The basis of least-cost formulation is to rank raw materials according to both price and nutritive value and then to find the cheapest compromise meeting all constraints. Only feed formulation on basis of digestible amino acids (AA) will provide AA in an amount sufficient for the requested performance of an animal (growth, production of eggs, fertility). Additionally, the use of all raw materials in diet formulation is enabled, even raw materials of a lower AA digestibility because balancing according to animal’s requirement is possible (e.g., by supplementing AA). For the determination of digestibility different methods were developed. Impact factors such as a combined AA excretion of urine and feces, metabolization of indigested AA by intestinal microbes and their excretion, excretion of endogenous AA, and the variation of AA digestibility with age are considered by the concept of standardized ileal digestibility (SID). For determination of SID, apparent ileal AA digestibility is measured in growing broilers is standardized for a table value of endogenous AA losses. The concept has been introduced in feed formulation for broilers in the early 2000s. A first data set with SID coefficients for 20 raw materials plus combined values for peas and beans has been published in 2004 (Lemme et al.). A scan of recent literature as well as own research delivered data allowing for an extension of the number of raw materials to 24 backed by 36 references. The number of data backing coefficients for a raw material varies between 1 (soy protein concentrate and soybean full fat) and 70 (rapeseed/canola meal). Also the number of data backing single AA coefficients with a raw material varies between 0 (mostly for cysteine, tryptophan, and nonessential amino acids) and 70 (essential amino acids except tryptophan). For an improvement of a table for SID coefficients future research should concentrate on less investigated raw materials and consider always the determination of SID for cysteine, tryptophan and nonessential amino acids.

Key Words: amino acid, standardized ileal digestibility, broiler

The objective of this study was to determine the effect of mild coccidial vaccine challenge on standardized ileal amino acid digestibility (SIAAD) in 21- and 42-d-old broilers fed a corn-soybean meal-DDGS-poultry by-product meal based diet. The study was designed as a 2 × 2 factorial arrangement of treatments with 2 ages (d 21 and 42) and 2 levels of coccidial vaccine (Coccivac B) challenge (−/+ with 10× of coccidial vaccine). Each treatment combination was replicated 5 times and 40 birds were raised in d 21 and 192 for d 42) were randomized to experimental treatments in a complete randomized design. Half of the birds consisting of 8 replicate cages/treatment were challenged, CHA (d 15 and 36 for birds sampled on d 21 and 42, respectively) with 10× of coccidial vaccine, whereas the remaining half were not challenged (NCH). Standardized ileal amino acid digestibility on d 21 and 42 was determined by correcting apparent ileal amino acid (AA) digestibility values for basal ileal endogenous amino acid (EAA) losses generated within the same study from 21- and 42-d-old CHA and NCH birds fed a nitrogen-free diet. Significant interactions (P < 0.05) or tendency for interaction (P < 0.1) between age and treatment for ileal EAA losses were observed for most of the AA except for Cys. Ileal EAA losses for Met, Trp, Arg, and nitrogen (N) were lower (P < 0.05) in 42-d old NCH birds compared with 42-d-old CHA birds. There were significant interactions between age and treatment with apparent and standardized ileal DM, N, and AA digestibility values being lower (P < 0.05) in 21-d-old CHA birds. Apparent and standardized ileal DM, N, and AA digestibility for the NCH birds at 21 and 42 d old were not different (P > 0.05). However, coccidial vaccine challenge resulted in a decrease in apparent and standardized digestibility in 21-d-old CHA birds. The difference in SIAAD between the NCH and CHA 21-d-old birds for Met, Lys, Thr, and Val was 9.7, 10.4, 19.4, and 20.1 percentage units, respectively. Results from this study showed that coccidial CHA significantly influenced ileal AA digestibility on d 21 compared with 42-d-old birds.

Key Words: broiler, coccidial challenge, endogenous amino acid, standardized digestibility

The study was conducted to determine the effects of low ambient temperature (LAT) and dietary methionine hydroxyl analog (MHA) supplementation on the growth performance, blood parameters, and heart index, which is a sign of ascites syndrome, in broilers from 8 to 28 d of age. At 8 d, 800 birds were randomly assigned to 2 temperature (LAT and normal ambient temperature, NAT) and 4 dietary MHA addition (0, 0.17, 0.34 and 0.51%) in a 2 × 4 factorial arrangement of treatments (10 replicate pens with 10 birds per pen). Broilers in LAT were raised at 14°C to 16°C during 8 to 28 d, whereas groups in NAT were raised at 24°C to 26°C. Growth performance, blood parameters, and heart index were evaluated on d 14, 21 and 28. Data were analyzed by 2-way ANOVA using the GLM procedure of SAS. The whole experimental period, LAT decreased (P < 0.01) final BW, BW gain and ADFI, and markedly increased (P < 0.01) feed-to-gain ratio. Blood hematocrit (HCT) and red blood cell count (RBC) were increased (P < 0.01) by LAT. Low temperature also increased (P < 0.05) heart index of broiler at 21 and 28 d of age. Blood hemoglobin (d 14 and 21), RBC and HCT (d 21) concentration, and heart index (d 28) were decreased (P < 0.05) with an increase in dietary MHA supplementation. There was interaction (P < 0.05) between LAT and dietary MHA supplementation on HCT and RBC on d 14 and d, and a tendency (P = 0.06) for interaction (HCT) on d 21. These results suggested that LAT decreased growth performance and caused ascites syndrome to develop in broiler. However, dietary MHA supplementation mitigated the development of ascites syndrome in broiler under the condition of LAT.

