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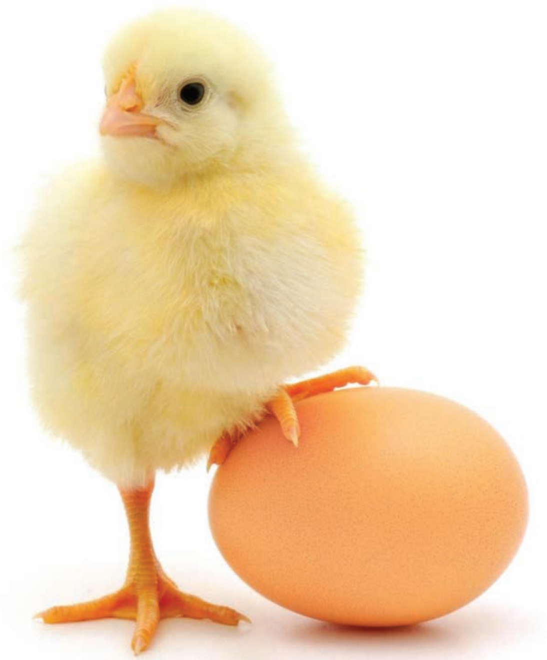

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Short Communication
Broiler Genetics May Influence Performance Response When Fed Low Crude Protein Diets

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Abstract
Background and Objective: Genetic selection for rapid growth and increased meat yield in a short period of time has greatly improved feed efficiency. However, the increased pressure for growth has prompted unforeseen consequences of other stressors on the broiler bird. These stressors utilize energy and nutrients that otherwise would be utilized for growth. This study was designed to evaluate how two genetic lines would perform while consuming less protein as a potential model to evaluate feed additives that may improve digestibility or immune and oxidative status. **Materials and Methods:** A field study was conducted and a reduced protein model was used in these two experiments. In experiment 1, Cobb 500 male broiler chicks were randomly allocated to one of two dietary treatments: Nutrient adequate basal diet and the basal diet with reduced crude protein. In experiment 2, Cobb 700 male broiler chicks were randomly assigned to the experimental diets used in experiment 1. **Results:** Body weight was decreased in Cobb 500 broilers compared with Cobb 700 broilers when dietary crude protein was reduced. Furthermore, Cobb 500 broilers consumed less feed compared with Cobb 700 broilers when dietary crude protein was reduced. **Conclusion:** As a producer, it is essential to find the point of maximum economic efficiency for the strain of broilers being reared. These data indicated differences among broiler genetic lines and dietary crude protein need to be considered when formulating diets.

Key words: Broiler, amino acid, crude protein, meat production, growth performance

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Genetic selection has been used to maximize growth rate and feed efficiency in modern broiler chickens at an unprecedented rate[1-3]. Research has shown the diverse production potentials offered by gender, genotype and environment and how nutrition, particularly energy and nutrient levels, can influence those potentials[4-6]. Geneticists have selected the breeds for improved body weight with the aim of increasing the salable product (e.g. carcass weight) with the same or reduced inputs (e.g. feed)[4]. Genetic differences in growth rate, feed intake and feed efficiency have been reported between genotypes[4,6-8]. In addition, genetic differences influence the response of chicks to varying levels of dietary crude protein[4]. Amino acids fed to broilers through dietary crude protein are the most advantageous in terms of meat production. The manipulation of dietary protein can have various effects on broiler performance. Frap[9] observed differences in body weight, feed intake and carcass composition. Although, this qualitative relationship has been well known for many years, it is still not widely used in profit maximization models.

A study completed by Parsons and Baker[10] showed a significant linear reduction in both rate and efficiency of gain when dietary protein was decreased from 24-16%, but minimal effect was observed when dietary protein was decreased from 24-20%. Whereas Summers *et al.*[11] found no significant differences in weight gain, feed intake, or feed conversion ration with the feeding of various dietary protein levels. Genotype may also impact this model, as Smith and Petsi[4] showed that a "high yield" broiler strain required a higher dietary protein level to maximize body weight and feed efficiency when compared with a "fast growing" broiler strain. Genetic selection has primarily focused on increased meat yield with less inputs, this may contribute to unforeseen consequences on broiler health[12]. Development, maintenance and the use of the immune system utilizes energy and nutrients[13], diverting these from growth. The objective of the current experiment was to evaluate how amino acids are utilized when crude protein is reduced and how different genetic lines impact this model of development.

