Characterization of growth patterns and carcass characteristics of male and female broilers from four commercial strains fed high or low density diets

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ABSTRACT Over the last few decades, the poultry industry has seen the emergence of various market segments that are beneficial for rearing various flock sizes. Two concurrent experiments consisting of 1,200 broilers each were conducted to evaluate the effects of broiler size and diet on the performance of four commercially available broiler strains, including 2 standard yielding (**SY**) and 2 high yielding (**HY**) strains. Within each experiment (Experiment 1: males, Experiment 2: females), a small bird (38 and 40 d processing) and big bird (47 and 54 d processing) debone market were targeted to give variable carcass size. Two polyphasic diets were fed based on varying of amino acid densities. The low-density diet (**L**) consisted of 1.20, 1.10, 1.00, and 0.96% digestible Lys and the high-density diet (**H**) consisted of 1.32, 1.21, 1.10, and 1.06% across the 4-phases, respectively, with similar essential amino acid to digestible Lys ratios between the L and H diets in each phase. Weekly BW, BW gain, feed intake, and feed conversion ratio were assessed, as well as processing yields during both experiments. Broilers fed the H diets responded better than those fed the L diets, regardless of sex, with increased BW and decreased FCR ($P < 0.05$). Male HY strains provided the highest carcass yields ($P < 0.05$) compared to SY strains, with no differences observed in females ($P > 0.05$). High density diets (Diet H) also produced increases in carcass, breast, and tender yield ($P < 0.05$) for males, but that trend was not present in carcass yield for females ($P < 0.05$). Overall, strain impacted performance traits and carcass yields. Therefore, the use of specific strains and amino acid density for various market segments is beneficial for integrators to maximize return.

Key words: broiler, amino acid density, sex, strain, yields

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INTRODUCTION

The world poultry market is continually adapting to meet consumer demands for variety in lean protein sources. To meet this demand, continual genetic selection by primary breeder companies is conducted to lower feed conversion (**FCR**) and increase breast meat yield in broilers (Kerr et al., 1999). Broiler performance, as indicated by BW, feed intake (**FI**), and FCR, have been shown to vary among broiler strains (Smith and Pesti, 1998; Smith et al., 1998). Standard and high yielding broiler strains are the two main categories of broilers found in the commercial market. Previous data have shown that standard yielding broilers can have twice the body weight gain of their high yielding counterpart (Han and Baker, 1993). High yielding strains are selected to have increased high value breast meat yield while standard yielding strains have better FCR (Mehaffey et al., 2006). However, López et al. (2011) found that strain had no impact on live growth performance for BW when broilers were grown to 42 d. Differences among strains can be beneficial for selecting flocks for economic advancement. With significant differences reported in feed intake and FCR between strains, integrators are optimizing production costs by reducing feed cost, which represents the largest input cost in live production (Jackson et al., 1982; Abdullah et al., 2010; Maynard et al., 2019).

Bird sex has also been shown to influence broiler performance. Growth rates for female broilers tend to plateau at earlier ages than male broilers, corresponding with increased fat deposition for female birds (Waldroup et al., 1990). These differences in growth patterns result in higher body weights and lower FCR for male broilers (Coon et al., 1981). Differences attributed to sex also extend to carcass traits, with female broilers producing higher white meat percent yield, whereas male broilers produce higher dark meat yields (Corzo et al., 2005). Some researchers have indicated

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that because of the difference in growth patterns between males and females, nutritional requirements are also dependent on broiler sex (Han and Baker, 1993). While minor differences in amino acid requirements have been reported between male and female broilers, the largest differences have been observed for the digestible lysine requirement (Hunchar and Thomas, 1976; Han and Baker, 1993; Rosa et al., 2001a,b; Dozier et al., 2009; Maynard et al., 2020). These responses have led researchers to theorize that essential amino acid requirements, expressed relative to digestible lysine, are similar between the sexes (Wu, 2014). However, absolute amino acid requirement of male broilers is drastically higher than that of female broilers (Wu, 2014).

Dietary amino acid concentrations directly impact the performance and meat yield of broiler chickens. Corzo et al. (2005) found that broilers fed a high density amino acid diet, when compared to broilers fed a low density diet, produced lower levels of fat but increased breast meat and tender percent yield. Dozier et al. (2008) reported that dietary amino acid needs vary for broilers raised for different markets (i.e., fast food vs. tray pack). Body weight gain, for example, positively responds to increased amino acid density from hatch to 5 wk of age, whereas it is not as responsive post 5 wk (Dozier et al., 2008). Vieira and Angel (2012) established that standard yielding broilers respond favorably to higher density diets for performance when compared to high yielding strains. A multitude of projects have assessed the effects of amino acid density in the diet and have concluded that feeding diets with increased amino acid density result in better FCR, body weight gain (**BWG**), and higher breast meat yield (Corzo et al., 2005; Dozier et al., 2008, 2009; López et al., 2011; Vieira and Angel, 2012). Therefore, the aim of the present work was to assess the effects of dietary amino acid levels on growth performance and yield traits of both sexes of 4 commercial broiler strains when slaughtered at different target weights.

MATERIALS AND METHODS

All animal rearing was approved by the Institutional Animal Care and Use Committee at the University of Arkansas (protocol # 20016).

Animal Husbandry

Two concurrent experiments were conducted using a total of 2,400 sex separate broiler chicks from 4 commercial strains (2 standard yielding [**SYA** and **SYB**] and 2 high yielding [**HYA** and **HYB**]) that were sourced from a local commercial hatchery. Experiment 1 utilized 1,200 male broiler chicks, whereas Experiment 2 utilized 1,200 female broiler chicks. Upon arrival to the University of Arkansas poultry research farm, 25 broiler chicks were group weighed and placed in 1.2 × 1.82-meter floor pens (48 pens per experiment; 0.09 m^2 per bird). Each pen was outfitted with fresh pine shavings, a hanging feeder, and a nipple drinker water line. Birds were allowed unrestricted access to feed and water throughout the trial. Environmental conditions were maintained in a closed-sided house with a set point temperature of 32°C when placed. The set point was reduced by 2°C each week resulting in an endpoint temperature of 15°C. A lighting schedule was set at 24 light:0 dark from d 0 to 1, 23 light:1 dark from d 1 to 7, and 16 light:8 dark from d 7 to 54 for the remainder of the trial (Maynard et al., 2019). Crumbled starter diets were fed from d 0 to d 14, whereas the grower, finisher, and withdrawal diets were fed as pellets from 15 to 28, 29 to 42, and 43 to 54 d of age, respectively. Weekly BW and FI were recorded by pen and used to calculate individual BWG and FCR. Mortality and culled birds were collected and weighed twice daily to allow for calculation of mortality corrected feed conversion ratio.

Dietary treatments

Diets were fed across 4 feeding phases, including starter (d 0−14), grower (d 15−28), finisher (d 29−42), and withdrawal (d 43−54). High and low amino acid density diets were formulated for each dietary phase (Table 1). Digestible lysine levels were 1.20, 1.10, 1.00, and 0.96% for the low amino acid density diets and 1.32, 1.21, 1.10, and 1.06% for the high amino acid density diets for the starter, grower, finisher, and withdrawal phases, respectively. Given that amino acid requirements and recommendations are strain specific and that 4 unique broiler strains were used in this experiment, these amino acid densities were chosen to represent the low and high range of amino acid densities fed in commercial practice. Dietary treatments were intended to be held constant throughout both experiments, but starter diets were inadvertently switched resulting in dietary treatments of high, low, low, low (Diet L) and low, high, high, high (Diet H).

