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Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Effect of Strain and Finisher Diet Non-Phytate Phosphorus Level on Performance and Litter Composition in Large Tom Production

A.M. Evans[1], B.N. Swiger[1], K.P. Blemings[1], M.S. Lilburn[2] and J.S. Moritz[1]
[1]Department of Animal and Nutritional Sciences, Davis College of Agriculture, Davis, CA-95616, USA
Natural Resources and Design, West Virginia University,
WV-26506, Morgantown, North-Central West Virginia, USA
[2]Department of Animal Sciences, Ohio State University, OH-44691, Wooster, USA

Abstract: Sustainable practices relative to manure nutrient content are essential to commercial turkey production due to the perception that land application of poultry manure is a primary contributor to watershed eutrophication. The objective of our research was to determine the effect of finisher diet non-phytate phosphorus (nPP) levels on large tom performance and litter composition. Two experiments of similar concept were conducted and each experiment was a 2×2 factorial arrangement of treatments utilizing two commercial strains and two levels of dietary nPP (normal and low). In Experiment 1, dietary nPP was reduced during the last finisher diet [Normal (0.37) and Low (0.31)]. In Experiment 2, dietary nPP was reduced in the last 2 finisher diets [Normal (0.58) and Low (0.55) in the Finisher 1 diet and Normal (0.40) and Low (0.38) in the Finisher 2 diet]. Performance measurements were recorded from d 1-136 and d 1-126 in Exp 1 and 2, respectively and litter phosphorus (P) levels were determined. In Exp 1, both strains had similar ending weight (EW) and Strain B had an improved feed conversion ratio (FCR). There were no differences in performance or litter P due to nPP level, indicating the potential to decrease feed cost but not environmental impact. In Exp 2, Strain A had greater EW but increased FCR compared to Strain B. Regression equations that standardized strain EW predicted a decreased time of production and FCR for Strain A. The lower nPP level applied in both finisher diets decreased total litter P ($p<0.065$).

Key words: Turkey, non-phytate phosphorus, genetic strain, performance, litter phosphorus

INTRODUCTION

There are several challenges associated with maintaining profitability in large tom turkey production. Among these are choosing the commercial genotype or strain that optimizes feed conversion ratio (FCR), ending weight (EW) and breast yield according to each company's market needs. There have been concerns with "skeletal weakness" in commercial toms for over 40 years. In 1971 the National Turkey Federation sponsored a symposium at Iowa State University to address this and the same correlated factors we recognize today were discussed then (i.e. litter condition, skeletal pressures due to rapid growth, diet). The cost of turkey research combined with a significant decline in the number of poultry research institutions have contributed to commercial diets often containing levels of total P and nPP that are well in excess of NRC (1994) recommendations. This comes at a time when there is also increased attention on the environmental consequences of using poultry litter as fertilizer. Much of the concern is due to the potential impact of manure phosphorus (P) on the environment. The contribution of P from agricultural soils to the potential for eutrophication within large bodies of water has changed our dietary management practices with respect to mineral levels. Due to the perception that land application of manure is a primary point source of P, strategies to minimize manure P have become a priority for poultry producers.

Dietary P is essential for growth and adequate skeletal development and this is particularly important for rapidly growing heavy toms (Waldroup, 1999). The NRC (1994) recommendations for available P or what we may best estimate analytically, non-phytate phosphorus (nPP), have not changed since 1984 although the market weight of toms has increased from approximately 14 kg to 19 kg at 19 wk of age. Roberson *et al*. (2004) reported that toms fed diets containing 145% versus 100 or 75% of the NRC (1994) recommended levels of Ca and nPP from 9 to 17 week had significant increases in tibia strength and bone ash at 15 and 17 week of age but also increased litter P. The inclusion of nPP containing ingredients in the diet is expensive but necessary due in part to the fact that the digestibility of P in common feed ingredients is highly variable (Van der Klis and Versteegh, 1996). The chemical definition of nPP is the difference between the analyzed phytate phosphorus (PP) content of an ingredient or feed and the analyzed

