

Metabolism and Nutrition V: Enzymes

198 Phytase supplementation of canola meal based diets on phosphorus bioavailability and performance of broiler chicks. J. I. Sultan*¹, S. Khalil¹, A. Javed¹, M. Yaqoob¹, and M. Yousaf¹, ¹*Institute of Animal Nutrition and Feed Technology, University of Agriculture, Faisalabad, Pakistan*, ²*Department of Livestock Management, University of Agriculture, Faisalabad, Pakistan*, ³*Department of Poultry Science, University of Agriculture, Faisalabad, Pakistan, Faisalabad, Pakistan.*

The present study was conducted to investigate the supplementation effect of phytase to canola meal based diet on bioavailability of phosphorus (P) and performance of broiler chicks. Two hundred and forty day-old commercial Arbor Acres broiler chicks were used in a completely randomized design with 2 × 2 factorial arrangements of treatments. The chicks were randomly divided into 12 experimental units of 20 chicks each. Four isonitrogenous (CP: 20) and isocaloric (ME, 2,800 kcal/kg) experimental diets were formulated using 2 levels of canola meal, i.e., 15 and 20% supplemented with 2 levels of phytase, i.e., 600 and 800 IU/kg. The chicks were fed for 6 week. Feed intake was increased ($P < 0.05$) by increasing phytase level from 600 to 800 IU/kg in chicks fed 15% canola meal diet; however, it was decreased ($P < 0.05$) in chicks fed 20% canola meal diet. Weight gain and feed conversion ratio also decreased ($P < 0.05$) with increasing phytase level from 600 to 800 IU/kg in chicks fed 20% canola meal diet; however, it was increased ($P < 0.05$) in chicks fed 15% canola meal diet. The broiler chicks performed better, when fed diets containing 15% canola meal supplemented with 600 IU/kg and 20% canola meal supplemented with 800 IU/kg. Increasing phytase level from 600 to 800 IU/kg resulted in increased ($P < 0.05$) serum P, whereas increasing canola meal from 15 to 20% resulted in decreased ($P < 0.05$) serum P. The results of the study inferred that phytase supplementation to canola meal based diet improved the performance and P availability.

Key Words: weight gain, FCR, P bioavailability, canola meal, phytase

199 The effect of phytase, protease and carbohydrase on ileal amino acid digestibility of corn/soy diets for broilers: Complimentary mode of action? A. J. Cowieson*, *Danisco Animal Nutrition, Marlborough, Wiltshire, United Kingdom.*

The additivity of carbohydrase and phytase in the diets of broilers has been demonstrated several times by various authors. However, the relative effects on ileal amino acid digestibility is reported less often though this information is both scientifically enlightening and highly relevant to least-cost poultry production. The effect of phytase on ileal amino acid digestibility is thought to be related to a reduction in the loss of endogenous protein from the terminal ileum and is associated with the antinutritive effect of phytate in the GI tract. Carbohydrases and proteases also confer improvements in ileal amino acid digestibility and this may be related to improved access for endogenous enzymes to encapsulated or poorly soluble nutrients, as well as augmentation of endogenous enzyme systems. In recent studies (Ravindran et al., 2006; Cowieson and Ravindran, 2008) the mean response to phytase and a carbohydrase/protease multi-enzyme system on ileal amino acid digestibility was 4.4 and 2.9%, respectively. Further, there was a strong ($r^2 = 0.74$; $P < 0.01$) correlation between the improvement in ileal amino acid digestibility with phytase and with that of carbohydrase/protease

suggesting similar underlying modes of action, which intuitively reduces the likelihood of additivity. However, in a further study (Cowieson et al., 2006) which assessed the effect of a combination of carbohydrase, protease, and phytase, the mean improvement in ileal amino acid digestibility was 7.3% suggesting mechanistic additivity. Instructively, on an individual amino acid basis, there was subadditivity or even synergy between phytase and carbohydrase, trends that suggest differences in absorptive and secretory physiology in response to the ingestion of different exogenous enzymes. It can be concluded that exogenous enzymes can influence apparent digestibility of amino acids via different mechanisms and in order to maximize magnitude and consistency of bioefficacy an appreciation for the mode of action and likely additivity should be considered.

Key Words: enzyme, amino acid digestibility, broiler

200 Influence of dietary phytic acid and source of microbial phytase on ileal endogenous amino acid flows in broiler chickens.

