Dietary amino acid density (AA) and fat content may affect intestinal physiology and xylanase efficiency. A study was conducted to evaluate the effects of AA, additional energy from fat post-pellet (FL), and xylanase levels (X) in corn-soybean diets with DDGS on broiler performance. A total of 2,112 day-old male Ross 708 broilers were placed in 96 pens. The 16 treatments consisted of diets formulated with 2 AA densities (High and Low, 10% difference), 2 FL (0 and 100 kcal/kg ME) and 4 levels of X (0, 8000, 16000 and 32000 BXU/kg). Starter, grower and finisher diets were fed from 1 to 16, 17 to 35 and 36 to 49 d of age, respectively. BW gain (BWG), FI and FCR were obtained at 16, 35, 42 and 49d of age. At 49d, 3 broilers were selected based on pen mean BW, carcass yield and cut up parts were evaluated. Data were analyzed as a CRBD with a 2 × 2 × 4 factorial design. An interaction between AA and X levels on broiler performance.

**Key Words:** enzyme, DFM, broiler, combination, *Lactobacillus*
Key Words: broiler, enzyme, performance, Bacillus, direct fed microbial

246 Influence of combinations of a direct-fed microbial and exogenous enzymes on nutrient digestibility in broilers at 11 and 21 days of age. L. F. Romero1, S. E. Indrakumar1, and V. Ravindran2.

Two studies with 11-d-old and 21-d-old Ross-308 male broilers evaluated the digestibility of nutrients in response to dietary combinations of xylanase, amylase, protease and a B. subtilis direct-fed microbial (DFM). Day old chicks were administered a live coccidiosis vaccine and assigned to 1 of 6 dietary treatments with 8 replicate cages and 8 birds per cage. Four chicks per cage were randomly selected at 11 d and 21 d for collection of ileal digesta samples. A 3 × 2 factorial arrangement was used. Three enzyme levels were: 1) no enzyme, 2) xylanase from T. reesei and amylase from B. licheniformis (XA), or 3) XA plus protease from B. subtilis (XAP). Two levels of DFM were: 1) no DFM, or 2) a combination of spores from 3 defined strains of B. subtilis (DFM).

Diets contained corn, soybean meal, corn DDGS, and wheat middlings. Apparent ileal digestibility of energy and protein were measured at both 11 and 21 d using TiO2 (0.3%) as marker. Ileal digestibility of fat and starch, and AMEn (total collection) were evaluated only at 21 d. Data were analyzed with ANOVA. At 11 d, a main effect of enzyme was present for ileal digestible energy (IDE), where XA and XAP increased IDE by 118 and 128 kcal/kg DM compared with treatments without enzymes. No effects on protein digestibility and no interactions were detected at 11 d. At 21 d, main effects of enzymes and DFM were detected on IDE and AMEn, with increments on digestibility for both enzymes and DFM versus unsupplemented diets, with no interactions present. Ileal protein and fat digestibility was affected only by enzymes at 21 d (P < 0.05), whereas starch digestibility was affected by DFM, enzymes, and exhibited an interaction (P < 0.05). Interestingly, the DFM + XAP treatment increased IDE by 152 kcal/kg DM, but only 110 kcal/kg DM were explained by increments in the digestibility of starch, fat and protein, suggesting an effect on fiber disappearance, which was subsequently confirmed by evaluation of NSP digestibility. These enzymes and DFM may have complementary effects on nutrient digestibility in broilers.

Key Words: Bacillus, broiler, digestibility, direct-fed microbial

247 Effect of dried distillers grain with solubles (DDGS) and rye on growth performance and gut health of broilers as affected by enzyme supplementation. F. Yan*, J. Dibner, M. Vazquez-Anon, and C. Knight, Novus International Inc., St. Charles, MO.

