55 d FCR	0–55 d mortality %	Total protein intake g[6]
Progeny (B)										
Low AA[7]	326	1,153[b]	1,949[b]	2,992[b]	1.174[a]	1.457[a]	1.631[a]	1.841[a]	5.4	3,844[b]
High AA[8]	351	1,243[a]	2,122[a]	3,197[a]	1.137[b]	1.393[b]	1.569[b]	1.769[b]	5.0	3,942[a]
SEM	5.5	13.2	22.0	43.6	0.0056	0.0059	0.0093	0.0103	1.1	17.3
Maternal (H)										
Low AA	340	1,198	2,054	3,144	1.163	1.425	1.592	1.798	7.4	3,838[b]
High AA	338	1,197	2,016	3,045	1.148	1.425	1.608	1.812	4.9	3,943[a]
SEM	6.7	18.2	28.1	43.8	0.0071	0.0086	0.0106	0.0136	1.0	17.0
Pullet BW (P)										
Control	344	1,213	2,044	3,101	1.156	1.424	1.603	1.812	6.5	3,851[b]
Increased	334	1,182	2,026	3,088	1.155	1.426	1.597	1.798	5.8	3,935[a]
SEM	6.1	15.4	28.2	47.0	0.0077	0.0092	0.0114	0.0123	1.1	18.2
P x H × B interaction										
P × H × B interaction										3,742[e]
Control × Low × Low										3,844[c,d]
Control × Low × High										3,836[d]
Control × High × Low										3,966[a,b]
Control × High × High										3,821[d,e]
Increased × Low × Low										3,844[b,c]
Increased × Low × High										3,961[a,b]
Increased × High × Low										4,027[a]
Increased × High × High										18.9
P-values										
P × H × B	0.7458	0.7822	0.8151	0.1756	0.6643	0.3973	0.9705	0.3593	0.6498	<0.0001
H × B	0.8047	0.5941	0.8567	0.9530	0.4171	0.5838	0.6233	0.4229	0.4502	<0.0001
P × B	0.2165	0.4716	0.7514	0.7975	0.1194	0.7811	0.5343	0.9928	0.6498	<0.001
P × H	0.1760	0.2874	0.9452	0.6112	0.9608	0.8443	0.7386	0.4358	0.2922	<0.0001
B	0.0018	<0.0001	<0.0001	0.0006	<0.0001	<0.0001	<0.0001	<0.0001	0.8796	0.0003
H	0.7962	0.9434	0.1968	0.0803	0.0612	0.9569	0.2134	0.2848	0.1013	<0.0001
P	0.1936	0.0901	0.5373	0.8223	0.8765	0.7845	0.6583	0.2924	0.6498	0.0021

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).

[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2797 kcal/kg ME.

[2]High amino acid breeder diets were 15% crude protein.

[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.

[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.

[5]FCR is adjusted for mortality.

[6]Total protein equals total g CP fed to pullets to 22 wk, hens from 22 to 45 wk, and broilers from d 1 to 55 d.

[7]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.

[8]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

Table 11. Effects of dietary amino acid and maternal treatment of processing yield parameters in Cobb 700 female broilers. The birds were progeny from 45 wk old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Effects	Carcass, %	Fillet, %	Tender, %	Total white, %	Drum, %	Thigh, %	Wing, %	Abdominal fat, %
Progeny (B)								
Low AA[5]	78.3[b]	22.2[b]	4.8[b]	34.5[b]	9.0[a]	13.9	7.2[b]	1.8[a]
High AA[6]	79.0[a]	24.2[a]	5.0[a]	36.8[a]	9.9[b]	13.7	7.4[a]	1.5[b]
SEM	0.19	0.25	0.04	0.29	0.07	0.14	0.04	0.05
Maternal (H)								
Low AA	78.7	23.3	4.9	35.7	8.9	13.6[b]	7.3	1.7
High AA	78.7	23.1	4.9	35.6	9.0	14.0[a]	7.3	1.6
SEM	0.21	0.32	0.04	0.39	0.07	0.13	0.05	0.07
Pullet BW (P)								
Control	78.8	23.2	4.9	35.7	9.0	13.7	7.3	1.7
Increased	78.6	23.2	4.8	35.6	8.9	13.9	7.4	1.6
SEM	0.20	0.33	0.04	0.41	0.08	0.14	0.05	0.06
P-values								
P × H × B	0.3811	0.2983	0.9211	0.4171	0.3850	0.6340	0.3366	0.6122
H × B	0.9451	0.6475	0.2056	0.8041	0.8301	0.3309	0.3931	0.1204
P × B	0.6333	0.1061	0.2038	0.1683	0.1628	0.9199	0.9529	0.1671
P × H	0.7914	0.8832	0.1043	0.6160	0.4309	0.9102	0.9061	0.4115
B	0.0108	<0.0001	0.0002	<0.0001	0.0247	0.4039	0.0203	0.0009
H	0.9623	0.7473	0.6685	0.6702	0.2389	0.0064	0.8950	0.1057
P	0.4482	0.9234	0.2622	0.9507	0.4716	0.5320	0.1610	0.0982

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2,797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[6]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

that dietary protein intake of the dam influences carcass yield.