Processing

Broilers from both experiments were processed on 2 separate days targeting carcass sizes 2.5 and 3.8 kg to correspond with small bird and large bird debone market weights. Birds were processed on d 38 and 47 in Experiment 1 and d 40 and 54 for Experiment 2. Following a 10-h feed withdrawal period, 12 randomly selected broilers from each pen were transported to the University of Arkansas pilot processing plant, and individually weighed upon arrival. Birds were then hung on inline shackles, electrically stunned (11 V, and 11 mA for 11 s), exsanguinated, scalded in hot water (53.8°C, 2 min), and then defeathered (Mehaffey et al., 2006). Prior to mechanical evisceration, necks and hocks were manually removed from each bird. Following evisceration, abdominal fat was collected according to Waldroup et al. (1990), weighed, and hot carcass weights were recorded. Carcasses were then subjected to a 0.25-h prechill, at 12°C, before being placed in 0°C

Table 1. Experimental[1] starter (0 to 14 d), grower (15 to 28 d), finisher (29 to 42 d), and withdrawal diets (43 to 54 d) fed to male and female broilers from 0 to 54 d of age.

Item, % as-fed	Starter		Grower		Finisher		Withdrawal	
	L	H	L	H	L	H	L	H
Corn	60.610	55.201	63.010	58.513	65.559	62.644	65.396	64.468
Soybean meal	34.288	38.824	30.943	34.694	27.513	29.886	27.738	28.355
Poultry fat	1.608	2.445	2.834	3.522	3.999	4.419	4.063	4.136
DL-methionine	0.319	0.376	0.274	0.329	0.260	0.321	0.226	0.301
L-lysine?HCl	0.206	0.225	0.183	0.212	0.162	0.219	0.104	0.213
L-threonine	0.133	0.157	0.099	0.126	0.079	0.117	0.048	0.109
Limestone	1.090	1.063	1.052	1.029	1.014	0.999	1.013	1.009
Dicalcium phosphate	0.974	0.958	0.835	0.821	0.695	0.687	0.693	0.692
Salt	0.405	0.399	0.411	0.406	0.418	0.415	0.418	0.417
Vitamin and mineral premix[2]	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Choline chloride (60%)	0.055	0.041	0.047	0.036	0.040	0.032	0.039	0.037
Phytase[3]	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Coccidiastat[4]	0.050	0.050	0.050	0.050	0.000	0.000	0.000	0.000
Calculated composition, % unless noted otherwise[4]								
AME, kcal/kg	3,000	3,000	3,100	3,100	3,200	3,200	3,200	3,200
CP	21.50	23.34	20.00	21.54	18.50	19.54	18.50	18.92
Ca	0.90	0.90	0.84	0.84	0.78	0.78	0.78	0.78
Available P	0.45	0.45	0.42	0.42	0.39	0.39	0.39	0.39
Na	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Digestible Lys	1.20	1.32	1.10	1.21	1.00	1.10	0.96	1.06
Digestible TSAA	0.90	0.99	0.83	0.91	0.78	0.86	0.75	0.83
Digestible Thr	0.82	0.90	0.74	0.81	0.67	0.74	0.64	0.71
Digestible Val	0.92	0.99	0.86	0.92	0.80	0.84	0.81	0.81
Digestible Ile	0.83	0.91	0.78	0.84	0.72	0.76	0.72	0.73
Digestible Arg	1.31	1.44	1.21	1.32	1.11	1.18	1.12	1.13
Digestible Trp	0.24	0.27	0.22	0.24	0.20	0.22	0.21	0.21
Total Gly+Ser	1.99	2.15	1.86	1.99	1.72	1.81	1.73	1.75
Analyzed composition, %								
CP	24.45	24.9	22.7	23.85	20.55	21.05	20.25	21.05

[1]L = low amino acid density; H = high amino acid density.
[2]The vitamin and mineral premix contained (per kg of complete feed): manganese, 100.0 mg; zinc, 100.0 mg; iron. 50.0 mg; copper, 11.3 mg; iodine, 1.5 mg; selenium, 0.2 mg; vitamin A, 7716 IU; vitamin D_3, 2756 ICU; vitamin E, 17 IU; vitamin B_{12}, 0.01 mg; menadione, 0.83 mg; riboflavin, 6.61 mg; d-pantothenic acid, 6.61 mg; thiamine, 1.10 mg; niacin, 27.56 mg; pyridoxine, 1.38 mg; folic acid, 0.69 mg; biotin, 0.03 mg; choline, 385.81 mg.
[3]OptiPhos 2,000 was added to provide 250 FTU/kg (Huvepharma, Peachtree City, GA).
[4]Supplied 60g of salinomycin Na per 907.2 kg of complete feed to prevent coccidiosis.

immersion chilling tanks for 2.5-h with manual agitation. At 3-h postmortem, chilling tanks were then drained of water, and carcasses re-weighed and deboned to determine *Pectoralis major* and *P. minor*, wing, and whole leg weights. Part weights were then divided by individual back dock live weight to determine percent yields.

Statistical Analysis

Pen served as the experimental unit and treatments were assigned in a randomized complete block design, with pen location serving as the blocking factor. Experiments (males, females) were analyzed separately. Both experiments were comprised of a 2 × 4 factorial arrangement (diet × strain), with each treatment represented by 6 replicate pens of 24 birds. Mortality data were arcsine square root transformed prior to statistical analysis. All live data were subjected to a 2-way ANOVA using JMP Pro 14 software to detect effects of strain or diet and their subsequent interactions. Statistical significance was set at $P \leq 0.05$. Where appropriate, means were then separated using a Student's *t* test.

Results for each processing within each experiment were combined and analyzed as a 2 × 2 × 4 factorial (diet x carcass size x strain). All processing data were subjected to a 3-way ANOVA using JMP Pro 14 software to detect effects of strain, carcass size, or diet and their subsequent interactions. Statistical significance was set at $P \leq 0.05$. Where appropriate, means were then separated using a Student's *t* test.

RESULTS

Analyzed values for dietary crude protein were higher than formulated values for all feeding phases. Overall, analyzed crude protein trends agreed with formulated values, displaying separation in the formulated low and high diets. Overall final broiler performance exceeded breeder specifications for all strains, regardless of Experiment. Final mortality in Experiment 1 and Experiment 2 was 1.75% and 2.00%, respectively.

Experiment 1 Live Performance of Males

Live performance data from Experiment 1 can be found in Tables 2 through 5. Body weight gain was influenced ($P < 0.05$) by broiler strain throughout the experimental period, while diet had no effect on BW gain ($P > 0.05$). Weekly assessment results of cumulative BW gain indicated that SYA had the highest ($P < 0.05$) BW gain, HYB had the lowest, and HYA and SYB were

Table 2. Live performance[1] of male broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 14 d post-hatch.