A study was conducted to evaluate effect of high levels of DDGS and rye on growth performance and gut health of broilers as influenced by a nonstarch polysaccharides (NSP) degrading enzyme blend (Cibenza CSM, Novus International Inc.). The study consisted of 8 treatments: corn soy control (T1), T2 = T1+30% DDGS, T3 = T1+16% corn bran, T4 = T1+38% rye, T5 = T4+enzyme, T6 = T1+25% rye, T7 = T6+30% DDGS, and T8 = T7+enzyme. Corn bran at 16% provided the same level of crude fiber as that contained in 30% DDGS. Each diet was fed to birds per pen. Experimental treatments consisted of a positive control (PC) diet, a negative control (NC) diet (ME reduced 88 kcal/kg) and the NC diet with the inclusion of 3 NSP enzymes, fed according to each manufacturer’s recommendation. The 3 NSP products compared were a thermo-tolerant xylanase (NSP-X), an amylase, xylanase and protease based product (NSP-XAP) and an α galactosidase + xylanase based product (NSP-XG). Experimental diets were fed ad libitum in 4 phases (starter, grower, finisher and withdrawal) to 60 d of age. Feed intake (FI), body weight gain (BWG), and feed conversion adjusted for mortality (FCR) and body weight (awtFCR) were recorded at 42 and 60 d of age. Reducing the ME in the NC diet decreased animal performance by increasing FCR and awtFCR compared with the PC at both d 42 and 60 (P < 0.001). Birds fed the NSP-X and NSP-XG diets resulted in FCR (d 42 and 60) and awtFCR (d 42) equal to the PC fed birds with the NSP-XAP being intermediate and not significantly different from the NC group (P < 0.001). At d 60, however, the awtFCR for the NSP-X treatment resulted in equal performance to the PC with both the NSP-XG and NSP-XAP treatments being intermediate and not significantly different from the NC (P < 0.001). Although not significant, awtFCR between the 3 NSP enzymes were separated by 0.06 pts at d 60. The results from this experiment demonstrated the biggest response in performance came from the pure xylanase with no advantage for the multi-enzyme products when fed in today’s modern commercial diets.

Key Words: xylanase, multi-enzyme, broiler, feed efficiency


Bacillus


Multi-enzyme products are reportedly optimized to combat the challenges of modern broiler diets which contain higher percentages of DDGS (arabinoxylans and cellulose) and animal proteins. The objective of this study was to evaluate the performance of a thermo-tolerant xylanase enzyme (Econase XT), against NSP products composed of multiple enzymes in a commercial diet containing corn, soy, DDGS and animal protein. Ross 708 × Hubbard M99 male broilers were randomly divided into 5 treatments with 8 pens per treatment and 20 birds per pen. Experimental treatments consisted of a positive control (PC) diet, a negative control (NC) diet (ME reduced 88 kcal/kg) and the NC diet with the inclusion of 3 NSP enzymes, fed according to each manufacturer’s recommendation. The 3 NSP products compared were a thermo-tolerant xylanase (NSP-X), an amylase, xylanase and protease based product (NSP-XAP) and an α galactosidase + xylanase based product (NSP-XG). Experimental diets were fed ad libitum in 4 phases (starter, grower, finisher and withdrawal) to 60 d of age. Feed intake (FI), body weight gain (BWG), and feed conversion adjusted for mortality (FCR) and body weight (awtFCR) were recorded at 42 and 60 d of age. Reducing the ME in the NC diet decreased animal performance by increasing FCR and awtFCR compared with the PC at both d 42 and 60 (P < 0.001). Birds fed the NSP-X and NSP-XG diets resulted in FCR (d 42 and 60) and awtFCR (d 42) equal to the PC fed birds with the NSP-XAP being intermediate and not significantly different from the NC group (P < 0.001). At d 60, however, the awtFCR for the NSP-X treatment resulted in equal performance to the PC with both the NSP-XG and NSP-XAP treatments being intermediate and not significantly different from the NC (P < 0.001). Although not significant, awtFCR between the 3 NSP enzymes were separated by 0.06 pts at d 60. The results from this experiment demonstrated the biggest response in performance came from the pure xylanase with no advantage for the multi-enzyme products when fed in today’s modern commercial diets.