The 3-way interaction for male progeny from 32-week-old breeders suggests that either the CHH or IHL male progeny had the highest ($P < 0.05$) drumstick yield. On further investigation of the main effects, there is a tendency for higher ($P < 0.05$) drumstick yield of the 32-week-old male progeny of hens fed high AA diets; however, the male progeny themselves had the highest ($P < 0.05$) yield when fed low AA diets. There was a 2-way interaction between the 32-week male broiler progeny fed high AA from pullets of increased BW at 27 d, but there was not a main effect of pullet BW treatments. Previous work would also suggest that maternal dietary intake of protein influenced BW of their progeny (Spratt and Leeson, 1987; Brake, 2003). This suggests that there may be an epigenetic response from the pullet BW effecting early male progeny BW; however, the effect was only from young hen and not sequential ages. Although hen AA nutrition can impact progeny BW (Spratt and Leeson, 1987; Lopez and Leeson, 1994, 1995a), subsequent research should assess pullet nutrition on progeny BW.

These studies suggest that increasing dietary AA of the hens can result in an increase in dark meat yield, and conversely lowering dietary AA of the hens would result in a decrease of dark meat yield. Kidd (2003), reviewed past studies that investigated dietary CP of hens and suggested reducing CP of the hens below those previously reported for good egg weight, resulting in no detrimental effects of the progeny. Spratt and Leeson (1987) found that maternal dietary protein influenced carcass yield and quality which are key economic traits within the commercial poultry industry. As dark meat yield is not of high interest with high-yielding broilers as that of white meat yield these would agree that lowering hen dietary AA could reduce dark meat yield.

CONCLUSIONS

In addition to broiler dietary AA density impacting broiler performance and carcass yields, it appears that pullet conditioning and hen dietary AA density also affect broiler progeny performance and yields. There may be an epigenetic effect of pullet BW and broiler characteristics of carcass yield, early BW and FCR, and tender yield. Investigation of more levels of pullet BW or more extreme pullet BW could lead to better understanding of the effects seen in these studies. Also, of interest is the effect of dietary AA of the dam on the dark meat yield of her progeny. Further investigation should be done on varying levels of dietary hen AA densities of high-yielding broiler breeders to understand if there may be an effect on dark meat yield and conversely that of white meat yield.

DISCLOSURES

The authors did not provide any conflict of interest statement.

Table 12. Effects of dietary amino acid and maternal treatment of production parameters in Cobb 700 male broilers. The birds were progeny from 45 wk old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Treatment	13 d BW g	27 d BW g	39 d BW g	55 d BW g	0–13 d FCR[5]	0–27 d FCR	0–39 d FCR	0–55 d FCR	0–55 d mortality %	Total protein intake g[6]
Progeny (B)										
Low AA[7]	324	1,217[b]	2,169[b]	3,458[b]	1.179[a]	1.463[a]	1.650[a]	1.837[a]	6.4	3,975[b]
High AA[8]	333	1,316[a]	2,394[a]	3,627[a]	1.148[b]	1.394[b]	1.555[b]	1.784[b]	8.3	4,107[a]
SEM	4.5	11.4	21.3	65.4	0.0084	0.0066	0.0130	0.0155	1.7	16.5
Maternal (H)										
Low AA	327	1,263	2,281	3,530	1.175	1.433	1.612	1.803	9.7	3,994[b]
High AA	330	1,270	2,282	3,555	1.153	1.424	1.594	1.818	9.2	4,092[a]
SEM	4.5	15.8	33.1	66.9	0.0100	0.0094	0.0159	0.0157	1.6	18.7
Pullet BW (P)										
Control	331	1,275	2,302	3,574	1.169	1.437[a]	1.613	1.823	9.4	3,996[b]
Increased	326	1,258	2,261	3,511	1.158	1.420[b]	1.593	1.799	9.5	4,086[a]
SEM	4.5	16.5	31.3	63.0	0.0094	0.0098	0.0154	0.0174	1.6	19.2
P × H × B interaction										
Control × Low × Low										3,907[d]
Control × Low × High										3,989[c,d]
Control × High × Low										3,992[c,d]
Control × High × High										4,112[a,b]
Increased × Low × Low										3,964[c,d]
Increased × Low × High										4,133[a,b]
Increased × High × Low										4,054[b,c]
Increased × High × High										4,195[a]
SEM										17.8
P-values										
P × H × B	0.7791	0.5226	0.2308	0.7205	0.0739	0.8994	0.3203	0.3335	0.5520	<0.0001
H × B	0.4307	0.8420	0.5760	0.3251	0.2390	0.5138	0.5024	0.6791	0.6100	<0.0001
P × B	0.8683	0.5043	0.7611	0.3304	0.4594	0.1384	0.5885	0.7418	0.8984	<0.0001
P × H	0.8383	0.9894	0.6492	0.4658	0.7346	0.3969	0.3035	0.2169	0.3517	<0.0001
B	0.1935	<0.0001	<0.0001	0.0524	0.0076	<0.0001	<0.0001	0.0118	0.7018	<0.0001
H	0.5581	0.6903	0.9657	0.7639	0.0597	0.2719	0.2439	0.3995	0.8648	0.0007
P	0.4381	0.3043	0.1792	0.4579	0.3385	0.0265	0.2096	0.2135	0.7018	0.0019