Corresponding Author: J.S. Moritz, Department of Animal and Nutritional Sciences, Davis College of Agriculture, Natural Resources and Design, West Virginia University, WV-26506, Morgantown, USA

total P content (Angel and Applegate, 2001). It has been determined that 28.2% of the phytate molecule is P (Angel *et al*., 2002) and nPP is more readily digested compared with bound PP. While it is well accepted that reducing dietary P will contribute to reduced litter P, the accelerated growth of commercial toms and the importance of P to skeletal integrity can influence both the welfare of a flock in addition to mortality and feed conversion during the latter stages of growth (Rath *et al*., 2000). The cost of leg problems combined with the dearth of published data on phosphorus requirements of commercial toms have contributed to fairly high safety margins for dietary P in commercial diets, particularly for older toms. Phase feeding has been implemented in commercial turkey production to meet a bird's nutrient requirements with specific diet formulations based on body weight and age. The finisher phase represents an opportunity to reduce dietary nPP and litter P because skeletal growth has largely stopped (Turner and Lilburn, 1992) and the finisher period represents approximately 50-60% of total feed consumed. The objective of this research was to determine strain and finisher diet nPP level effects on performance and litter composition of large tom turkeys.

MATERIALS AND METHODS

Male poults from two commercial strains (A = Nicholas Turkeys, Aviagen Group, EW Group, Visbek, Germany; B = Hybrid Turkeys, Hendrix Genetics, Boxmeer, the Netherlands) were used in each of two experiments. All poults were randomly allocated at d 1 to 16 pens (6.1×5.2 m) in the West Virginia University, Reymann Memorial Farm, turkey research facility. All pens contained fresh wood shavings on top of concrete flooring. The barn utilized tunnel ventilation and radiant brooders. Feed and water were provided for *ad libitum* consumption with bell drinkers and an augered feed pan system. In addition, each pen contained an automated bird and feed dump scale (Chore-Time Brock Incorporated, Milford, IN). Both Exp contained 8 replicate pens specific to strain; however, the number of poults initially placed per pen was 76 and 90 in Exp 1 and 2, respectively. The temperature and lighting programs followed standard industry protocols (Virginia Poultry Growers Cooperative, 2009-2011).

Within each experiment, a typical industry 6 phase feeding approach was used where 8 diets were fed. For Exp 1, the diet of experimental interest (Finisher 2) was fed from 113 to 136 d while in Experiment 2, Finisher 1 was fed from 78 to 112 d and Finisher 2 from 113 to 126 d. Pelleted diets were fed during all phases except starter 1 and 2 that utilized crumbled feed. Diets were formulated to industry standards and dietary treatments were only applied to the finisher phase diets which contained either normal (Norm) or Low dietary nPP levels. All diets were manufactured at a commercial feed mill (Virginia Poultry Growers Cooperative, Broadway, VA). Diets contained corn, soybean meal, poultry by-product meal, wheat middlings, animal/vegetable blended fat, tricalcium P, monocalcium P and a commercial phytase. Diet formulations were proprietary; however, P assays were conducted on feed samples (NP Analytical Laboratories, St. Louis, MO). In addition, proximate analysis data was obtained for diets fed in Exp 2 (NP Analytical Laboratories, St. Louis, MO). The low nPP diets for both Exp 1 and 2 were created by decreasing and/or removing supplemental inorganic P (i.e. tricalcium P and monocalcium P). Phytase (1000 FTU/kg) was included in both finisher diets and our assumption was a release of 0.1% nPP. In Exp 1, the analyzed total P levels in the finisher 2 diets were 0.55% (Norm) and 0.46% (Low) with corresponding calculated nPP levels of 0.37% (Norm) and 0.31% (Low), respectively. Thus, the calculated nPP excluding phytase release was reduced 19% for the 23 d experimental period. The Exp 2 diet analysis and P assay results are shown in Table 1. The nPP levels were reduced by approximately 5% in the norm and low diets over the entire 48 d experimental period, again excluding phytase release. The lack of similarity of nPP reduction between studies may be associated with a compounding calculation error of total P and phytic acid analysis or the fact that these diets were prepared in a commercial feed mill during a standard work day, that would likely decrease batching/mixing precision relative to a research oriented feed mill.