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The effects of phytic acid (PA) and 2 sources of exogenous phytase (bacterial vs. fungal) on the flow of endogenous amino acids at the terminal ileum of broilers were assessed using a peptide alimentation method. Phytic acid (as the sodium salt) was included in a purified diet at 8.5 and 14.5 g/kg and each diet was fed without or with a fungal (*Aspergillus niger*-derived) or a bacterial (*Escherichia coli*-derived) microbial phytase at 500 FTU/kg diet. Increasing the concentration of PA in the diet from 8.5 g/kg to 14.5 g/kg increased ($P < 0.001$) the flow of all measured amino acids by an average of 68%, with a range from 17% for proline to 145% for phenylalanine. The flow of endogenous aspartic acid, serine, glutamic acid, glycine, leucine, tyrosine, phenylalanine and histidine were increased by more than the mean, indicating changes in the composition of endogenous protein in response to the presence of higher concentrations of PA. Supplementation of both phytases reduced ($P < 0.001$) the flow of endogenous amino acids but the reduction tended ($P = 0.06$) to be greater for the bacterial phytase compared with the fungal phytase. These data suggest that the capacity of different phytases to counteract the antinutritive properties of PA vary and that a substantial part of the amino acid and energy responses observed following phytase supplementation in broiler chickens stem from reduced endogenous amino acid flows.

Key Words: phytase, endogenous loss, phytate

201 Comparative broiler performance and phosphorus equivalency of thermostable coated phytases to 2,000 FTU/kg feed.

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The objective of the present study was to compare broiler performance and bone mineralization from 2 commercially available thermostable

phytase variants included in pelleted diets to 2,000 FTU/kg. Male Ross 308 broilers were assigned at day-old to 8 dietary treatments and reared from 0–11 d in 16 floor pens (35 birds per pen and 2 pen replicates/treatment). At 11 d 50 randomly selected birds from each treatment group were transferred to smaller wire cages with 25 replicate cages of 2 birds per treatment from 12–21 d of age. Dietary treatments were: positive control (PC), negative control (NC) reduced by 0.23% total P and 0.10% calcium. The remaining 6 treatments comprised the NC diet supplemented with 500, 1,000, or 2,000 FTU/kg phytase from either phytase F (coated fungal *Peniophora lycii* phytase) or B (coated bacterial *Escherichia coli* phytase). All diets were pelleted at 90°C. Body weight (BW) gain and feed intake were determined from 0–11 d and 12–21 d and tibia ash at 21 d of age. Increasing phytase dose from 0 to 2,000 FTU/kg resulted in a linear increase in broiler BW gain, feed intake, and tibia ash ($P < 0.001$). There was a significant ($P < 0.001$) main effect of phytase source and a phytase source \times phytase dose interaction for BW gain and feed intake, with 2,000 FTU/kg phytase B being the only treatment able to restore 11–21 d BW gain and feed intake to the same level as the PC diet that contained 0.23% more total P. Broiler tibia ash increased linearly to 2,000 FTU/kg ($P < 0.001$) and tended to be higher ($P = 0.08$) when phytase B was added to the NC diet. Tibia ash was restored to the PC diet with 1,000 FTU/kg phytase B vs. 2,000 FTU/kg phytase F. These results suggested that broiler performance and bone mineralization responded up to 2,000 FTU/kg phytase but that standard P equivalency values should not be assumed when using different sources of phytase.

Key Words: broiler, phosphorus, phytase

202 Effects of amylase and β -glucanase on the availability of true metabolizable energy and digestibility coefficient of corn in roosters. J. C. C. Carvalho¹, J. A. G. Brito¹, V. A. Costa¹, A. G. Bertechini¹, F. Piracés², and J. O. B. Sorbara^{*2}, ¹Universidade Federal de Lavras, Lavras, MG, Brazil, ²DSM Nutritional Products, São Paulo, SP, Brazil.