	0 to 7 d					0 to 14 d			
Treatment	BW d0	BW d7	BWG	FI	FCR	BW d14	BWG	FI	FCR
Interactions (n = 6)									
SYA, H	0.041	0.182	0.141	0.164	1.171[a]	0.465	0.424	0.522	1.234
SYA, L	0.041	0.185	0.144	0.150	1.035[b]	0.474	0.433	0.507	1.171
HYA, H	0.039	0.171	0.132	0.138	0.882[c]	0.452	0.413	0.490	1.191
HYA, L	0.039	0.167	0.129	0.135	1.049[ab]	0.430	0.392	0.463	1.182
SYB, H	0.038	0.167	0.129	0.138	1.033[b]	0.439	0.401	0.476	1.190
SYB, L	0.038	0.168	0.130	0.132	1.011[bc]	0.442	0.404	0.457	1.134
HYB, H	0.038	0.161	0.123	0.143	1.178[a]	0.403	0.365	0.449	1.234
HYB, L	0.038	0.161	0.123	0.131	1.063[ab]	0.406	0.369	0.432	1.172
SEM	0.0003	0.0021	0.0021	0.0057	0.0465	0.0069	0.0068	0.0083	0.0134
Main effect of strain[2] (n = 24)									
SYA	0.041[a]	0.184[a]	0.140[a]	0.157[a]	1.103	0.470[a]	0.429[a]	0.514[a]	1.203[a]
HYA	0.039[b]	0.169[b]	0.131[b]	0.136[b]	0.966	0.441[b]	0.402[b]	0.476[b]	1.186[ab]
SYB	0.038[c]	0.167[b]	0.127[b]	0.135[b]	1.022	0.440[b]	0.403[b]	0.467[b]	1.162[b]
HYB	0.038[c]	0.161[c]	0.121[c]	0.137[b]	1.120	0.405[c]	0.367[c]	0.441[c]	1.203[a]
SEM	0.0002	0.0015	0.0015	0.0040	0.0328	0.0049	0.0048	0.0059	0.0095
Main effect of diet (n = 48)									
Low	0.038	0.168	0.130	0.132	1.011	0.442	0.404	0.457	1.134[b]
High	0.038	0.167	0.129	0.138	1.033	0.439	0.401	0.476	1.190[a]
SEM	0.0003	0.0021	0.0021	0.0057	0.0465	0.0069	0.0068	0.0083	0.0134
P-values									
Strain	<0.001	<0.001	<0.001	0.001	0.006	<0.001	<0.001	<0.001	0.012
Diet	1.000	0.741	0.649	0.414	0.740	0.759	0.770	0.112	0.006
Strain × Diet	0.981	0.465	0.449	0.744	0.009	0.133	0.123	0.894	0.160

[a-c]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's t test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.

intermediate through 4 wk of age (Tables 2 and 3). At d 35, BW gain was highest ($P < 0.05$) for SYA broilers, followed by SYB, HYA, and HYB broilers with separation between all broiler strains ($P < 0.05$; Table 4). At 42 d of age, SYA and SYB broilers had the highest ($P < 0.05$) BW gain, HYB the lowest, and HYA intermediate. A strain × diet interaction ($P < 0.05$) was observed for 0 to 47 d BW gain where SYA broilers fed Diet L had the highest BW gain and HYB broilers fed Diet L had the lowest (Table 5).

Similar to BW gain, feed intake was influenced ($P < 0.05$) by strain throughout the experimental period but was

Table 3. Live performance[1] of male broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 28 d post-hatch.

	0 to 21 d				0 to 28 d			
Treatment	BW d21	BWG	FI	FCR	BW d28	BWG	FI	FCR
Interactions (n = 6)								
SYA, H	0.989	0.948	1.220	1.288[a]	1.644	1.604	2.214	1.382
SYA, L	1.000	0.959	1.237	1.283[ab]	1.689	1.648	2.310	1.407
HYA, H	0.959	0.920	1.183	1.243[c]	1.593	1.554	2.176	1.406
HYA, L	0.929	0.891	1.163	1.304[a]	1.549	1.511	2.142	1.419
SYB, H	0.960	0.922	1.148	1.237[c]	1.613	1.575	2.124	1.350
SYB, L	0.936	0.898	1.128	1.252[bc]	1.587	1.549	1.113	1.366
HYB, H	0.870	0.833	1.062	1.274[ab]	1.457	1.419	1.957	1.384
HYB, L	0.851	0.813	1.053	1.291[a]	1.408	1.370	1.963	1.448
SEM	0.0124	0.0124	0.0157	0.0107	0.0259	0.0258	0.0263	0.0227
Main effect of strain[2] (n = 24)								
SYA	0.995[a]	0.954[a]	1.228[a]	1.286	1.667[a]	1.626[a]	2.262[a]	1.394
HYA	0.944[b]	0.906[b]	1.173[b]	1.273	1.571[b]	1.532[b]	2.159[b]	1.412
SYB	0.948[b]	0.910[b]	1.138[c]	1.245	1.600[b]	1.562[b]	2.119[b]	1.358
HYB	0.860[c]	0.823[c]	1.057[d]	1.282	1.432[c]	1.394[c]	1.960[c]	1.416
SEM	0.0088	0.0088	0.0111	0.0076	0.0183	0.0182	0.0186	0.0160
Main effect of diet[3] (n = 48)								
L	0.936	0.898	1.128	1.252	1.587	1.549	2.113	1.366
H	0.960	0.922	1.148	1.237	1.613	1.575	2.124	1.350
SEM	0.0124	0.0124	0.0157	0.0107	0.0259	0.0258	0.0263	0.0227
P-values								
Strain	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.056
Diet	0.180	0.176	0.388	0.327	0.484	0.483	0.772	0.613
Strain × Diet	0.360	0.358	0.615	0.023	0.253	0.258	0.087	0.662

[a-c]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's t test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0–14, and Low from d 15–28; Diet H = Low from d 0–14, and High from d 15–28.

Table 4. Live performance[1] of male broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 42 d post-hatch.