Performance data including EW, FCR and pen mortality percentage were measured weekly throughout both studies. Automated bird and feed scales were calibrated routinely and individual bird weights were manually taken twice during the study (d 42 and d 136 and 126 in Exp 1 and 2, respectively) to confirm the automated bird scale accuracy. Litter samples were collected from standardized locations within each pen and then pooled prior to analysis. The pooled sample from each pen was analyzed for total P and inorganic P (New Jersey Feed Laboratory Incorporated, Ewing, NJ). Inorganic P was determined because this form of P is most immediately available to plants for growth. Total P was determined by ICP emission spectroscopy (AOAC method 985.01) after each sample was dry-ashed, treated with nitric acid and dissolved in HCl. Analysis of inorganic P consisted of a direct extraction method. A test portion of the litter sample was extracted with ammonium citrate at pH 7.0 in the presence of disodium ethylenedinitrilotetraacetic acid (EDTA) to complex calcium and magnesium. Inorganic P was determined colorimetrically and percent P_2O_5 was calculated (AOAC method 993.31). Litter samples were taken on d 112 and d 136 for Exp 1 and on d 78 and d 126 for Exp 2 to coincide with pre and post- dietary nPP treatment administration. At the end of each experiment, all toms were transported to a

Table 1: Diet Proximate analysis and phosphorus[1] Assays Experiment 2

Percentage	Starter 1	Starter 2	Grower 1	Grower 2	Finisher 1 Norm[4] nPP	Finisher 1 Low nPP	Finisher 2 Norm nPP	Finisher 2 Low nPP
Moisture	10.4	12.3	12.2	12.0	12.1	12.2	12.2	12.6
Protein	26.3	22.3	24.9	22.9	20.2	20.8	16.7	16.6
Fat	10.7	11.1	8.99	9.7	11.1	10.1	11.8	11.9
Crude Fiber	2.95	2.5	2.79	2.32	2.25	2.46	2.41	2.53
Ash	6.84	6.3	6.15	5.88	5.58	5.4	4.84	4.25
Total Phosphorus	0.915	0.875	0.894	0.792	0.752	0.769	0.564	0.571
Phytic Acid	1.000	0.859	0.904	0.839	0.620	0.767	0.593	0.671
nPP[2 3]	0.633	0.633	0.639	0.555	0.577	0.553	0.397	0.382

[1]Diet proximate analysis/phosphorus assays conducted on feed samples, NP Analytical Laboratories, St. Louis, MO
[2]nPP = Non-Phytate Phosphorus
[3](%) Non-phytate phosphorus was calculated by (%) Total Phosphorus-(0.282 x(%) Phytic Acid))
It has been determined that 28.2% of phytic acid is phosphorus (Angel *et al*., 2002)
It is important to note that all diets contained a phytase (1,000 FTU/kg) and the (%)
nPP calculation does not account for any P sparing effect
The (%) nPP would need to be elevated by 0.1% to approximate the (%) nPP of the diet formulation
[4]Norm = Normal

commercial processing plant (Virginia Poultry Growers Cooperative, Hinton, VA). Both experiments were conducted according to West Virginia University Animal Care and Use Committee Guidelines (Protocol #08-0904).

Statistical methods: All data were statistically analyzed using the GLM procedure of Statistical Analysis System (SAS Institute, 2009). The experimental unit for all live production measurements was a pen of 76 and 90 birds for Exp 1 and 2, respectively. For the first 6 weeks of each study, data was analyzed using strain as the only factor (data not shown). After initiation of nPP treatments, each study was analyzed as a factorial. The 2 (Strain) x 2 (nPP Level) factorial randomized complete block design utilized 4 replicate pens per treatment (8 replicate pens per main effect). The main effects of Strain and nPP Level as well as the Strain x nPP Level interactions were tested. Fisher's least significant difference multiple comparison tests were used to further compare treatment means. Linear and quadratic regression analyses were performed in order to generate prediction equations for FCR and grow-out time in Exp 2 since EW differed. If relationships were not significantly quadratic then the quadratic term was removed from the model. Prediction equations were generated by using a varying number of weekly data points due to the regression relationship being dependent upon which portion of the growth curve was utilized. Pearson correlation coefficients were also generated to describe the fit of each model. The authors do not believe that there is one correct method to generate these predictions, thus intended to provide readers with data that demonstrates this variability. Statistical significance was based on p = 0.05. Letter superscripts were used to indicate differences among means.

RESULTS

Experiment 1: There were no significant Strain differences in 136 d EW or mortality (Table 2). However, Strain B toms had a significant improvement in mortality adjusted FCR (2.25 vs. 2.16; $p<0.022$). There were no nPP Level or any Strain by nPP Level interactions for EW, FCR, or percentage mortality. There were no Strain effects for total P or inorganic P levels in the litter prior to changing dietary nPP Levels ($p>0.05$; Table 3) and no effects of Strain, nPP Level, or interaction on litter P at the end of the study.