The use of enzymes in animal nutrition, particularly for poultry, represents a possibility of optimizing the use of cereals such as corn, resulting in a better use of these nutrients. This trial aimed to evaluate the use of a carbohydrase on the energy and dry matter digestibility of corn. Metal cages with individual drinkers and feeders were used. The trial included 32 cecectomized Leghorn roosters and each bird was an experimental unit. The roosters were fasted for 24 hours and then forced to eat 30 grams of each experimental feed. The effects of increasing inclusion levels (0, 100, 200, 300, 400, and 500 ppm) of enzyme complex (EC, Ronozyme[®] A) were studied. The experimental design was fully randomized with 6 treatments and 10 replicates. The fecal material was used to determine dry matter, crude energy and nitrogen in order to establish the coefficient of dry matter apparent digestibility (CDMAD) and true metabolizable energy corrected for the nitrogen balance (TME_n). The data was analyzed using the QRP (Quadratic Response Plateau) with linear and nonlinear regression analysis to determine the optimum EC level to be used in order to maximize the studied variables. The best data adjustment for CDMAD was for QRP ($P < 0.01$) with a maximum estimated point for EC being 422 ppm with a CDMAD of 67.99% (which represents a CDMAD improvement of 7%). The adjustment with the linear model (quadratic response, $y = 63.3008 + 0.0223x - 0.00003x^2$; $R^2 = 0.94$; $P < 0.05$) made it possible to estimate (derivation of the regression equation) the 459 ppm level to maximize the CDMAD. The best data adjustment for TME_n was for QRP ($P < 0.01$) with a maximum

estimated point for EC being 461 ppm, with a TME_n of 3,850 kcal (improving corn TME_n by 118 kcal). The adjustment with the linear model (quadratic response, $y = 3732.5 + 0.5103x - 0.00055x^2$; $R^2 = 0.97$; $P < 0.05$) made it possible to estimate (derivation of the regression equation) the 492 ppm EC level to maximize TME_n. The inclusion of increasing Ronozyme[®] A levels increased corn TME_n and CDMAD, confirming that its use in poultry diets improves corn digestibility.

Key Words: Sibbald, enzymes, digestibility

203 Effect of β -glucanase and α -amylase supplementation either individually or in combination with xylanase for broiler chickens after 21 days of age on performance and production cost. J. O. B. Sorbara^{*1,2}, A. E. Murakami¹, E. S. Nakage¹, E. M. Massuda¹, R. L. H. Guerra¹, and F. Urganani¹, ¹Universidade Estadual de Maringá, Maringá, PR, Brazil, ²DSM Nutritional Products, São Paulo, SP, Brazil.

A few papers have been recently published suggesting that age-related maturity of the digestive tract must be taken into account when using enzymes in poultry feed. And some of these papers that used enzymes during the entire lifetime of the bird show a better response at the end of the rearing period. Therefore, a trial was conducted to determine if 1 or 2 commercial enzymes can be used, individually or in combination, to supplement a corn and soybean meal based feed after broilers chicken were 21 days of age. The trial was conducted in floor pens in a completely randomized design with 4 treatments and 5 replicates with 34 male Cobb broilers each. The treatments included a positive control (PC); a negative control (NC) with a reduction of metabolizable energy (ME) by 120 kcal/kg less than the PC; NC + 400 ppm Ronozyme[®] A (NC+A, β -glucanase and α -amylase); and NC + 400 ppm Ronozyme[®] A + 100 ppm Ronozyme[®] WX (NC+A+WX, xylanase) from 21 to 40 d. The birds were reared from 1 to 20 days of age in the same environmental conditions and the starter feed was the same for all treatments and was not supplemented with any exogenous enzyme. Performance parameters were measured from 21 to 40 days and production cost was calculated using actual feedstuffs price (100%) and decreasing or increasing corn, soybean meal and oil price by 40% (60, 80, 120, and 140%) all other feedstuffs, including enzymes price remained unaltered. The body weight gain (BWG) and feed intake (FI) were affected by treatments ($P < 0.05$). The supplementation of enzymes increase the FI when compared to the NC ($P < 0.05$) and the Ronozyme[®] A+WX supplementation increased the BWG from 21 to 40 days when compared to the NC. The economic evaluation shows that enzymes can reduce production cost, even when feedstuffs price decrease by 40%. However, the more the feedstuffs price decreases, the smaller will the difference between the treatments with enzymes and the controls without enzymes be.

Key Words: enzymes, performance, production cost

204 The effect of B-Mannanase (Hemicell Feed Enzyme) and high levels of distillers dried grains on turkey hen performance. M. E. Jackson^{*1}, K. R. Stephens¹, and G. F. Mathis², ¹ChemGen Corp, Gaithersburg, MD, ²Southern Poultry Research, Athens, GA.