	0 to 35 d				0 to 42 d			
Treatment	BW d35	BWG	FI	FCR	BW d42	BWG	FI	FCR
Interactions (n = 6)								
SYA, H	2.378	2.338	3.209[b]	1.379	3.136	3.095	4.424[b]	1.482
SYA, L	2.408	2.367	3.387[a]	1.432	3.260	3.220	4.676[a]	1.534
HYA, H	2.291	2.252	3.171[b]	1.391	3.083	3.044	4.401[b]	1.516
HYA, L	2.208	2.169	3.131[b]	1.452	2.931	2.892	4.341[b]	1.557
SYB, H	2.349	2.311	3.101[b]	1.338	3.218	3.180	4.378[b]	1.450
SYB, L	2.278	2.241	3.103[b]	1.388	3.081	3.043	4.381[b]	1.514
HYB, H	2.138	2.100	2.854[c]	1.360	2.923	2.886	4.023[c]	1.475
HYB, L	2.092	2.054	2.875[c]	1.401	2.850	2.812	4.032[c]	1.521
SEM	0.0306	0.0305	0.0394	0.0129	0.0541	0.0540	0.0510	0.0137
Main effect of strain[2] (n = 24)								
SYA	2.393[a]	2.352[a]	3.298	1.405[ab]	3.198[a]	3.157[a]	4.550	1.508[b]
HYA	2.249[c]	2.211[c]	3.151	1.421[a]	3.007[b]	2.968[b]	4.371	1.536[a]
SYB	2.314[b]	2.276[b]	3.102	1.363[c]	3.149[a]	3.112[a]	4.379	1.482[b]
HYB	2.115[d]	2.077[d]	2.864	1.381[bc]	2.886[c]	2.849[c]	4.028	1.498[b]
SEM	0.0216	0.0216	0.0278	0.0091	0.0383	0.0382	0.0361	0.0097
Main effect of diet[3] (n = 48)								
L	2.278	2.241	3.103	1.388[a]	3.081	3.043	4.381	1.514[a]
H	2.349	2.311	3.101	1.338[b]	3.218	3.180	4.378	1.450[b]
SEM	0.0306	0.0305	0.0394	0.0129	0.0541	0.0540	0.0510	0.0137
P-values								
Strain	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.003**
Diet	0.112	0.110	0.974	**0.010**	0.081	0.081	0.967	**0.002**
Strain × Diet	0.270	0.271	**0.046**	0.883	0.054	0.053	**0.020**	0.836

[a-d]Means without a common within column within effect superscript were determined to be significantly different ($P < 0.05$) by a Student's t test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0−14, and Low from d 15−42; Diet H = Low from d 0−14, and High from d 15−42.

not influenced ($P > 0.05$) by diet. For the 0 to 7 d period, SYA broilers had higher ($P < 0.05$) feed intake than all other broiler strains (Table 2). At d 14, SYA broilers had higher ($P < 0.05$) feed intake than HYB, while HYA and SYB broilers were intermediate (Table 2). At d 21, SYA broilers had the highest ($P < 0.05$) feed intake followed by HYA, SYB, and HYB broilers with separation ($P < 0.05$) between all strains (Table 3). On d 28, trends in feed intake returned to those observed at d 14 where SYA broilers had higher ($P < 0.05$) feed intake than HYB, while HYA and SYB broilers were intermediate (Table 3). A strain × diet interaction ($P < 0.05$) was

Table 5. Live performance[1] of male broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 47 d post-hatch.

	0 to 47 d			
Treatment	BW d47	BWG	FI	FCR
Interactions (n = 6)				
SYA, H	3.813[ab]	3.572[ab]	4.986[b]	1.446
SYA, L	3.787[ab]	3.746[ab]	5.197[a]	1.466
HYA, H	3.569[bc]	3.530[bc]	4.970[b]	1.476
HYA, L	3.404[cd]	3.365[cd]	4.885[b]	1.509
SYB, H	3.892[a]	3.854[a]	4.895[b]	1.404
SYB, L	3.590[b]	3.552[b]	4.907[b]	1.455
HYB, H	3.409[cd]	3.371[cd]	4.590[c]	1.445
HYB, L	3.335[d]	3.297[d]	4.619[c]	1.490
SEM	0.0611	0.0611	0.0508	0.0186
Main effect of strain[2] (n = 24)				
SYA	3.700	3.859	5.091	1.456[ab]
HYA	3.487	3.448	4.928	1.493[a]
SYB	3.841	3.803	4.901	1.429[b]
HYB	3.372	3.334	4.604	1.468[a]
SEM	0.0432	0.0432	0.0359	0.0131
Main effect of diet[3] (n = 48)				
L	3.590	3.552	4.907	1.455
H	3.892	3.854	4.895	1.404
SEM	0.0611	0.0611	0.0508	0.0186
P-values				
Strain	**<0.001**	**<0.001**	**<0.001**	**0.014**
Diet	0.245	0.246	0.867	0.057
Strain × Diet	**0.044**	**0.0442**	**0.044**	0.829

[a-d]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's t test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0−14, and Low from d 15−47; Diet H = Low from d 0−14, and High from d 15−47.

observed for feed intake on d 35 where FI was highest for SYA broilers fed Diet L, lowest for HYB broilers fed Diets H and L, and intermediate for all other broilers fed either Diet H or Diet L (Table 4). This interaction continued ($P < 0.05$) throughout the experiment (Tables 4 and 5).

An interaction ($P < 0.05$) was observed for 0 to 7 d FCR where SYA and HYB broilers fed Diet H had the highest FCR, HYA broilers fed Diet H had the lowest, and SYA broilers fed Diet L and SYB fed Diet H were intermediate (Table 2). An interaction was again observed at d 21 where SYA broilers fed Diet H, HYA broilers fed Diet L, and HYB broilers fed Diet L had the highest FCR, HYA and SYB broilers fed Diet H had the lowest, and all others being intermediate (Table 3). No differences ($P > 0.05$) were observed on 0 to 28 d FCR as a result of strain, diet, or their interaction. For the main effect of strain on 0 to 35 d FCR, HYA broilers had higher ($P < 0.05$) FCR than SYB, while HYA and HYB were intermediate (Table 4). The main effect of diet on 0 to 35 d FCR indicated that broilers fed Diet L had a higher FCR ($P < 0.05$; Table 4). High yielding strain A had higher ($P < 0.05$) FCR for the 0 to 42 d period than all other broilers (Table 4). As with 0 to 35 d FCR, the main effect of diet indicated that broilers fed Diet L had higher FCR. At the conclusion of the experiment (0 to 47 d), FCR was highest ($P < 0.05$) for HYA and HYB broilers, lowest for SYB broilers, and intermediate for SYA broilers (Table 5).

Experiment 1 Processing of Males

No strain × diet × carcass interactions were observed for any processing measurement in Experiment 1 (males, Table 6). Chilled carcass yields were higher ($P < 0.05$)

Table 6. Carcass and parts yields (%) of male broilers of various strains fed Diet Low (L) or Diet High (H) and processed at a live weight of approximately 2.5 or 3.8 kg.