Experiment 2: The Strain A toms had a 0.68 kg improvement in EW at 126 d (17.90 vs. 17.22 kg; $p<0.045$) but increased mortality adjusted FCR (2.21 vs. 2.18; $p<0.01$; Table 4). Regression equations that standardized Strain EW predicted a decreased time of production (4-5 d) and FCR (2-3 pts) for the Strain A toms (Table 5). It is important to note that Exp 2 Strain A toms were a test product and differed from Exp 1 Strain A toms. Strain did not affect percentage mortality. There was no nPP level or Strain by nPP Level interaction effects on EW, FCR or percentage mortality ($p>0.05$). Litter total P and inorganic P levels prior to changing dietary nPP Levels in the last 2 finisher diets were not different ($p>0.05$; Table 6). There was an approach to decrease in 126d litter total P ($p<0.065$) in toms fed the Low nPP Level diets but no effect on inorganic P and no Strain by nPP Level interactions ($p>0.05$; Table 6).

DISCUSSION

In both the experiments, the EW followed breeder company expected performance standards and the significant Strain differences in FCR for Exp 1 was similar to what is observed in commercial practice (Danny Wilburn, Virginia Poultry Growers Cooperative, personal communication). When designing experiments with potential commercial application, no difference in

Table 2: Main effects of strain and dietary non-phytate phosphorus level on ending tom performance experiment 1

	Ending weight d 136 (kg)	Feed Conversion Ratio[1] d 1-136 (kg/kg)	Mortality (%)[2] d 1-136
Strain A Low nPP[3]	20.02	2.25	14.16
Strain A Norm nPP[4]	19.85	2.25	11.81
Strain B Low nPP	19.71	2.14	16.92
Strain B Norm nPP	20.05	2.17	13.71
ANOVA P-value	0.758	0.111	0.342
Marginal means			
Strain A	19.94	2.25[a]	12.98
Strain B	19.89	2.16[b]	15.31
Low nPP diets[5]	19.87	2.20	15.54
Norm nPP diets[6]	19.95	2.21	12.76
Main effects and interaction probabilities			
Strain effect	0.843	0.022	0.244
nPP Level effect	0.742	0.734	0.172
Strain x nPP Level	0.335	0.592	0.823
SEM	0.391	0.023	1.324

[1]Feed conversion ratio (Feed:Gain) was calculated using mortality weight
[2]Mortality percentage is based on a beginning pen number of 76
[3]nPP = Non-Phytate Phosphorus
[4]Norm = Normal
[5]Low Non-Phytate Phosphorus had 0.31% calculated nPP
[6]Normal Non-Phytate Phosphorus had 0.37% calculated nPP
[a-b]Values within columns with different superscripts differ significantly ($p<0.05$)

Table 3: Main effects of strain and dietary non-phytate phosphorus level on phosphorus content of litter experiment 1

	Total P[1] level in litter at d 112 (%)	Inorganic P[2] level in litter at d 112 (%)	Total P level in litter at d 136 (%)	Inorganic P level in litter at d 136 (%)
Strain A Low nPP[3]	1.00	0.90	1.08	0.94
Strain A Norm nPP[4]	1.07	0.94	1.09	0.95
Strain B Low nPP	1.01	0.93	1.11	0.93
Strain B Norm nPP	1.08	0.96	1.07	0.93
ANOVA P-value	0.367	0.733	0.751	0.951
Marginal means				
Strain A	1.03	0.92	1.08	0.94
Strain B	1.04	0.94	1.09	0.93
Low nPP diets[5]	1.01	0.93	1.10	0.94
Norm nPP diets[6]	1.06	0.93	1.08	0.93
Main effect and interaction probabilities				
Strain effect	0.930	0.548	0.719	0.646
nPP Level effect	0.292	1.000	0.425	0.646
Strain x nPP Level	0.504	0.272	0.294	0.393
SEM	0.029	0.023	0.019	0.017

[1]P: Phosphorus
[2]Neutral Ammonium Citrate - inorganic phosphorus analysis conducted on "as is" litter samples, New Jersey Feed Lab Inc., Trenton, NJ
[3]nPP: Non-Phytate Phosphorus
[4]Norm: Normal
[5]Low Non-Phytate Phosphorus had 0.31% calculated nPP
[6]Normal Non-Phytate Phosphorus had 0.37% calculated nPP