Key Words: xylanase, multi-enzyme, broiler, feed efficiency
An 8-wk (69 to 77 wk of age) trial was conducted to evaluate the energy sparing effect of non-starch polysaccharide (NSP) multi-enzyme blend (2000U endo-xylanase, 75U endo-β-glucanase and 25U α-galactosidase/g of product; Cibenza CSM feed additive) in laying hens fed iso-nitrogenous corn-SBM and wheat-SBM based diets with varied AMEn levels. A total of 216 Hy-Line W-36 laying hens were assigned to 6 treatments with 36 cages/treatment and 1 hen/cage. The data were analyzed using both 1-way ANOVA (for all 6 treatments) and 2x2 factorial design with 2 diets (corn-SBM vs. wheat-SBM) and 2 energy levels (0 and 80 kcal/kg diet reduction). The treatments consisted of: Corn-SBM diet, T1 (2820 kcal); T1 less 80 kcal, T2; T2+0.05 NSPases blend, T3; Wheat-SBM diet, T4 (2820 kcal); T4 less 80 kcal, T5; T5+0.05% NSPases blend, T6. Measurements included were weight gain, cumulative (c) feed intake (FI), cFCR on egg mass, egg production, egg weight and viscosity (jejunal and ileal). Reduction of 80 kcal reduced (P < 0.05) weight gain in wheat based diets (T5) compared with T4, while supplementation of NSPases (T6) brought back the performance that was similar (P > 0.05) to +ve control (T4). FI was reduced and FCR on egg mass improved (P < 0.05) in hens fed diets supplemented with NSPases (T3 and T6) compared with their respective –ve controls (T2 and T5) and further these variables were either the same (P > 0.05) or better than their respective +ve controls (T1 and T4). Viscosity for T6 was reduced (P < 0.05) compared with T4 and T5 and was similar to T1, T2, and T3 (P > 0.05). Factorial output indicated an improvement in weight gain (by 28g), FCR (by 13 points) and FI (5g less) for hens fed NSPases compared with non-NSPases fed groups (enzyme effect, P < 0.05). Supplementing wheat based diets increased weight gain by 26g, reduced FCR efficiency by 12 points, and increased FI by 5g/d compared with hens fed corn based diets (diet effect, P < 0.05). In summary, NSP enzymes could spare 80 kcal/kg diet in laying hens without compromising production and FCR irrespective of diets tested while reducing intestinal viscosity in wheat based diets.

**Key Words:** layer, corn, wheat, NSPase

250 Performance of laying lens from 22 to 40 weeks-of-age: Effects of supplementing a sorghum-soybean meal-corn (DDGS) diet that is low in energy and available phosphorus with an enzyme complex containing non-starch polysaccharide (NSP) enzymes and a α-phytase. C. Soto*1, F. Rosas1, M. Forat2, V. Navarro3, R. B. Shirley4, and V. Brito1, 1Adisseo de México S.A. de C.V., Guadalajara, Jalisco, México, 2Instituto Nacional de Investigación Animal S.A. de C.V., Querétaro QRO, México, 3Adisseo USA, Alpharetta, GA, 4Euronutec Premix, Querétaro QRO, México.

The following layer trials evaluated the production benefits of Rovabio Max (RM; a complex of 19 carbohydrases plus a 6-α-phytase), when supplemented into sorghum-SBM-corn DDGS diets. Experiment 1: 320 Hy-Line W36 hens were fed a nutritionally adequate positive control (PC) diet without RM (T1), a reformulated PC with −100 kcal/kg ME and −0.15% aP without (T2) or with the addition of RM (T3), or a reformulated PC with −80 kcal/kg ME, −1.5% amino acids, −0.15% aP and RM (T4). Experiment 2: 288 Hy-Line W36 layers were fed a nutritionally adequate PC diet without any enzyme (T1) or a reformulated PC diet with −95 kcal/kg ME and −0.20% aP without any enzyme (T2), with RM (T3) or with a multi-enzyme cocktail from *Aspergillus niger* that contained a phytase and 6 other carbohydrases (T4). Experiment 1: Daily feed intake (DFI, g/day) was higher (P < 0.05) in T3 (86.4) than T1, T2 and T4 (85.7, 85.5 and 85.7). Feed conversion ratio (FCR) was significantly higher for T2 and T3 (1.72 and 1.72) compared to T1 (1.64); T4 was similar to T1-T3 (1.66). Egg production % (EP) was significantly lower for T2 and T3 vs. T1 (89.0 and 90.1 vs. 92.4); T4 was similar to T1 and T3 (92.2). Egg mass (EM; grams/egg) for T2 (50.2) was significantly lower than T1 and T4 (52.6 vs. 51.9), but the same as T3. No differences were detected in egg weight (EW), weight gain (WG), average daily weight gain, shell micro-fractures or broken egg % among treatments. Experiment 2: EP for T2 was lower (P < 0.05) than T1 (74.8 vs. 79.0); there was no difference between T1, T3 and T4. The EM of T1 and T3 (42.3 and 42.5) were significantly higher than T2 (39.6); T1, T3 and T4 did not differ. FCR for T2 and T4 (2.17 and 2.10) were significantly higher than T1 and T3 (2.00 and 2.01). No statistical differences in DFI, EW, micro-fractures, broken-egg %, or yolk color were detected. These results demonstrate the benefits of supplementing lower energy and aP layer diets with Rovabio Max.