	Yield (%)						
Treatment	Hot carcass	Fat	Cold carcass	Wing	Breast	Tender	Leg quarter
Interactions[1] (n = 6)							
SYA, H, 2.5	73.84	1.01	76.55	7.59	20.08	4.28	22.34
SYA, L, 2.5	73.31	1.15	76.03	7.58	19.19	4.10	22.77
HYA, H, 2.5	74.38	0.98	76.77	7.53	21.51	4.48	21.94
HYA, L, 2.5	74.03	1.06	76.64	7.54	20.77	4.45	21.98
SYB, H, 2.5	73.81	0.79	76.31	7.58	20.07	4.22	22.92
SYB, L, 2.5	73.57	0.99	76.32	7.74	19.00	4.06	23.17
HYB, H, 2.5	74.85	0.77	77.25	7.53	22.30	4.67	22.08
HYB, L, 2.5	74.38	0.95	77.00	7.63	21.49	4.46	22.26
SYA, H, 3.8	75.21	1.13	77.42	7.48	22.68	4.51	22.12
SYA, L, 3.8	74.70	1.21	76.73	7.42	21.75	4.44	22.35
HYA, H, 3.8	76.14	1.03	78.25	7.35	24.05	4.78	22.02
HYA, L, 3.8	75.08	1.22	77.32	7.40	22.96	4.69	21.80
SYB, H, 3.8	75.23	0.91	77.38	7.44	21.99	4.44	23.00
SYB, L, 3.8	74.60	1.08	76.77	7.54	20.79	4.29	23.21
HYB, H, 3.8	76.07	0.87	78.07	7.32	24.90	4.70	21.64
HYB, L, 3.8	75.45	1.03	77.57	7.38	23.39	4.71	21.71
SEM	0.174	0.043	0.272	0.058	0.214	0.050	0.152
Treatment	Hot carcass	Fat	Cold carcass	Wing	Breast	Tender	Leg quarter
Main effect of strain[2] (n = 24)							
SYA	74.26^{c}	1.12^{a}	76.68^{b}	7.52^{ab}	20.92^{c}	4.33^{b}	22.39^{b}
HYA	74.90^{b}	1.07^{a}	77.25^{a}	7.45^{b}	22.32^{b}	4.60^{a}	21.93^{c}
SYB	74.30^{c}	0.94^{b}	76.69^{b}	7.57^{a}	20.46^{d}	4.25^{c}	23.08^{a}
HYB	75.19^{a}	0.90^{b}	77.47^{a}	7.46^{b}	23.02^{a}	4.63^{a}	21.92^{c}
SEM	0.087	0.021	0.136	0.029	0.107	0.025	0.076
Main effect of carcass size[3] (n = 48)							
2.5	74.02^{b}	0.96^{b}	76.61^{b}	7.59^{a}	20.55^{b}	4.34^{b}	22.43^{a}
3.8	75.31^{a}	1.06^{a}	77.44^{a}	7.41^{b}	22.81^{a}	4.57^{a}	22.23^{b}
SEM	0.062	0.015	0.096	0.021	0.076	0.018	0.054
Main effect of diet[4] (n = 48)							
L	74.39^{b}	1.08^{a}	76.80^{b}	7.53^{a}	21.17^{b}	4.40^{b}	22.41
H	74.94^{a}	0.94^{b}	77.25^{a}	7.48^{b}	22.20^{a}	4.51^{a}	22.26
SEM	0.062	0.015	0.096	0.021	0.076	0.018	0.054
P-values							
Strain	**<0.001**	**<0.001**	**<0.001**	**0.016**	**<0.001**	**<0.001**	**<0.001**
Carcass Size	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.009**
Diet	**<0.001**	**<0.001**	0.001	0.097	**<0.001**	**<0.001**	0.052
S × CS	0.682	0.983	0.757	0.678	0.114	0.143	**0.046**
S × D	0.733	0.611	0.845	0.217	0.745	0.602	0.256
CS × D	0.080	0.963	0.092	0.635	0.161	0.164	0.312
S × CS × D	0.483	0.605	0.826	0.926	0.712	0.237	0.963

[a-d]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's *t* test

[1]Values reported are on a percent basis in relation to live weight.

[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.

[3]2.5 kg = small bird market, 3.8 kg = big bird debone market.

[4]Diet L = High from d 0–14, and Low from d 15–47; Diet H = Low from d 0–14, and High from d 15–47.

Table 7. Live performance[1] of female broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 14 d post-hatch.

	0 to 7 d					0 to 14 d			
Treatment	BW d0	BW d7	BWG	FI	FCR	BW d14	BWG	FI	FCR
Interactions (n = 6)									
SYA, H	0.040	0.176	0.136	0.144	1.018	0.433	0.393	0.479	1.222
SYA, L	0.040	0.178	0.138	0.145	1.009	0.446	0.405	0.483	1.192
HYA, H	0.039	0.169	0.130	0.142	1.004	0.419	0.381	0.467	1.227
HYA, L	0.038	0.171	0.132	0.142	1.034	0.426	0.388	0.469	1.210
SYB, H	0.037	0.161	0.124	0.136	1.004	0.413	0.376	0.455	1.220
SYB, L	0.037	0.161	0.124	0.130	1.048	0.418	0.381	0.445	1.168
HYB, H	0.037	0.156	0.119	0.132	0.979	0.381	0.344	0.425	1.237
HYB, L	0.037	0.155	0.118	0.126	0.843	0.382	0.344	0.411	1.200
SEM	0.0003	0.0019	0.0019	0.0032	0.0510	0.0048	0.0047	0.0053	0.0114
Main effect of strain[2] (n = 24)									
SYA	0.040[a]	0.177[a]	0.137[a]	0.144[a]	1.013	0.439[a]	0.399[a]	0.481[a]	1.207
HYA	0.038[b]	0.170[b]	0.131[b]	0.142[a]	1.019	0.423[b]	0.384[b]	0.468[b]	1.219
SYB	0.037[c]	0.161[b]	0.124[c]	0.133[b]	1.026	0.416[b]	0.379[b]	0.450[c]	1.194
HYB	0.037[c]	0.156[c]	0.119[d]	0.129[b]	0.911	0.381[c]	0.344[c]	0.418[d]	1.218
SEM	0.0002	0.0014	0.0013	0.0023	0.0360	0.0034	0.0033	0.0038	0.0081
Main effect of diet[3] (n = 48)									
Low	0.037	0.161	0.124	0.130	1.048	0.418	0.381	0.445	1.168[b]
High	0.037	0.161	0.124	0.136	1.004	0.413	0.376	0.455	1.220[a]
SEM	0.0003	0.0019	0.0019	0.0032	0.0510	0.0048	0.0047	0.0053	0.0114
P-values									
Strain	<0.001	<0.001	<0.001	<0.001	0.095	<0.001	<0.001	<0.001	0.118
Diet	1.000	0.807	0.755	0.183	0.544	0.464	0.472	0.201	0.002
Strain × Diet	0.986	0.820	0.813	0.569	0.289	0.646	0.661	0.304	0.475

[a-d]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's *t* test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0–14, and Low from d 15–28; Diet H = Low from d 0–14, and High from d 15–28.

for HYA and HYB broilers than SYA and SYB broilers. Breast yields were highest ($P < 0.05$) for HYB broilers followed by HYA, SYA, and SYB broilers. Whole leg yields were highest ($P < 0.05$) for SYB broilers, lowest for HYA and HYB broilers, and intermediate for SYA broilers. Broilers processed at 3.8 kg displayed larger ($P < 0.05$) hot carcass, fat, chilled carcass, breast, and tender yields than broilers processed at 2.5 kg which had greater ($P < 0.05$) wing and whole leg yields (Table 6). Feeding Diet H resulted in higher ($P < 0.05$) hot carcass, chilled carcass, breast, and tender yields but lowered ($P < 0.05$) fat pad percentage compared with broilers fed Diet L (Table 6).