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]FCR is adjusted for mortality.
[6]Total protein equals total protein fed to pullets, hens to 45 wks of age, and the broiler.
[7]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[8]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

Table 13. Effects of dietary amino acid and maternal treatment of processing yield parameters in Cobb 700 male broilers. The birds were progeny from 45 wk old broiler breeder hens fed either low[1] or high[2] amino acid diets and that were reared on either control[3] or increased[4] BW.

Treatment	Carcass, %	Fillet, %	Tender, %	Total white, %	Drum, %	Thigh, %	Wing, %	Abdominal fat, %
Progeny (B)								
Low AA[5]	77.8[b]	20.7[b]	4.3[b]	32.1[b]	9.9	14.7	7.4	1.4[a]
High AA[6]	79.1[a]	22.7[a]	4.4[a]	34.3[a]	9.8	14.6	7.5	1.1[b]
SEM	0.18	0.19	0.04	0.31	0.06	0.11	0.05	0.06
Maternal (H)								
Low AA	78.3	21.7	4.3	33.2	9.8	14.5[b]	7.5	1.3
High AA	78.6	21.7	4.4	33.2	9.9	14.8[a]	7.4	1.3
SEM	0.22	0.30	0.04	0.37	0.06	0.11	0.06	0.06
Pullet BW (P)								
Control	78.6	22.0	4.4[a]	33.6	9.8	14.5	7.4	1.3
Increased	78.2	21.3	4.3[b]	32.8	9.9	14.8	7.5	1.2
SEM	0.21	0.29	0.04	0.37	0.07	0.11	0.05	0.06
P × H × B interaction								
Control × Low × Low			4.2[b]					
Control × Low × High			4.6[a]					
Control × High × Low			4.4[a,b]					
Control × High × High			4.5[a]					
Increased × Low × Low			4.3[a,b]					
Increased × Low × High			4.3[a,b]					
Increased × High × Low			4.2[b]					
Increased × High × High			4.3[a,b]					
SEM			0.4					
H × B interaction								
Low AA × low AA						14.8[a]		
Low AA × high AA						14.4[b]		
High AA × low AA						14.7[a,b]		
High AA × low AA						14.9[a]		
P-values								
P × H × B	0.4868	0.5586	0.0213	0.2909	0.8403	0.4291	0.3362	0.3834
H × B	0.4075	0.0796	0.5543	0.1503	0.4104	0.0075	0.3344	0.8855
P × B	0.2050	0.2744	0.1382	0.5083	0.1120	0.9439	0.2856	0.6679
P × H	0.3264	0.6138	0.1764	0.7088	0.8715	0.9294	0.8627	0.9078
B	<0.0001	<0.0001	0.0008	<0.0001	0.0687	0.1535	0.2068	0.0002
H	0.1892	0.4764	0.6385	0.3711	0.2338	0.0448	0.6679	0.9778
P	0.1048	0.0767	0.0102	0.0940	0.2184	0.7538	0.3862	0.0948

[a-b]Mean values within a row that have different letters are different at $P < 0.05$ (Tukey's Test).
[1]Low amino acid breeder diets were 14% crude protein and isocaloric to the high AA breeder diet at 2797 kcal/kg ME.
[2]High amino acid breeder diets were 15% crude protein.
[3]Control pullet BW represent the Cobb 700 breeder guide weights. BW were achieved each week through regulated feed intake.
[4]Increased pullet BW were achieved each week through regulated feed intake higher than those on the control body weight curve.
[5]Low AA broiler diets were more than 2% lower crude protein than the high amino acid broiler diets.
[6]High AA broiler diets were more than 2% higher crude protein than the low amino acid broiler diets.

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