B-mannan, a polysaccharide found in soybean meal and other plant proteins, exhibits powerful antinutritive effects in monogastrics. The enzyme B-mannanase (Hemicell) has been shown to improve performance and live weight uniformity in turkeys in corn-soybean meal type

diets. Distillers dried grains with solubles (DDGS), a by-product of ethanol production, has become a common feed ingredient in regions where it is economical. An experiment was conducted to evaluate the efficacy of B-mannanase in corn-soybean meal based diets vs. diets containing a high level of DDGS. A 2×2 factorial arrangement of dietary treatments consisted of commercial diets containing 0 and 15% DDGS with and without B-mannanase at the manufacturer's recommended dosage. Basal diets were formulated to have equal levels of metabolizable energy and essential nutrients within each test period. Treatments were assigned to 8 replicate pens with 15 Nicholas female turkeys per pen. Body weight was determined at 0, 3, 6, 9, and 12 weeks of age and feed consumption was determined between these ages. There were no significant interactions between B-mannanase and DDGS for any variable. 15% DDGS resulted in significant reductions in live weight and feed efficiency during most test periods, the largest differences observed at earlier stages. At 12 weeks of age, B-mannanase increased live weight 2.3% ($P < 0.05$) with corn-soybean meal diets and improved weight adjusted feed conversion by 13.8 and 13.9 points without and with 15% DDGS, respectively ($P < 0.05$). The experiment demonstrated that B-mannanase is a viable method in which to reduce feed costs with the current high feed ingredient prices in corn-soybean meal based diets with and without DDGS.

Key Words: turkeys, hemicell, DDGS

205 The effect of dietary supplementation of Alltech VegPro enzyme on amino acid digestibility in turkeys. M. S. Lilburn^{*1}, J. Pierce², and A. E. Sefton², ¹The Ohio State University/OARDC, Wooster, OH, ²Alltech Inc., Lexington, KY.

Semi-purified diets containing soybean meal as the sole source of protein or practical type corn-soy diets were fed to commercial poults from 28 to 34 d of age. The diets were supplemented or unsupplemented with Alltech VegPro enzyme. There were 4 poults per experimental pen and 10 replicate pens per diet. There was an additional replicate group of pens that were fed a diet with hydrolyzed casein for determination of endogenous amino acid flow. The supplemental enzyme was supplied by a commercial company and enzyme specific activity was confirmed by Alltech Inc. Ileal digesta was collected from each bird and pooled by pen. Each pool was freeze dried and analyzed by ion-exchange chromatography for total amino acids and chromium. For the semipurified diets, supplemental enzyme consistently increased amino acid digestibility by 0.5 to 1.0% for most amino acids and 2.0% for threonine but the improvements were not significant. Enzyme supplementation increased individual amino acid digestibility by 1 to 2% in the practical diet and the improvements were significant for lysine, methionine, threonine, and valine. The standard errors for the practical diets were considerably lower than those observed with the semipurified diets, thus increasing the sensitivity of the assay.

Key Words: enzyme, soybean meal, amino acids

206 GalliPro[®]—Same performance in energy-reduced diets for broilers. I. Knap^{*} and B. T. Lund, *Chr. hansen A/S, Boege Alle, Hoersholm, Denmark.*

To evaluate the performance improving effect of GalliPro[®] (*B. subtilis* DSMZ 17299) in broiler diets based on corn/soybean meal/soy oil (100%ME) and compared to a similar diet reduced 4% in metabolizable

energy (96%ME).

800 one-day-old male Ross 308 broiler chicks were randomly distributed in a factorial design 2×2 (diet \times probiotic) with 4 treatments, 8 replicates and 25 birds per experimental unit (floor pen) in the starter phase and 20 birds in the grower/finisher phase. The starter diets had, respectively, 55.2 or 58.1% corn, 37.3 or 36.8% soybean meal, 3.4 or 1.1% soy oil and 12.69 or 12.18 MJ/kg ME and a grower/finisher diet had, respectively, 60.6 or 63.5% corn, 31.5 or 31.0% soybean meal, 4.2 or 1.8% soy oil and 13.19 or 12.66 MJ/kg ME. The treatments were Control and GalliPro[®] (8×10^5 CFU/g) in 100% ME diets and Control and GalliPro[®] (8×10^5 CFU/g) in 96% ME diets. A digestibility trial ran in parallel: 128 males, 26 days old Ross 308 broilers fed the same grower/finisher diet. The similar factorial design 2×2 (diet \times probiotic) with 4 treatments, 8 replicates and 4 birds per experimental unit (cage). After adaptation of 5 days, feed consumption and excreta production per pen and the metabolizable energy values (apparent ME and apparent nitrogen-corrected ME) were calculated over the next 7 days.