Experiment 2 Live Performance of Females

No strain × diet interactions ($P > 0.05$) were observed for any live performance measurement in Experiment 2 (females, Tables 7 through 10). Body weight gain for the 0 to 7 d period was highest ($P < 0.05$) for SYA followed by HYA, SYB, and HYB with separation between all strains (Table 7). Weekly cumulative BW gain for the 0 to 14 and 0 to 21 d periods was highest ($P < 0.05$) for SYA broilers, lowest for HYB broilers, and intermediate for HYA and SYB broilers (Tables 7 and 8). For the 0 to 28 d period, BW gain was highest ($P < 0.05$) for SYA broilers followed by SYB, HYA, and HYB broilers with separation between all broiler strains (Table 8). Weekly cumulative BW gain for the 0 to 35 through 0 to 49 d periods was highest ($P < 0.05$) for SYA broilers, lowest for HYB broilers, and intermediate for SYB and HYA broilers (Tables 8–10). Body weight gain at the conclusion of the experiment (0–54 d) was higher ($P < 0.05$) for SYA and SYB broilers than for HYA and HYB broilers (Table 10).

Feed intake was highest ($P < 0.05$) for SYA and HYA broilers and lowest for SYB and HYB broilers during the 0 to 7 d period (Table 7). For the 0 to 14 and 0 to 21 d periods, feed intake was highest ($P < 0.05$) for SYA broilers followed by HYA, SYB, and HYB broilers with separation between all broiler strains (Tables 7 and 8). For the 0 to 28 and 0 to 42 d periods, feed intake was highest ($P < 0.05$) for SYA broilers, lowest for HYB broilers, and intermediate for HYA and SYB broilers (Tables 8 and 10). On d 49 feed intake was highest ($P < 0.05$) for SYA and SYB broilers and lowest for HYA and HYB broilers. At the conclusion of the experiment (0–54 d) SYA broilers had the highest ($P < 0.05$) feed intake, HYB the lowest, and HYA intermediate. Standard yielding strain B had a feed intake similar ($P > 0.05$) to SYA and HYA broilers (Table 10).

Feed conversion ratio was not influenced by strain ($P > 0.05$) for the 0 to 7 or 0 to 14 d periods (Table 7). For the 0 to 14 d period, FCR was highest ($P < 0.05$) for broilers fed Diet H and lowest for broilers fed Diet L. The main effect of strain on FCR for the 0 to 21 d period displayed the highest ($P < 0.05$) FCR for SYA and HYA broilers and lowest for SYB and HYB broilers (Table 8). For the 0 to 28 d period, FCR was highest ($P < 0.05$) for HYA broilers followed by SYA, HYB, and SYB broilers with separation between all strains (Table 8). For the 0 to 35 and 0 to 42 d periods, FCR was highest ($P < 0.05$) for SYA and HYA broilers and lowest for SYB and HYB broilers (Table 9). At d 49, FCR was highest ($P < 0.05$) for HYA broilers, lowest for HYB broilers, and

Table 8. Live performance[1] of female broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 28 d post-hatch.

	0 to 21 d				0 to 28 d			
Treatment	BW d21	BWG	FI	FCR	BW d28	BWG	FI	FCR
Interactions (n = 6)								
SYA, H	0.914	0.874	1.121	1.273	1.496	1.456	2.020	1.394
SYA, L	0.906	0.866	1.143	1.311	1.476	1.436	2.064	1.438
HYA, H	0.859	0.821	1.076	1.288	1.387	1.349	1.911	1.421
HYA, L	0.869	0.831	1.106	1.322	1.402	1.364	1.976	1.450
SYB, H	0.875	0.838	1.056	1.231	1.440	1.402	1.906	1.366
SYB, L	0.861	0.824	1.060	1.288	1.423	1.386	1.932	1.395
HYB, H	0.800	0.763	0.985	1.262	1.311	1.274	1.767	1.389
HYB, L	0.780	0.743	0.977	1.262	1.302	1.265	1.785	1.415
SEM	0.0094	0.0093	0.0121	0.0144	0.0172	0.0172	0.0214	0.0054
Main effect of strain[2] (n = 24)								
SYA	0.910[a]	0.870[a]	1.132[a]	1.292[a]	1.486[a]	1.446[a]	2.042[a]	1.416[b]
HYA	0.864[b]	0.826[b]	1.091[b]	1.305[a]	1.395[c]	1.356[c]	1.943[b]	1.435[a]
SYB	0.868[b]	0.831[b]	1.058[c]	1.259[b]	1.431[b]	1.394[b]	1.919[b]	1.381[d]
HYB	0.790[c]	0.753[c]	0.981[d]	1.262[b]	1.306[d]	1.269[d]	1.776[c]	1.402[c]
SEM	0.0066	0.0066	0.0085	0.0102	0.0122	0.0121	0.0151	0.0038
Main effect of diet[3] (n = 48)								
L	0.861	0.824	1.060	1.288[a]	1.423	1.386	1.932	1.395[a]
H	0.875	0.838	1.056	1.231[b]	1.440	1.402	1.906	1.366[b]
SEM	0.0094	0.0093	0.0121	0.0144	0.0172	0.0172	0.0214	0.0054
P-values								
Strain	**<0.001**	**<0.001**	**<0.001**	**0.005**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Diet	0.292	0.288	0.816	**0.008**	0.489	0.501	0.398	**0.001**
Strain × Diet	0.418	0.413	0.401	0.274	0.733	0.723	0.698	0.332

[a-d]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's *t* test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0−14, and Low from d 15−28; Diet H = Low from d 0−14, and High from d 15−28.

Table 9. Live performance[1] of female broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 42 d post-hatch.

	0 to 35 d				0 to 42 d			
Treatment	BW d35	BWG	FI	FCR	BW d42	BWG	FI	FCR
Interactions (n = 6)								
SYA, H	2.113	2.072	2.924	1.410	2.727	2.687	4.078	1.532
SYA, L	2.067	2.027	2.989	1.474	2.705	2.665	4.122	1.599
HYA, H	1.967	1.928	2.747	1.415	2.587	2.549	3.864	1.550
HYA, L	1.952	1.914	2.847	1.484	2.564	2.526	3.963	1.612
SYB, H	2.059	2.022	2.757	1.352	2.722	2.685	3.942	1.505
SYB, L	2.020	1.983	2.805	1.414	2.703	2.666	4.009	1.550
HYB, H	1.878	1.841	2.551	1.373	2.525	2.488	3.833	1.507
HYB, L	1.862	1.825	2.594	1.403	2.408	2.371	3.860	1.560
SEM	0.0245	0.0244	0.0325	0.0115	0.0278	0.0278	0.0443	0.0088
Main effect of strain[2] (n = 24)								
SYA	2.090[a]	2.050[a]	2.956[a]	1.442[a]	2.716[a]	2.676[a]	4.100[a]	1.565[a]
HYA	1.959[c]	1.921[b]	2.797[b]	1.449[a]	2.576[b]	2.537[b]	3.913[b]	1.581[a]
SYB	2.040[b]	2.003[a]	2.781[b]	1.383[b]	2.712[a]	2.675[a]	3.976[b]	1.527[b]
HYB	1.870[d]	1.833[c]	2.572[c]	1.388[b]	2.466[c]	2.429[c]	3.846[c]	1.533[b]
SEM	0.0173	0.0172	0.0230	0.0082	0.0197	0.0197	0.0313	0.0062
Main effect of diet[3] (n = 48)								
L	2.020	1.983	2.805	1.414[a]	2.703	2.666	4.009	1.550[a]
H	2.059	2.022	2.757	1.352[b]	2.722	2.685	3.942	1.505[b]
SEM	0.0245	0.0244	0.0325	0.0115	0.0278	0.0278	0.0443	0.0088
P-values								
Strain	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Diet	0.270	0.265	0.311	**<0.001**	0.638	0.638	0.294	**0.001**
Strain × Diet	0.898	0.893	0.809	0.337	0.231	0.234	0.865	0.613

[a-d]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's *t* test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0−14, and Low from d 15−42; Diet H = Low from d 0−14, and High from d 15−42.

intermediate for SYB broilers (Table 10). Feed conversion ratio for SYA broilers was intermediate ($P > 0.05$) of that of SYB and HYB broilers. At the conclusion of the experiment (0−54 d), FCR was highest for HYB broilers, lowest for HYA broilers, and intermediate for SYA and SYB broilers (Table 10). For the 0 to 21 to 0 to 49 d periods, broilers fed Diet L had a higher ($P < 0.05$) FCR than broilers fed Diet H (Tables 8−10).