**Key Words:** available phosphorus, carbohydrase, laying hen, phytase, metabolizable energy


To test the effect of several inclusion levels of *Citrobacter braakii* (CBP) phytase (Ronozyme HiPhos), on phytate P (PP) release, 420 50-wk-old-Bovans White hens were randomly allocated to 7 treatments with 5 replicates of 12 hens each. The hens were housed in an experimental open hen house with curtains. Feed and water were provided ad libitum. The experimental period lasted 12 weeks, first 8 weeks for adaptation and 4 last weeks for data collection. Treatment 1 was a basal corn-SBM diet deficient only in non-phytate P (NPP), 0.12%; Treatments 2 and 3 were added with constant increases of 0.11% inorganic P, to get a linear hen response to P addition. Treatments 4 to 7 were the addition of 300, 600, 1,200, and 1,800 phytate units (FYT)/kg to the basal diet. Data was analyzed as a CRD. The results from treatments 1 to 3 were analyzed by a regression model to test for a significant linear response (P < 0.05). Then for every level of CBP added (treatments 4 to 7) the linear regression equation was solved to find out the equivalent value of released P. Egg production (EP), feed intake (FI), and feed efficiency (FE) showed no significant differences (P > 0.05) for treatments 2 to 7, only vs. TRT 1 (P < 0.05). Eggshell strength (ESS) was not affected (P > 0.05) by treatment. Following the significant (P < 0.001) linear response equations for Tibia strength (TS), kg/cm² (Y = 28.16X + 17.42, R² = 0.84), Tibia Ca (TC), % (Y = 11.6X + 14.2 R² = 0.80), Tibia P (TP), % (Y = 11.6X + 6.1, R² = 0.81) and T ash (TA) (Y = 33.3X + 38.1 R² = 0.80). Under the experimental conditions of the present trial, EP, FI, FE, and ESS were not a sensitive parameter to measure P release, whereas, tibia parameters showed the following average P release values per level of CBP inclusion in the corn-SBM diet: 300 FYT/kg = 0.099%, 600 FYT/kg = 0.141%, 1,200 FYT/kg = 0.182%, and 1,800 FYT/kg = 0.198%.

**Key Words:** *Citrobacter braakii*, hen, phytase, phosphorus

252 Evaluation of an enzyme complex in broiler diets based on sorghum, soybean meal and corn dried distillers grains with reduced metabolizable energy levels. A. E. Lópeza1, J. C. Remusc1, C. Kromm1, E. Ávila González2, and J. Arce Menocal3, 1DuPont Animal Nutrition, Mexico City, Mexico, 2Centro de Enseñanza, Investigación y Extensión en Producción Avícola FMVZ-UNAM, Tlahuac, Mexico City, Mexico, 3Universidad Michoacana de San Nicolás de Hidalgo FMVZ, Mexico.
The objective of this study was to evaluate performance and carcass yield of broilers fed sorghum, soybean meal and corn dried distillers grains (DDG) diets with different metabolizable energy (ME) levels with or without multi-enzyme complex (EN) containing endo-1,4-β-xylanase (600 units/g from T. longibrachiatum), β-glucanase (800 units/g from B. subtilis) and α-amylose (800 units/g from B. amyloliquifaciens). 1800 Ross 308 male chicks were randomly distributed in a 3 x 2 design with 6 replicates of 50 birds each for this 46 d trial. Three base diets, differing in ME, were fed w/o EN. Treatments (trt) were: 1) Control, 2) trt 1 less 70 kcal/kg, 3) trt 1 less 140 kcal/kg, 4) trt 2 + 500 g EN/t, 5) trt 3 + 500 g EN/t, 6) trt 1 + 500 g EN/t. Diets were formulated to meet broiler nutrient needs (NRC, 1994) with the exception of AME for trts 2 to 5. Mash feed was used during 3 feeding stages: 1-21, 22-35 and 36-46 days. Performance and mortality were measured weekly and at 46 days. At 46 days, 4 birds per replicate were used (24 birds per trt) for percentage boneless breast and abdominal fat vs. body weight assessment. Means were analyzed using a repeated measures design, with weeks of age as time variable and the results of breast and fat pad as percentage vs. body weight. Variance analyses was run, and mean comparison was done using Fisher LSD. Software was StatSoft Statistica 6.0, 2003. Bird performance was lower (P < 0.01) with reduced energy. Enzyme use improved weight and FCR (P < 0.01). Main effect differences (P < 0.01) were observed for weight, gain and FCR due to diet and product. Breast yield and fat pad decreased (P < 0.01) with reduced diet energy. With EN use, birds at all 3 ME levels had improved breast yield (P < 0.01). Under the stated conditions, beneficial effects of an EN complex were observed on broiler weight, FCR and breast yield.