Use of GalliPro[®] in the 100%ME diet improved body weight at slaughter by 0.9% and FCR by 1.9% compared to the 100% control diet. In the 96% ME diet the effect of GalliPro[®] was 1.8% on WG and 1.8% on FCR. The effect on FC was most pronounced in the grower/finisher phase. The improvements were 2.4% (100% ME diet) and 3.7% (96% ME diet). Use of GalliPro[®] in a 100% ME diet improved the metabolized energy (nitrogen-corrected) of the diet by 2%, whereas the improvement was 3.6% in the 96% ME diet.

The conclusion is that GalliPro can be used not only on top of a nutrient-optimized diet, but with even better effect in energy-reduced diets. The efficacy results obtained with GalliPro[®] in 96% ME diets were not significantly different from those obtained with a 100% ME diet.

Key Words: broiler performance, energy-reduced diet, GalliPro[®]

207 Effects of amylase and β -glucanase on the availability of true metabolizable energy and digestibility coefficient of sorghum in roosters. J. C. C. Carvalho¹, L. S. B. Queiroz¹, H. B. Braga¹, A. G. Bertechini¹, J. Lecznieski², and J. O. B. Sorbara^{*2}, ¹Universidade Federal de Lavras, Lavras, MG, Brazil, ²DSM Nutritional Products, São Paulo, SP, Brazil.

The use of corn for ethanol production inflates the price, and alternative ingredients such as sorghum need to be considered. The use of carbohydrase to increase energy and nutrient digestibility is another tool that should be considered in a period of high feedstuff prices. Therefore, the present trial had the objective of evaluating the use of a carbohydrase on the energy and dry matter digestibility variables of sorghum. Metal cages with individual drinkers and feeders were used. The trial included 32 cecectomized Leghorn roosters and each bird was an experimental unit. The roosters were fasted for 24 hours and then forced to eat 30 grams of each experimental feed. The effects of increasing inclusion levels (0, 100, 200, 300, 400, and 500 ppm) of enzyme complex (EC, Ronozyme[®] A) were studied. The experimental design was fully randomized with 6 treatments and 8 replicates, with a time replicate in a subdivided parcel design. The fecal material was used to determine dry matter, crude energy, and nitrogen to establish the coefficient of dry matter apparent digestibility (CDMAD) and true metabolizable energy corrected for nitrogen balance (TME_n). The data were analyzed using the QRP (Quadratic Response Plateau) with linear and nonlinear regression analysis to determine the optimum EC level to be used to maximize the studied variables. The best data adjustment for CDMAD was for QRP ($y = 64.06 + 0.0258x - 0.00003x^2$; $R^2 = 0.97$; $P < 0.05$) with a maximum estimated point for EC being 397 ppm with

a CDMAD of 69,19% (which represents a CDMAD improvement of 8%). The best data adjustment for TME_n was for QRP ($y = 3,565.1 + 0.54616x - 0.0007x^2$; $R^2 = 0.95$; $P < 0.05$) with a maximum estimated point for EC being 433 ppm, with a TME_n of 3,665.35 kcal (improving sorghum TME_n by 100 kcal). The inclusion of increasing Ronozyme[®] A levels increased sorghum TME_n and CDMAD, confirming that its use in poultry diets improves sorghum digestibility.

Key Words: Sibbald, enzymes, digestibility

208 Differences in corn energy with the use of α -amylase and β -glucanase for broilers in various production stages. J. C. C. Carvalho¹, R. L. Rios¹, E. M. C. Lima¹, A. G. Bertechini¹, F. Piracés², and J. O. B. Sorbara^{*2}, ¹Universidade Federal de Lavras, Lavras, MG, Brazil, ²DSM Nutritional Products, São Paulo, SP, Brazil.