MATERIALS AND METHODS

This study was approved by the Animal Care and Use Committee, Texas A&M University (TAMU) Institutional Animal Care and Use Committee (AUP # 2018-0181) and were consistent with the Guide for the Care and Use of Animals in Research and Teaching Guidelines[14].

Experimental design: Two experiments were conducted to evaluate the effects of dietary crude protein (CP) on growth performance of Cobb broiler chickens. In experiment 1, a total of 360 day-of-hatch Cobb 500 male broiler chicks were used. Birds were equally housed at 18 birds per pen, with ten replicate pens per treatment, for a total of 20 pens (0.91 m$\times$1.83 m). Birds were allotted to pens to achieve equal pen weights across treatment groups. Each pen contained pine shavings as bedding material and equipped with one bell feeder and nipple drinking system. Birds were allowed *ad libitum* access to feed and water. Birds were housed in an environmentally controlled tunnel ventilated broiler house, with a lighting regime of 22L: 2D from 1-14 days of age and 20L: 4D from 15-42 days of age. In experiment 2, a total of 288 day-of-hatch Cobb 700 male broiler chicks were used. Birds were equally housed at 18 birds per pen, with eight replicate pens per treatment, for a total of 16 pens (0.91 m$\times$1.83 m). Birds allotted to pens to achieve equal pen weights across treatment groups. Each pen contained pine shavings as bedding material and equipped with one bell feeder and nipple drinking system. Birds were allowed *ad libitum* access to feed and water. Birds were housed in an environmentally controlled tunnel ventilated broiler house, with a lighting regime of 22L: 2D from 1-14 days of age and 20L: 4D from 15-42 days of age.

Experimental diets: All diets were corn and soybean meal based. Calculated nutrient content of diets fed to broilers in experiment 1 and 2 is presented in Table 1. Analyzed nutrient content of the experimental diets is presented in experiment 1 (Table 2), experiment 2 (Table 3). Pens were blocked within and treatments were assigned at random to one of two dietary treatments. The experimental diets included a nutrient adequate basal diet (BD) and one reduced basal diet (RD). The BD diet was formulated to total amino acid and energy levels of that found in a typical industry diet. The RD was the BD reduced by 1.5% crude protein (CP). Birds were fed a three-phase diet consisting of a starter (day 1-14, crumble), grower (day 15-28, pellet) and finisher (day 29-42, pellet). Pelleting temperature was maintained at 70°C.

Growth performance: Mortalities were collected, recorded and weighed daily. Birds and feed were weighed weekly on day 7, 14, 21, 28, 35 and 42 (at the end of each dietary phase) for the determination of body weight (BW), body weight gain (BWG), feed intake (FI) and calculation of BW-corrected feed conversion ratio (FCR).

Table 1: Calculated nutrient content of diets fed to broilers in experiment 1 and 2

	Starter (day 1-14)		Grower (day 15-28)		Finisher (day 29-42)	
Nutrients (%)	BD	RD	BD	RD	BD	RD
ME, kcal, kg	3008	3008	3086	3086	3160	3160
Protein, crude (%)	22.00	20.50	20.00	18.50	19.00	17.50
AV-Lysine (%)	1.18	1.10	1.05	0.98	0.95	0.88
AV-Methionine (%)	0.58	0.55	0.52	0.48	0.47	0.43
AV-TSAA (%)	0.88	0.83	0.80	0.74	0.74	0.68
AV-Threonine (%)	0.78	0.73	0.71	0.65	0.67	0.62
Calcium (%)	0.90	0.90	0.84	0.84	0.76	0.76
avP (%)	0.45	0.45	0.42	0.42	0.38	0.38

ME: Metabolizable energy, AV: Available, TSAA: Total sulfur amino acids, avP: Available phosphorus

Table 2: Analyzed nutrient content of diets fed to broilers in experiment 1[1]