**Key Words:** multi-enzyme complex, broiler, sorghum, corn-DDG, breast-yield

253 NSP degradating capacity of commercial xylanases on corn diet in broilers and piglet ileal digesta. N. R. Pedersen*,1, P. Schimler1, I. Knap1, and D. Pettersson1, 1Novozymes A/S, Bagsvaerd, Denmark, 2DSM Nutritional Products, NP Innovation Animal Nutrition & Health, Basel, Switzerland.

To evaluate if enzyme effects are species related, the hydrolytic effect of 6 commercial xylanase products on ileal content of broilers and swine fed on a corn-soya diet were examined. Digesta from ileum was collected from 10 piglets sacrificed 15 d and from 60 broilers sacrificed after 27 d of feeding on a corn-soya diet. Samples from each species were pooled, freeze-dried and used as substrate. After hydrolyses of the arabinoxylans in the diet by the NSP enzymes, released soluble xylose oligomers, after acid hydrolyses were detected spectrophotometrically. All treatments were performed in triplicate. Comparison of means was performed by Tukey-Kramer HSD test using JMP 9.02. In poultry digesta, a multicomponent product from Trichoderma and Penicillium species and a xylanase-β-glucanase product had significantly higher hydrolytic activity (P < 0.05) when compared with the control. The increase in relative soluble xylose was 15% for the Trichoderma, 31% for the Penicillium and 42% for the xylanase-β-glucanase products. The monocomponent Trichoderma reesei and a triple enzyme product did not significantly hydrolyse the arabinoxylan. Using piglet digesta, both Trichoderma products showed significant capacity for hydrolysing the arabinoxylan (P < 0.05) when compared with the control (59 and 73% increase in relative soluble xylose). The multicomponent enzyme from Penicillium species, the xylanase-β-glucanase and the triple enzyme products had no hydrolytic effect. These results indicate that the effects of the enzymes are species related. The response on digesta varied from no effect compared with the control to significant hydrolysis. The multicomponent Trichoderma product showed significant hydrolysing capacity in broilers (15% increase in relative soluble xylose) and piglets (75% increase in relative soluble xylose). The monocomponent Trichoderma product showed significant effect only on piglet digesta (P < 0.05), whereas the xylanase from Penicillium species and the 2 component enzyme preparation showed significant effects only on broiler digesta (P < 0.05). The triple enzyme product did not show any significant effect on either species.

**Key Words:** xylanase, corn, soy, piglet, broiler

254 Effect of enzymatic complex on growth performance of boilers at different dietary levels of wheat. S. Naveed*,1, I. Ahmed1, T. N. Pasha1, A. Mahmud1, Y. A. Ditta1, and A. K. Khan2, 1University of Veterinary and Animal Sciences, Lahore, Punjab, Pakistan, 2University of Agriculture, Faisalabad, Pakistan.