Forecasts point out that energy sources used worldwide will undergo changes, and some of the crops that are presently essential in poultry production chain will be directly involved in energy production. The most coherent use of enzymes in poultry diets will be based on knowledge about their interaction with the substrate plus the economic aspects involved. The present study evaluated the effects of corn inclusion levels and supplementation with an enzyme complex on apparent metabolizable energy of corn for broilers. The metabolic assays was divided into 3 stages: prestarter (day 1–7), starter (day 14–21) and final (day 35–42). Male Cobb-500 broiler chicks were used, maintained in 72 cages with individual feeders and drinkers. The trial involved 4 diets with different corn levels (0, 20, 30, and 40%) replacing the reference diet. Four levels of enzyme complex (EC, Ronozyme[®] A; 0, 200, 300, and 400 ppm) supplementation were associated. The analyzed variable was the AME_n . In general differences in AME_n increases for all production stages for corn inclusion ($P < 0.01$) and EC supplementation level ($P < 0.01$) and no interaction corn inclusion vs. EC supplementation level were detected ($P > 0.05$). The EC supplementation had linear effect for all phases ($P < 0.05$). The following equations were determined for the prestarter, starter and final phase: $y = 3,409.21 + 0.3622x$ ($R^2 = 0.99$); $y = 3,665.06 + 0.4610x$ ($R^2 = 0.95$); $y = 3,659.71 + 0.7226x$ ($R^2 = 0.99$), respectively. The use of amylase and glucanase was effective in improving corn AME_n , and differences were higher in the final production stage.

Key Words: Matterson, enzymes, digestibility

209 Enzyme complex containing NSP-enzymes and phytase improves the performance of broilers fed corn-based diet. M. Francesch^{*1} and P. A. Geraert², ¹IRTA-Animal Nutrition, Constantí, Spain, ²ADISSEO France SAS, Antony, France.

The present experiment was conducted to investigate the benefits of a multi-enzyme complex (RovabioTM Max) containing carbohydrases (from *Penicillium funiculosum*) and phytase (bacterial 6-phytase) activities on the performance of broilers.

Five basal diets based on corn and soybean meal were tested: one positive control (PC) diet formulated to be adequate in nutrient and 4 negative control (NC1 to NC4) diets with gradual decrease in energy (AME), crude protein (CP), digestible amino acids (DAA), available phosphorus (AP) and total calcium (Ca): NC1: –65 kcal/kg, –1.5% CP and DAA, –0.15 pcent point avP, –0.12 pcent point Ca; NC2: –85 kcal/

kg, –3.0% CP and DAA, –0.15 pcent point avP, –0.12 pcent point Ca; NC3: –65 kcal/kg, –1.5% CP and DAA, –0.20 pcent point avP, –0.16 pcent point Ca; NC4: –85 kcal/kg, –3.0% CP and DAA, –0.20 pcent point avP, –0.16 pcent point Ca. NC diets were supplemented or not with RovabioTM Max supplying 1,100 visco units of endo- β -1,4-xylanase, 100 AGL units of endo-1,3(4)- β -glucanase, and 500 phytase units of 6-phytase per kg of feed.

2,160 day-old Ross male broilers were distributed into 9 experimental treatments, 6 replicates, 40 birds per pen. Growth performances were determined at 21 and 42 days where tibias from 2 chickens per pen were also collected for bone mineralisation determinations.

Supplementation of the NC reformulated diets with the multienzyme complex improved feed intake, weight gain and feed conversion. 42-d bodyweight were comparable to those observed in the PC group. 42-d feed conversion was even improved with RovabioTM Max supplementation on the lower reformulated diet (NC4) compared to PC. Moreover, the bone mineralisation did not significantly differ between enzyme supplemented NC groups and PC. These results support that the dietary supplementation with a multi-enzyme complex containing NSP-enzymes and phytase is efficient in reducing the phosphorus, energy and protein specifications of a corn-based diets without performance losses.

Key Words: NSP-enzymes, phytase, broilers

210 Effect of protein and energy levels on core body temperature dynamics and response to heat stress in meat-type chickens. M. J. Zuidhof^{*1}, R. A. Renema², D. S. Peters¹, J. Berezowski¹, F. I. L. Hernandez¹, and C. Annett¹, ¹Alberta Agriculture and Food, Edmonton, AB, Canada, ²University of Alberta, Edmonton, AB, Canada.