Table 10. Live performance[1] of female broilers from various strains fed Diet Low (L) or Diet High (H) from 0 to 54 d post-hatch.

	0 to 49 d				0 to 54 d			
Treatment	BW d49	BWG	FI	FCR	BW d54	BWG	FI	FCR
Interactions (n = 6)								
SYA, H	3.414	3.374	5.405	1.667	3.775	3.735	6.013	1.674
SYA, L	3.376	3.336	5.478	1.740	3.739	3.898	6.101	1.746
HYA, H	3.239	3.201	5.178	1.702	3.596	3.558	5.772	1.707
HYA, L	3.215	3.177	5.298	1.763	3.589	3.550	5.911	1.763
SYB, H	3.398	3.361	5.291	1.658	3.729	3.892	5.902	1.677
SYB, L	3.410	3.373	5.407	1.700	3.797	3.760	6.063	1.712
HYB, H	3.197	3.160	4.892	1.650	3.583	3.546	5.460	1.647
HYB, L	3.060	3.023	4.939	1.714	3.448	3.411	5.506	1.705
SEM	0.0355	0.0355	0.0514	0.0120	0.0444	0.0444	0.0601	0.0126
Main effect of strain[2] (n = 24)								
SYA	3.395[a]	3.355[a]	5.441[a]	1.703[ab]	3.757[a]	3.717[a]	6.057[a]	1.710[ab]
HYA	3.227[b]	3.189[b]	5.238[b]	1.732[a]	3.592[b]	3.554[b]	5.841[b]	1.735[a]
SYB	3.404[a]	3.367[a]	5.349[a]	1.679[b]	3.763[a]	3.726[a]	5.983[ab]	1.694[bc]
HYB	3.128[c]	3.091[c]	4.915[c]	1.682[c]	3.515[b]	3.479[b]	5.483[c]	1.676[c]
SEM	0.0251	0.0251	0.0363	0.0085	0.0314	0.0314	0.0425	0.0089
Main effect of diet[3] (n = 48)								
L	3.410	3.373	5.407	1.700[a]	3.797	3.760	6.063	1.712
H	3.398	3.361	5.291	1.658[b]	3.729	3.892	5.902	1.677
SEM	0.0355	0.0355	0.0514	0.0120	0.0444	0.0444	0.0601	0.0126
P-values								
Strain	**<0.001**	**<0.001**	**<0.001**	**0.002**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Diet	0.805	0.805	0.119	**0.019**	0.287	0.287	0.066	0.057
Strain × Diet	0.199	0.201	0.874	0.597	0.165	0.167	0.776	0.523

[a-c]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's t test.
[1]BW = body weight, BWG = body weight gain, FI = feed intake, FCR = feed conversion ratio.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]Diet L = High from d 0–14, and Low from d 15–54; Diet H = Low from d 0–14, and High from d 15–54.

Experiment 2 Processing of Females

No strain × diet × carcass interactions were observed for any processing measurement in Experiment 2 (Table 11). Breast meat yield was highest ($P < 0.05$) for HYB broilers, lowest for SYA broilers, and intermediate for HYA and SYB broilers. Tender yields were higher ($P < 0.05$) for HYA and HYB broilers than for SYA and SYB broilers (Table 11). Female broilers processed at 2.5 kg yielded lower ($P < 0.05$) for all processing yields, except for whole leg, than broilers processed at 3.8 kg (Table 11). Female broilers fed Diet H had higher ($P < 0.05$) breast and tender yields and lower ($P < 0.05$) fat and wing yields than broilers fed Diet L (Table 11).

DISCUSSION

In both experiments, d 0 BW varied among strains due to the age of the breeder flocks the chicks were sourced from (SYA, 40 wk; SYB 35 wk; HYA, 37 wk; HYB, 36 wk). Reports in the literature show that initial chick weight (i.e., hatching egg weight) can influence BW, BW gain, and carcass parts weights but does not necessarily affect FCR or carcass yields (Proudfoot and Hulan, 1981; Vieira and Moran, 1998). Therefore, discussion of live performance for both experiments will focus on FCR.

Interestingly, the occurrence of a strain × diet interaction for male FCR was not consistent, only appearing for the 0 to 7 and 0 to 21 d periods. The latter interaction occurred 7 days after a change in dietary amino acid density due to the misplacement of starter feed at the beginning of the experiment. Studies evaluating research in the literature have theorized that a 7 to 10 d adaption period is necessary for broilers to normalize feed intake (Cherry et al., 1983; Leeson et al., 1996). The presence of these interactions may indicate that the efficiency by which the modern broiler can adapt to feed changes involving differences in nutrient density may be dependent upon the strain of broiler being fed. Corzo et al. (2010) conducted an amino acid density study evaluating the use of amino acid regimens in male Cobb × Cobb 500 broilers. Due to the style of study, Corzo et al. (2010) included treatments that emulate those fed during the current male study. At 14 d, Corzo et al. (2010) observed reduced FCR for broilers fed a higher density starter diet in agreement with the current findings. At 28 d, Corzo et al. (2010) observed a 5 point separation in FCR with broilers fed a high amino acid starter diet and medium amino acid grower diet having a FCR of 1.46, and broilers fed a medium amino acid starter diet and high amino acid grower diet having a FCR of 1.41. This separation in FCR was not observed in the present study at 28 d. Corzo et al. (2010) carried out their experiment to 42 d where the feeding regimen containing a high amino acid starter diet, medium amino acid grower diet, and medium amino acid finisher diet had an approximate 6.5 points of FCR higher than broilers fed a feeding regimen containing a medium amino acid starter diet, high amino acid grower diet, and high amino acid finisher diet. Similarly, a difference of approximately 6.5 points of FCR was observed between male broilers fed Diet H and Diet L in the current experiment. The aforementioned interactions were not observed in female broilers in Experiment 2. After the diets were switched at 14 d, the differences that were

Table 11. Carcass and parts yields (%) of female broilers of various strains fed Diet Low (L) or Diet High (H) and processed at a live weight of approximately 2.5 or 3.8 kg.