A study was conducted to determine the effect of enzymatic complex (xylanase, phytase, β-glucanase, amylase, protease, pectinase and cellulase) on boilers performance at different dietary levels of wheat to enhance the availability of nutrients by breakdown of non-starch polysaccharides for a period of 35 d. A total of 525 Hubbard day-old chicks were procured from locally renowned hatchery. These chicks were divided into 7 treatments; each was further divided into 5 replicates having 15 birds in each. Seven types of isocaloric and isonitrogenous feeds were prepared viz. A, B, C, D, E, F and G. Feed A was categorized as control diet (corn soy based). Diets B, C, D, E, F and G were formulated with different levels of wheat replacing corn with same level of soybean meal. Feed B, D and F were formulated containing 15%, 20% and 25% wheat without supplementation of exogenous enzymatic complex respectively. Feed C, E and G were formulated containing 15, 20, and 25% wheat supplemented with 0.02% enzymatic complex respectively. The data were analyzed using one-way ANOVA technique in CRD using SAS 9.1. It was found that the supplementation of enzymatic complex improved (P < 0.05) body weight gain, feed conversion ratio, relative weight of organs and intestinal length. There was a significant decrease (P < 0.05) in feed intake because of xylan in the wheat and in mortality by the decrease in vent pasting. The enzymatic complex improved the body weight and feed conversion ratio by degrading non-starch polysaccharides which were otherwise, not digested by birds due to absent of microflora.

**Key Words:** enzymatic complex, Hubbard, isocaloric, isonitrogenous and wheat


Two experiments were conducted to evaluate the effects of different carbohydrases (1-α-amylase, 200 kNU/β-glucanase, 350 FGB, 2-α-galactosidase, 35 U/g, galactomannanase, 110 U/g, xylanase, 1500 U/g +β-glucanase, 1100 U/g and 3-xylanase, 12,200 U/g+β-glucanase, 1,250 U/g and phytase 10,000 FTU/g) in corn/soybean meal based diets for broilers. In experiment 1, a total of 2160 male chicks Cobb 500 were randomly assigned to 72 floor pens, with 9 treatments and 8 replicates on a 3-stage feeding program (1–21 d, 22–35 d, and 36–42 d). Treatments were (1) positive control diet-PC, (2) negative control 1-NC-1 (–100 kcal/kg of AMEn, –3% of Met, Lys, and Thr, and –0.12 of Av P and Ca), (3) negative control 2-NC-2 (–150 kcal/kg of AMEn, –3% of the same amino acids, and –0.12 Av P and Ca, (4) NC-1+phytase (50g/t)+carbohydrase (50g/t)+carbohydrase (300g/t), (5) NC-1+phytase (50g/t)+carbohydrase (300g/t), (6) NC-1+phytase (50g/t)+carbohydrase (300g/t), (7) NC-1+phytase (50g/t)+carbohydrase (300g/t), (8) NC-1+phytase (50g/t)+carbohydrase (300g/t), (9) NC-1+phytase (50g/t)+carbohydrase (300g/t), (10) NC-1+phytase (50g/t)+carbohydrase (300g/t).
2 (200g/t), (6) NC-1+ phytase (50g/t)+carbohydrase 3 (100g/t), (7) NC-2+phytase (50g/t)+carbohydrase 1 (300g/t), (8) NC-2+phytase (50g/t)+carbohydrase 2 (200g/t), (9) NC-2+phytase (50g/t)+carbohy-
draste 3 (100g/t). Performance and carcass characteristics were evaluated. At 41 d of age, 2 birds per replicate were slaughtered to obtain carcass yields and fat pad. In experiment 2, 5 birds of 14 and 35 d of age, from each experimental unit from experiment 1, were relocated in 72 metabolism cages for energy balance studies (14–21 d and 35–42 d). In the period 1–21 d, NC-1+phytase+carbohydrase 1 (4) showed a similar result to the positive control for WG and FCR. The feed intake was not affected \( (P > 0.05) \) by treatments all time. There was recovery of WG compared with positive control with the phytase+carbohydrase 1 (4) and phytase+carbohydrase 3 (6) from 1 to 41 d. All treatments with NC-2 did not recover the WG of the positive control in total phase (1 to 41 d). All carbohydrases supplemented diets on NC-1 recovered 100 kcal of AMEn/kg diet during 14–21 d phase only. Carcass yield and fat pad were not affected \( (P > 0.05) \) by treatments. The enzymes combination in this study was unable to recover the performance and AMEn determined by the dietary reduction of 150 kcal/kg of AMEn.

**Key Words:** broiler performance, enzyme, metabolizable energy