	Starter (day 1-14)		Grower (day 15-28)		Finisher (day 29-42)	
	BD	RD	BD	RD	BD	RD
Moisture (%)	11.39	10.73	10.68	10.58	11.11	11.03
Dry matter (%)	88.61	89.27	89.32	89.42	88.89	88.97
Protein (crude) (%)	21.20	20.30	20.20	19.40	20.40	17.40
Fat (crude) (%)	4.14	5.47	3.84	4.62	5.32	4.53
Fiber (acid detergent) (%)	3.30	4.70	4.50	4.70	4.40	3.60
Ash (%)	5.43	7.84	5.65	6.47	4.81	4.66
Metabolizable energy (mcal/lbs)	1.36	1.36	1.37	1.38	1.40	1.41
Sulfur (total, %)	0.26	0.26	0.26	0.24	0.24	0.22
Phosphorus (total, %)	0.76	0.76	0.69	0.70	0.68	0.60
Potassium (total, %)	0.99	0.96	0.96	0.91	0.93	0.80
Magnesium (total, %)	0.16	0.16	0.17	0.16	0.16	0.15
Calcium (total, %)	1.00	0.95	1.06	0.95	0.79	0.84
Sodium (total, %)	0.12	0.12	0.10	0.13	0.11	0.10
Iron (total, ppm)	407.00	416.00	361.00	443.00	349.00	319.00
Manganese (total, ppm)	130.00	126.00	113.00	116.00	128.00	111.00
Copper (total, ppm)	18.00	25.40	16.60	22.40	16.20	15.00
Zinc (total, ppm)	115.00	126.00	120.00	115.00	117.00	119.00

[1]Analyzed nutrient package conducted by Midwest Laboratories, Inc., Omaha, NE, Trace mineral premix added at this rate yields, Manganese: 149.6 mg, Zinc: 125.1 mg, Iron: 16.5 mg, Copper: 1.7 mg, Iodine: 1.05 mg, Selenium: 0.25 mg, a minimum of 6.27 mg calcium and a maximum of 8.69 mg calcium per kg of diet. The carrier is calcium carbonate and the premix contain less than 1% mineral oil, Vitamin premix added at this rate yields, Vitamin A: 8,818 IU, Vitamin D3: 3,086 IU, Vitamin E: 37 IU, B12: 0.0132 mg, Riboflavin: 4.676 mg, Niacin: 36.74 mg, d-pantothenic acid: 16.17 mg, Choline: 382.14 mg, Menadione: 1.18 mg, Folic acid: 1.4 mg, Pyridoxine: 5.74 mg , Thiamine: 2.35 mg, Biotin per kg diet: 0.44 mg, The carrier is ground rice hulls

Table 3: Analyzed nutrient content of diets fed to broilers in experiment 2[1]

	Starter (day 1-14)		Grower (day 15-28)		Finisher (day 29-42)	
	BD	RD	BD	RD	BD	RD
Moisture (%)	9.91	11.06	11.31	10.93	11.78	11.10
Dry matter (%)	90.09	88.94	88.69	89.07	88.22	88.90
Protein (crude) (%)	21.90	20.60	20.20	18.50	18.90	17.10
Fat (crude) (%)	3.87	4.53	4.97	5.08	6.22	5.00
Fiber (acid detergent) (%)	2.60	4.60	2.90	3.70	1.90	2.20
Ash (%)	5.54	7.00	4.71	5.85	4.52	4.22
Metabolizable energy (mcal/lbs)	1.38	1.34	1.40	1.40	1.44	1.44
Sulfur (total, %)	0.29	0.26	0.26	0.24	0.23	0.21
Phosphorus (total, %)	0.82	0.80	0.75	0.72	0.70	0.66
Potassium (total, %)	1.13	1.00	1.01	0.95	0.92	0.85
Magnesium (total, %)	0.19	0.16	0.17	0.16	0.15	0.14
Calcium (total, %)	1.22	1.06	0.85	0.84	0.86	0.78
Sodium (total, %)	0.11	0.11	0.12	0.11	0.16	0.13
Iron (total, ppm)	398.00	460.00	374.00	383.00	354.00	341.00
Manganese (total, ppm)	124.00	147.00	112.00	112.00	103.00	118.00
Copper (total, ppm)	37.90	22.00	14.20	29.40	19.80	21.00
Zinc (total, ppm)	114.00	146.00	109.00	108.00	105.00	111.00