performance metrics of interest but potentially significant dietary cost savings has often been the hypothesis being tested and this was the underlying premise for the current studies. In one of the few studies with a similar objective to what was reported here, Roberson *et al.* (2004) reported that diets containing nPP formulated to 145% of the NRC (1994) recommendation significantly improved bone ash and other measures of tibia strength at 17 wk when compared with diets containing 100% of the NRC recommendations. The higher levels of nPP, however, also resulted in a 23% increase in litter P. The NRC (1994) recommendations for phosphorus do not include any adjustment for dietary phytase inclusion so that is an additional consideration in interpreting the experimental results. In Exp 1, the analyzed level of total P (0.55%) in the Norm treatments (Exp 1) and calculated nPP (0.37%) based on analyzed phytate concentration were similar to the NRC (1994) recommendations and also similar to the P treatment in Roberson *et al.* (2004) that was based on NCR recommendations. There were no differences between the Norm and Low nPP treatments in litter total P or inorganic P and the litter

Table 4: Main effects of strain and dietary non-phytate phosphorus level on ending tom performance experiment 2

	Ending weight d 126 (kg)	Feed conversion Ratio[1] d 1-126 (kg/kg)	Mortality %[2] d 1-126
Strain A Low nPP[3]	17.70	2.21[a]	8.25
Strain A Norm nPP[4]	18.10	2.21[a]	9.56
Strain B Low nPP	17.24	2.18[b]	11.70
Strain B Norm nPP	17.21	2.18[b]	9.89
ANOVA P-value	0.165	<0.0001	0.513
LSD[5]	-	0.006	-
SEM	0.638	0.002	1.570
Marginal means			
Strain A	17.90[a]	2.21[a]	8.90
Strain B	17.22[b]	2.18[b]	10.80
Low nPP diets[6]	17.47	2.20	9.97
Norm nPP diets[7]	17.65	2.20	9.73
Main effects and interaction probabilities			
Strain effect	0.045	<0.0001	0.258
nPP Level effect	0.540	0.871	0.878
Strain x nPP Level	0.465	0.157	0.346

[1]Feed conversion ratio (Feed:Gain) was calculated using mortality weight
[2]Mortality percentage is based on a beginning pen number of 90
[3]nPP: Non-Phytate phosphorus
[4]Norm: Normal
[5]Fisher's least significant difference
[6]Low Non-Phytate Phosphorus had 0.55 and 0.38% calculated nPP in finisher 1 and 2, respectively
[7]Normal Non-Phytate Phosphorus had 0.58 and 0.40% calculated nPP in finisher 1 and 2, respectively
[a-b]Values within columns with different superscripts differ significantly ($p<0.05$)

Table 5: Strain A performance predictions experiment 2

	Weekly data points[1]		
	18	9	3
Relationship between EW[2 3] and week	Quadratic[7]	Linear[9]	Linear[11]
Predicted Time[4] (wk)	17.27	17.47	17.49
R^2	0.995	0.993	0.900
Relationship between FCR[5] and EW	Quadratic[8]	Quadratic[10]	Linear[12]
Predicted FCR[6] (kg/kg)	2.15	2.16	2.16
R^2	0.993	0.976	0.862

[1]Number of weekly data points used in the prediction equation
[2]EW: Ending Weight
[3]EW used in pounds in prediction equations
[4]Predicted time for Strain A toms to reach Strain B tom 18 week EW of 17.22 kg
[5]FCR: Feed Conversion Ratio
[6]Predicted Strain A tom FCR at the same 18 wk 17.22 kg (37.95 pounds) EW as Strain B toms. For comparison, Strain B toms had a FCR of 2.18
[7]EW: -1.383048407+0.790550745(wk)+0.086105118(wk)^2
[8]FCR: 1.132046955+0.041989769(EW)+(-0.000402044)(EW)^2
[9]EW: 3.04208333 (wk)+(-15.20861111)
[10]FCR: 1.300809540+0.028056389(EW)-0.000142929 (EW)^{211}
EW: 3.02312500 (wk)+(-14.93145833)
[12]FCR: 0.023364073 (EW)+1.274082114

total P values are similar to what was reported by Roberson *et al*. (2004) for their NRC based P treatment. As mentioned previously, however, the diets in both the Norm and Low treatments contained phytase which would have put the actual nPP levels above the NRC (1994) or Roberson *et al*. (2004) NRC based P values. There were also no nPP Level effects on various performance metrics in Exp 2 where lower P values were incorporated in the first finisher diet and fed for a longer period of time. There was a 5 to 6% reduction in litter total P that approached significance ($p<0.065$) and the values were again similar to the NRC based P values reported by Roberson *et al*. (2004). Turner and Lilburn (1992) and Lilburn (2006) Proceedings of the Multi-State Poultry Nutrition Conference reported that linear skeletal growth is near complete by 14 week in commercial toms and the present data suggests that the latter stages of the growing period is the optimal time to reduce dietary and litter P without negatively impacting performance factors. This also presents the