Genetic selection of modern broilers has resulted in birds with impressive growth potential and improved feed efficiency. To determine the effect of various protein and energy levels on the dietary thermogenesis in broilers, 30 females of an experimental yield strain (Aviagen, Inc) were raised on a broiler breeder growth profile to 6 wk of age, and surgically implanted into the abdominal cavity with a live broadcasting temperature reader (1,700 readings/bird/d) through a 1.5 cm incision. Birds were housed individually in cages containing data loggers recording temperatures in the microclimate of each bird. After a 4-d recovery period, birds were randomly allocated to 1 of 6 diets with a 3 × 2 factorial arrangement of 85, 100, or 115% of recommended dietary balanced protein (DBP) levels (balanced for 6 most limiting amino acids) and 94 or 100% of recommended broiler ME levels (Cobb-Vantress recommendations for maximum yield). After 21 d on these diets, birds were exposed to an environmental temperature around 30°C. The effect of nutrition and heat stress on core body temperature was investigated. Body temperatures were higher in birds fed the low compared to high ME diet (39.6°C vs. 39.3°C; $P < 0.0001$). Body temperature was significantly different in all DBP treatments, with higher and lower DBP levels than recommended resulting in lower body temperature (39.4°C vs. 39.4°C vs. 39.7°C, respectively). Heat stress conditions increased body temperature by 0.42°C ($P < 0.0001$). Interactions between heat stress and both ME ($P < 0.0001$) and DBP ($P = 0.0016$) were significant. Body temperatures of low ME birds increased 0.37°C more than in birds fed higher ME. Body temperatures increased 0.60°C in birds fed 100% of recommended DBP, 0.37°C in birds fed 115%, and 0.29°C in birds fed 85% of recommended DBP. These results demonstrate that nutrition affects body temperatures of broilers, and that nutrient levels in feed can modulate their response to heat stress.

Key Words: core body temperature, diet-induced thermogenesis, broiler chickens

211 Effects of dietary protein and energy on broiler live performance to 36 days. F. I. L. Hernandez^{*1}, D. R. Korver², R. A. Renema², and M. J. Zuidhof¹, ¹Alberta Agriculture and Food, Edmonton, AB, Canada, ²Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada.

A study was carried out to investigate the effects of energy and protein levels on performance of Cobb Avian 48 broilers to 36 d. Chicks were randomly assigned to a 2 × 2 × 3 × 5 factorial arrangement of treatments, with 2 sexes; 2 levels of early nutrition (0 to 11 d); and after 11 d, 3 metabolizable energy (ME) levels and 5 dietary balanced protein (DBP) levels, balanced for 4 limiting amino acids. The 3 ME levels were 94, 97, and 100% of Cobb-Vantress dietary specifications for maximum growth rate and feed conversion ratio (FCR). The 5 DBP levels were 85, 92.5, 100, 107.5, and 115% of these same specifications. From 0 to 11 d, 2 prestarter nutrient densities were used, based on Cobb's starter recommendations for maximizing growth rate and FCR (HIGH), or for reduced feed cost (LOW). From 12 to 36 d of age, the prestarter treatment was nested within pens, which housed ME × DBP × sex interactions. By 36 d, the HIGH prestarter increased BW (2.14 vs. 2.08 kg; $P < 0.0001$). Male broilers were heavier than females ($P < 0.005$) in all levels of ME and DBP. Females had a higher cumulative FCR than males ($P < 0.0001$). In females, DBP did not affect cumulative FCR at 36 d. Males fed 100% through 115% DBP had a lower cumulative FCR than those fed 85 and 92.5% DBP ($P < 0.05$). Covariate analysis (adjusted for BW) indicated that breast yield was higher at 107.5 and 115% DBP than at 85% through 100% DBP (range: 389.7–381.4 g vs. 372.6–378.5 g, respectively; $P < 0.05$). Fat pad decreased with increasing DPB levels ($P < 0.0001$). Fat pad was higher at 100% ME than at 97% ME and 94% ME. Females had higher fat pad weight and lower eviscerated BW and legs yield. In conclusion, HIGH prestarter improved growth rate, males were more efficient than females, low DBP levels increased fat pad, and breast yield increased by 1 g for every 1.5% increase in DBP.

Key Words: live performance, metabolizable energy, dietary balanced protein

212 Methionine deficiency in chicks reduces hepatic recycling of dehydroascorbic acid and up-regulates renal L-gulonolactone oxidase activity. D. V. Maurice^{*}, S. F. Lightsey, and J. E. Toler, Clemson University, Clemson, SC.