Statistical analysis: The data were analyzed using Statistical Analysis System (SAS, SAS Institute) to determine if variables differed between treatment groups. The feed intake, feed conversion ratio, body weight, body weight gain was compared between groups using the GLIMMIX procedure of SAS. Probability values of less than 0.05 (p<0.05) were considered significant.

RESULTS AND DISCUSSION

Table 4 and 5 shows the performance data for experiment 1 and 2, respectively. In experiment 1, RD fed birds decreased BW (p<0.05) when compared with BD fed birds on day 21 and day 28. The BW of RD fed birds was decreased by 4.3 and 4.2% when compared with BD fed birds, respectively. No significant differences in BW (p>0.05) were observed on day 42, however, RD fed birds had numerically reduced BW (2.97 vs. 3.15) when compared with BD fed birds. In experiment 2, RD fed birds increased BW (p<0.05) when compared with BD fed birds on day 7, 14 and 21. The BW of RD fed birds was increased by 3.7, 7.4 and 3.0% when compared with BD fed birds, respectively. No significant differences in BW (p>0.05) were observed on day 42, however, RD fed birds had numerically greater BW (3.07 vs. 3.05) when compared with BD fed birds. The results from these experiments are consistent with previous research. A study conducted by Si *et al.*[15] reported Cobb 500 broilers fed reducing crude protein diets below 20% while providing recommended levels of indispensable amino acids resulted in a significant reduction in BW and further growth retardation was observed when dietary crude protein was decreased lower than 18%. Wang *et al.*[16] observed similar effects as Cobb 500 broilers reared on fresh litter fed RD decreased BW by 2.7% (p<0.05) when compared with those fed BD. These results indicate BW is decreased when dietary crude protein is reduced in Cobb 500 broilers when compared with Cobb 700 broilers, as BW decreased in RD fed birds in experiment 1 and BW increased in RD fed birds in experiment 2. Thus, protein level and genotype may have profound effects on BW.

In experiment 1, no significant differences in FI (p>0.05) were observed throughout the duration of the experiment. However, RD fed birds numerically decreased overall FI (4.84 vs. 4.99) when compared with BD fed birds. In experiment 2, RD fed birds increased cumulative FI (p<0.05) through day 7,

Table 4: Effect of basal diet, or reduced diet on growth performance of broilers in experiment 1[1]

	BW (kg)	BWG (kg)	FI (kg)	FCR
Day 1-7				
BD	0.177	0.134	0.146	1.096
RD	0.175	0.131	0.141	1.076
SEM	0.002	0.002	0.002	0.019
p-value	0.313	0.407	0.062	0.480
Day 1-14				
BD	0.508	0.464	0.562	1.230
RD	0.501	0.457	0.551	1.237
SEM	0.004	0.004	0.006	0.014
p-value	0.260	0.248	0.214	0.733
Day 1-21				
BD	1.104[a]	1.057[a]	1.351[a]	1.371[b]
RD	1.056[b]	1.008[b]	1.298[b]	1.413[b]
SEM	0.013	0.013	0.014	0.012
p-value	0.017	0.015	0.018	0.020
Day 1-28				
BD	1.828[a]	1.781	2.420	1.456
RD	1.751[b]	1.704	2.346	1.478
SEM	0.025	0.025	0.027	0.014
p-value	0.042	0.039	0.068	0.282
Day 1-35				
BD	2.625	2.577	3.723	1.557
RD	2.485	2.438	3.618	1.571
SEM	0.041	0.041	0.047	0.013
p-value	0.027	0.026	0.128	0.454
Day 1-42				
BD	3.151	3.102	4.991	1.727
RD	2.968	2.920	4.837	1.753
SEM	0.080	0.079	0.089	0.024
p-value	0.122	0.122	0.234	0.452