	Yield (%)						
Treatment	Hot carcass	Fat	Chilled carcass	Wing	Breast	Tender	Leg quarter
Interactions[1] (n = 6)							
SYA, H, 2.5	73.27	1.37	76.26	7.55	20.24	4.64	22.06
SYA, L, 2.5	73.22	1.44	76.20	7.61	19.92	4.64	22.97
HYA, H, 2.5	74.32	1.24	77.06	7.51	21.67	4.84	21.62
HYA, L, 2.5	73.80	1.48	76.43	7.64	21.06	4.83	21.44
SYB, H, 2.5	73.99	1.10	77.05	7.69	20.63	4.55	22.64
SYB, L, 2.5	73.37	1.26	76.42	7.88	19.70	4.45	22.57
HYB, H, 2.5	74.53	0.97	77.26	7.53	22.85	4.97	21.59
HYB, L, 2.5	74.19	1.12	76.78	7.73	21.74	4.85	21.83
SYA, H, 3.8	76.65	1.57	78.54	7.35	23.14	4.97	21.61
SYA, L, 3.8	77.14	1.41	79.08	7.20	24.03	4.98	21.07
HYA, H, 3.8	76.95	1.51	79.01	7.26	24.04	5.21	21.20
HYA, L, 3.8	76.61	1.75	78.39	7.36	22.97	5.00	21.84
SYB, H, 3.8	76.97	1.40	78.98	7.25	24.16	5.12	21.37
SYB, L, 3.8	76.89	1.57	78.43	7.34	23.23	5.01	21.57
HYB, H, 3.8	77.17	1.55	78.84	7.28	23.54	5.21	21.40
HYB, L, 3.8	76.97	1.41	78.75	7.31	23.94	5.09	21.39
SEM	0.346	0.077	0.362	0.068	0.453	0.073	0.355
Main effect of strain[2] (n = 24)							
SYA	75.07	1.45[a]	77.52	7.43	21.83[c]	4.81[b]	21.93
HYA	75.37	1.49[a]	77.72	7.44	22.44[ab]	4.97[a]	21.52
SYB	75.30	1.33[b]	77.72	7.54	21.93[bc]	4.78[b]	22.04
HYB	75.71	1.26[b]	77.91	7.46	23.02[a]	5.03[a]	21.55
SEM	0.162	0.036	0.169	0.032	0.212	0.034	0.166
Main effect of carcass size[3] (n = 48)							
2.5	73.81[b]	1.25[b]	76.68[b]	7.64[b]	20.98[b]	4.72[b]	22.09[a]
3.8	76.92[a]	1.52[a]	78.75[a]	7.29[a]	23.83[a]	5.07[a]	21.43[b]
SEM	0.114	0.025	0.120	0.022	0.150	0.024	0.117
Main effect of diet[4] (n = 48)							
L	75.25	1.43[a]	77.56	7.51[a]	22.07[b]	4.86[b]	21.84
H	75.48	1.34[b]	77.88	7.43[b]	22.53[a]	4.94[a]	21.69
SEM	0.113	0.025	0.118	0.022	0.148	0.024	0.116
P-values							
Strain	0.051	**<0.001**	0.455	0.063	**0.001**	**<0.001**	0.060
Carcass Size	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Diet	0.146	**0.012**	0.064	**0.012**	**0.031**	**0.016**	0.363
S × CS	0.156	**0.009**	0.367	0.064	**0.001**	**0.005**	**0.028**
S × D	0.391	**0.023**	0.236	0.136	0.160	0.547	0.987
CS × D	0.214	0.076	0.420	**0.045**	0.184	0.488	0.640
S × CS × D	0.966	0.328	0.916	0.726	0.292	0.638	0.099

[a-d]Means without a common superscript within column within effect were determined to be significantly different ($P < 0.05$) by a Student's *t* test.
[1]Values reported are on a percent basis in relation to live weight.
[2]SYA = Standard yielding A, HYA = high yielding A, SYB = standard yielding B, HYB = high yielding B.
[3]2.5 kg = small bird market, 3.8 kg = big bird debone market.
[4]Diet L = High from d 0−14, and Low from d 15−54; Diet H = Low from d 0−14, and High from d 15−54.

observed in female FCR, due to the effect of diet, were maintained throughout the rest of the study. The lack of observation of the strain × diet interaction in females as was observed in male broilers in Experiment 1 is potentially due to a reduced responsiveness of female broilers to dietary amino acid level and may indicate that females have a shorter adaptation time when nutrient density changes across feeding phases (Kidd et al., 2004).

Differences in FCR according to strain varied in the two studies presented here. Male broiler FCR trends show a difference between the cumulative FCR of both standard yielding strains and both of the high yielding strains, whereas in females differences were observed between SYA and HYA and SYB and HYB. Corzo et al. (2005) conducted a trial with a 3-level factorial arrangement of treatments evaluating diet density, sex, and strain and reported significant effects of strain on FCR where multipurpose strains (standard yielding strains) had lower FCR values than high-yielding strains. They also observed interactive effects of strain × sex on FCR, in which females all performed similarly, regardless of strain, while male multipurpose strains (standard strains) had improved FCR compared to male high-yielding strains (Corzo et al., 2005).

Differences in male carcass and parts yields as a result of strain primarily aligned with differences associated with the strains used. High yielding broilers had higher yields for carcass, breast, and tenders whereas the standard yielding broilers had higher yields for wings and leg quarters. High yielding strains are genetically selected for increased white meat yield while standard yielding strains are selected for more uniform growth and live performance traits (Dozier et al., 2009). Corzo et al. (2005) similarly found that high-yielding strains produced higher breast meat yield than multipurpose strains (standard yielding strains). Differences in their experiments showed that carcass part yields were limited to breast and tender yields and closely resembled the male data from Experiment 1 without observed effects on carcass, wing, and leg yields. The targeted change in yields associated with strains in females as opposed to that in males may be related to females having a larger breast meat yield than males, leaving less room to adjust the yields of other carcass parts and leading to numerical trends which generally agreed with those observed in males.

For both male and female broilers, increasing carcass size at slaughter influenced carcass and parts yields similarly with the exception of wing yield which decreased in males and increased in females. In a series of papers published by Brewer et al. (2012a,b,c,d) similar trends can be observed when increasing carcass size at slaughter as reported herein. These changes in carcass traits are likely attributed to the effects of allometric growth and genetic selection, where modern broilers prioritize lean muscle accretion (Zuidhof et al., 2014). Lean muscle accretion in allometric breast meat growth appear as convex curves, whereas internal organ growth is observed as concave growth within allometric liver growth curves (Zuidhof et al., 2014). Dietary treatments affected male and female broilers differently. Female fat, wing, breast, and tender yields responded to dietary treatment, whereas males expressed responses in hot carcass, fat, cold carcass, wing, breast, and tender yield. These parts encompass both an indicator of the efficiency of amino acid usage (i.e., fat) and the key area (i. e., white meat) in which amino acid density has the most effect (Kidd et al., 2005; Corzo et al., 2010).

CONCLUSION

In conclusion, male broilers reached target carcass weights at younger ages than females with better FCR. In this study, strain had an effect on male and female broiler performance and some carcass traits; SY strains reached higher final body weights while HY strains provided higher yields at final processing. The effect of amino acid density had minimal impact on growth performance parameters (e.g., BW, BWG, FI) with exception to FCR at increasing market ages (35 d and higher for males and 21 d and higher for females), which tended to be lower in high density diets.

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DISCLOSURES

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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