The effects of oxidative stress are well known and antioxidants alleviate adverse responses. Ascorbic acid (AsA), a potent antioxidant (AO) synthesized by poultry, is oxidized to dehydroascorbic acid (DAsA) that can be converted to AsA. Methionine (MET) plays a central role in metabolism and recent findings demonstrate that it functions not only as an antioxidant but also induces the expression of an AO protein. The paucity of information on the relationships between AsA and MET lead us to examine the effect of MET deficiency on tissue AsA, plasma total antioxidant capacity (PTAC), hepatic recycling of DAsA, and L-gulonolactone oxidase activity (GLOX). In each experiment commercial broiler chicks were grown in wire-floor cages to 24–25 days of age. A pen of 6 birds formed an experimental unit with 8 pens per treatment and 1 chick was sampled from each pen at termination. A corn-peanut meal-soybean meal diet with added MET (0.27%) and lysine HCl (0.3%) was the control diet (22.4% CP; 0.58% MET; 0.90% SAA) and the same diet without added MET was the MET deficient diet (22.4% CP; 0.32% MET; 0.63% SAA). The assayed values for the deficient diet were 21.8% CP; 0.31% MET; 0.65% SAA; 0.21% added lysine and 0.01% added MET (courtesy Evonik Degussa, Atlanta). Body weights were comparable in Expt 1 (851 vs. 834 g) with deficiency induced increase in feed intake (42.1 vs. 46.5 g/day) and significantly reduced by deficiency in Expt 2 (819 vs. 748 g). Plasma AsA, bursal AsA and PTAC were significantly reduced by MET deficiency but significant differences were not detected in splenic and testicular AsA. Hepatic recycling of DAsA was reduced by 18% in deficient chicks (17.8 vs. 13.7; $P < 0.01$) but changes in relative weight and hepatic AsA were not detected. In both experiments GLOX was significantly up-regulated by 28–29% in MET deficient chicks (464 vs. 364 units $P < 0.01$ and 566 vs. 438 units $P < 0.01$). The results demonstrated that MET deficiency induced increased GLOX and suggest that the 2 nutrients form a link in the AO defense system and contribute to homeostasis.

Key Words: ascorbic acid, L-gulonolactone oxidase, methionine deficiency

Genetics

213 The paternal effect of *Campylobacter jejuni* colonization in broilers. X. Li¹, C. Swaggerty², M. Kogut², H. Chiang¹, Y. Wang¹, K. Genovese², H. He², N. Stern³, and H. Zhou^{*1}, ¹Texas A&M University, College Station, ²ARS-USDA, College Station, ³ARS-USDA, Athens, GA.

Day-one broilers from 2 pure lines (A and B) and 2 F1 reciprocal crosses C and D were challenged with 105 cfu (colony forming unit) of *Campylobacter jejuni* (*C. jejuni*). Cloacal swab were collected on 3, 6, 10, and 13 dpi, and cecal contents on 7 and 14 dpi for *C. jejuni* counting, respectively. Colony categories in the swab and the number of *C. jejuni* colonies in cecal contents of each bird were recorded and relative bacterial numbers for the swab in each line were calculated. Number of bacteria in cecal content in line B was significantly higher than in line A ($P < 0.05$), and line C (A♀×B♂) significantly higher than line D (A♂×B♀) ($P < 0.05$) at both 7 and 14 dpi, respectively. Similar results were observed in cloacal swab. There was significant correlation between *C. jejuni* count in cloacal swabs and that in cecal content. The

results indicated that paternal effect might be one of important genetic factors influencing the resistance to *C. jejuni* colonization in broilers.

Key Words: *C. jejuni*, paternal effect, challenge

214 Differentially expressed soluble proteins in aortic cells from atherosclerosis-susceptible and resistant pigeons. S. C. Smith, E. C. Smith, M. L. Gilman, J. L. Anderson, and R. L. Taylor Jr.^{*}, University of New Hampshire, Durham.

Atherosclerotic cardiovascular disease is the leading cause of death in economically developed countries. Numerous hypotheses have attempted to explain the initiation of lesions but the underlying cause(s) remains unclear. Complex gene-environment interactions are believed to be involved in the disease. In attempts to understand genetic compo-