[1]All performance data is corrected for mortality, [a-e]Means within column with different superscripts differ at p<0.05

Table 5: Effect of basal diet, or reduced diet on growth performance of broilers in experiment 2[1]

	BW (kg)	BWG (kg)	FI (kg)	FCR
Day 1-7				
BD	0.162[b]	0.116[b]	0.175[b]	1.516
RD	0.168[a]	0.123[a]	0.186[a]	1.512
SEM	0.002	0.002	0.003	0.029
p-value	0.011	0.010	0.010	0.923
Day 1-14				
BD	0.447[b]	0.401[b]	0.496[b]	1.238
RD	0.483[a]	0.436[a]	0.544[a]	1.248
SEM	0.004	0.005	0.007	0.011
p-value	<0.001	<0.001	<0.001	0.540
Day 1-21				
BD	0.871[b]	0.824[b]	1.113[b]	1.351[b]
RD	0.898[a]	0.851[a]	1.192[a]	1.402[a]
SEM	0.007	0.007	0.013	0.012
p-value	0.017	0.023	<0.001	0.007
Day 1-28				
BD	1.579	1.529	2.075[b]	1.357
RD	1.607	1.561	2.141[a]	1.373
SEM	0.016	0.016	0.020	0.009
p-value	0.227	0.192	0.033	0.226
Day 1-35				
BD	2.359	2.309	3.379	1.463
RD	2.361	2.314	3.492	1.510
SEM	0.023	0.023	0.039	0.016
p-value	0.941	0.890	0.057	0.060
Day 1-42				
BD	3.054	3.003	4.983	1.659
RD	3.071	3.023	5.070	1.677
SEM	0.023	0.024	0.079	0.022
p-value	0.612	0.547	0.446	0.573

[1]All performance data is corrected for mortality, [a-e]Means within column with different superscripts differ at p<0.05

14, 21 and 28 when compared with BD fed birds. No significant differences in overall FI (p>0.05) were observed, however, RD fed birds numerically increased overall FI (5.07 vs. 4.98) when compared with BD fed birds. The results from these experiments are consistent with previous research. A study conducted by Filho *et al.*[17] reported dietary crude protein levels had no effect on feed intake in Cobb 500 broilers fed decreasing protein levels in the diet. In contrast, Uzu[18] found that decreasing protein levels from 20-16% lead to an increase in feed intake. These results indicate when dietary crude protein is reduced Cobb 500 broilers consume less feed when compared with Cobb 700 broilers, as FI decreased in RD fed birds in experiment 1 and FI increased in RD fed birds in experiment 2. Thus, protein level and genotype may have profound effects on feed intake.

In experiment 1, no significant differences in FCR or BWG (p>0.05) were observed between dietary treatments. However, RD fed birds numerically increased overall FCR (1.75 vs. 1.73) and decreased overall BWG (2.92 vs. 3.10) when compared with BD fed birds. In experiment 2, no significant differences in FCR or BWG (p>0.05) were observed between dietary treatments. However, RD fed birds numerically increased overall FCR (1.68 vs. 1.66) and increased overall BWG (3.02 vs. 3.00) when compared with BD fed birds. The results from these experiments are consistent with previous research. A study conducted by Si *et al.*[15] reported Cobb 500 broilers fed diets containing reduced dietary crude protein below 20% while providing recommended levels of essential amino acids resulted in increased FCR. Filho *et al.*[17] reported body weight gain and feed conversion were impaired with decreasing levels of dietary crude protein in the diet. Feed conversion was impaired in both Cobb 500 and Cobb 700 broilers fed diets with reduced dietary crude protein. However, RD fed birds in experiment 2 had a numerically lower FCR (1.68) when compared with RD fed birds in experiment 1 (1.75). Therefore, Cobb 700 broilers may be more efficient when fed reduced dietary crude protein when compared with Cobb 500 broilers.

CONCLUSION

It can be concluded that protein level and genotype may have profound effects on BW, FI, and FCR. As a producer, it is essential to find the point of maximum economic efficiency for the strain of broilers being reared. Dietary formulations need to be re-evaluated when feed ingredient prices change, or new genotypes are utilized.

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