Table 6: Main effects of strain and dietary non-phytate phosphorus level on phosphorus content of litter experiment 2

	Total P[1] level in litter at d 82 (%)	Inorganic P[2] level in litter at d 82 (%)	Total P level in litter at d 126 (%)	Inorganic P level in litter at d 126 (%)
Strain A Low nPP[3]	1.07	0.83	1.19	0.91
Strain A Norm nPP[4]	1.03	0.82	1.26	0.91
Strain B Low nPP	1.10	0.89	1.22	0.91
Strain B Norm nPP	1.04	0.83	1.28	0.93
ANOVA P-value	0.586	0.585	0.229	0.808
LSD[5]	-	-	-	-
SEM	0.039	0.037	0.032	0.017
Marginal means				
Strain A	1.05	0.82	1.23	0.91
Strain B	1.07	0.86	1.25	0.92
Low nPP diets[6]	1.09	0.86	1.21	0.91
Norm nPP diets[7]	1.04	0.82	1.27	0.92
Main effect and interaction probabilities				
Strain effect	0.640	0.401	0.426	0.727
nPP Level effect	0.218	0.368	0.065	0.532
Strain x nPP Level	0.826	0.557	0.787	0.532

[1]P: Phosphorus

[2]Neutral Ammonium Citrate-inorganic phosphorus analysis conducted on "as is" litter samples, New Jersey Feed Lab Inc., Trenton, NJ

[3]nPP: Non-Phytate Phosphorus, [4]Norm: Normal

[5]Fisher's least significant difference

[6]Low Non-Phytate Phosphorus had 0.31% calculated nPP

[7]Normal Non-Phytate Phosphorus had 0.37% calculated nPP

greatest opportunity for dietary cost savings because approximately 50-60% of total flock feed consumption is represented by the Finisher 1 and 2 diets. The Low nPP diets in both Exp 1 and Exp 2 were formulated primarily by removing inorganic rock based P. The lower levels of total P and nPP needed to further reduce litter P concentration would be dependent upon the levels of nPP coming from other dietary sources, particularly animal byproducts.

When comparing strains that vary in EW at a predetermined time, it is useful to adjust performance data to estimate FCR at a similar EW or estimate the time at which a desired EW is achieved. (Case *et al*., 2012, University of Guelph, Ontario, Canada). In order to better interpret Strain effect in Exp 2, linear and quadratic regression equations were generated using performance data summarized by week. However, the equations and predictions varied depending upon the derivation of the regression equation, more specifically the number of weekly performance variables used. For example, using the Exp 2, Strain B data as a basis for comparison with a 17.22 kg EW, 2.18 FCR and 126 d (18 week) grow-out time, the Strain A estimates for FCR and grow-out time differed depending on the number of weekly performance variables used to create the equation, i.e., 18 (week 1-18), 9 (week 10-18) or 3 (week 16-18) (Table 8). Using all 18 weekly ending weights, the relationship between EW and wk was quadratic ($p<0.0001$) and the relationship between FCR and EW was also quadratic ($p<0.0001$). This data set predicted that the time for Strain A toms to reach the same EW as Strain B toms would be 5 days shorter with a 3-point decrease in FCR. Using 9 weekly ending weights the relationship between EW and wk was linear ($p<0.0001$) and the relationship between FCR and EW was quadratic ($P = 0.0098$). This data set predicted that the time for Strain A toms to reach the same EW as Stain B toms would be 4 days shorter with a 2-point decrease in FCR. Using only 3 weekly ending weights the relationship between EW and wk was linear ($p<0.0001$) and the relationship between FCR and EW was linear ($p<0.0001$). This data set predicted that the time for Stain A toms to reach the same EW as Stain B toms would be 4 days shorter with a 2-point decrease in FCR. These prediction equations demonstrate that the number of data points incorporated into the regression equation may cause the predictions to vary, making it difficult to make accurate conclusions. Regardless, all prediction equations had high coefficients of determination (R^2) and demonstrated that Stain A grow-out time would be reduced and FCR would be decreased relative to Strain B when ending weight was standardized. As previously mentioned, it is important to note that Strain A toms in Exp 2 were a test product and differed from Stain A toms in Exp 1.

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