Key Words: ascites, broiler, blood parameter, low ambient temperature, methionine hydroxyl analogue
131 Effects of dietary lysine and methionine supplementation on the breast meat quality of male broilers. W. Zhai*,1, M. W. Schilling1, E. D. Peebles1, and Y. Mercier2,1Mississippi State University, Mississippi State, MS, 2Adisseo France, Commentry, France.

In a previous companion study, we found that broiler growth performance and meat yield were improved by the feeding of increased levels of dietary lysine (Lys) and methionine (Met). In the current study, effects of dietary lysine and Met supplementation on breast (pectoralis major) meat quality of male Ross × Ross 708 broilers were determined. A completely randomized block design with 2 × 4 factorial arrangement of treatments was applied (10 blocks and 8 treatments/block). The diets, including 2 Lys levels (1.013 and 1.216%) and 4 Met levels (0.304, 0.380, 0.456, and 0.532%), were fed from 21 to 42 d of age in the form of pellets. Data were analyzed by 2-way ANOVA using the MIXED procedures of SAS 9.3. Broilers were processed at 42 d of age. Supplementary Lys increased sarcoplasmic protein (soluble protein) solubility (P = 0.007), decreased cooking loss (higher cooking yield; P = 0.0009), decreased shear force (increased tenderness; P = 0.035), increased pH (less protein denaturation; P < 0.0001), and decreased the lightness (associated with higher muscle pH and cooking yield; P < 0.0001) of breast muscle. Dietary Lys and Met interacted to affect cooking loss, in that breast meat from birds fed the highest Lys and Met levels showed the lowest cooking loss (P = 0.02). In conclusion, supplemental dietary Lys and Met increased growth rate and meat yield without having any adverse effects on the meat quality parameters tested. Furthermore, the supplementation of diets with Lys and Met may improve some meat quality parameters.

Key Words: breast, broiler, lysine, meat quality, methionine

132 Cost effectiveness of supplemental dietary lysine and methionine for meat yield in male broilers. W. Zhai*,1, E. D. Peebles1, and Y. Mercier2,1Mississippi State University, Mississippi State, MS, 2Adisseo France, Commentry, France.

In a companion study, it was found that birds responded differently to dietary methionine (Met) when lysine (Lys) levels varied. In addition, the improvement in meat yield in response to Met supplementation was mainly due to improvements in relative front half rather than leg yields. In the current study, the cost effectiveness of utilizing dietary Lys and Met supplementation to promote broiler meat yield was investigated using male Ross × Ross 708 broilers. A completely randomized block design with 2 × 4 factorial arrangement (2 Lys × 4 Met levels) of treatments was applied (10 replicates) from 21 to 41 d of age. The 2 Lys levels were 100 and 120% of recommended levels from NRC (1994; 1.013 and 1.216% in the final diets), and the 4 Met levels were 80, 100, 120, and 140% of recommended levels (0.304, 0.380, 0.456, and 0.532% in the final diets). Data were analyzed by ANOVA of SAS 9.3 using the GLM procedure. The cost of feed was calculated based on the price of ingredients from an adjacent area at the starting time of the experiment. Carcass part values were calculated based on historical data and 0.532% in the final diets). Data were analyzed by ANOVA of SAS 1994 (1.013 and 1.216% in the final diets), and the 4 Met levels were (T1 = 1.20% of Lys and 2950 kcal of ME/kg; T2 = 1.20% of Lys and 3050 kcal of ME/kg; and T3 = 1.35% of Lys and 3050 kcal of ME/kg) and 3 dietary energy densities (D100: the diet was fed as such; D90 and D80, the original diet was diluted with sand to get energy densities at 90 and 80%, respectively). The last 3 d, total excreta were collected and in an additional group of chicks the endogenous excretion of Lys was determined. At the end, birds were killed to determine the protein and Lys content and retention. Chicks killed at the beginning were used to correct for initial protein and Lys content. Results were subjected to ANOVA. The daily Lys intake and excretion was similar among dietary treatments, but the TFDLys was lowest (P < 0.01) in T3 (89.6%) compared with T1 (92.5%) and T2 (91.8%). The body protein and Lys content were not different among dietary treatments, but the ELys was lowest (P < 0.01) in T3 (61.0%) intermediate in T2 (67.3%) and highest in T1 (71.0%). In summary, chicks fed a diet with higher Lys and ME content (T3) had lower TFDLys and ELys for protein deposition compared with chicks fed a diet with lower Lys and energy content (T1); also chicks fed a diet with a lower Lys content but higher ME showed lower ELys for protein deposition.

Key Words: digestible lysine, metabolizable energy, efficiency of lysine utilization, chick

133 Effects of dietary lysine and energy on the efficiency of lysine utilization in starter chicks. S. Gomez*,1,2 and M. L. Angeles1,1National Institute of Forestry, Agriculture and Livestock Research, Ajuchitan, Queretaro, Mexico, 2Faculty of Higher Studies Cuautitlan-UNAM, Ajuchitan, Queretaro, Mexico.

The objective of this study was to evaluate the true fecal digestibility of lysine (TDFLys) and the efficiency of Lys (ELys) use for protein deposition in chicks from 3 to 12 d of age fed different levels of digestible Lys and ME. One hundred eighty Ross B308 chicks were allocated in groups of 5 per pen in a starter battery. Birds were randomly distributed in one of 9 treatments in a factorial arrangement of 3 diets (T1 = 1.20% of Lys and 2950 kcal of ME/kg; T2 = 1.20% of Lys and 3050 kcal of ME/kg; and T3 = 1.35% of Lys and 3050 kcal of ME/kg) and 3 dietary energy densities (D100: the diet was fed as such; D90 and D80, the original diet was diluted with sand to get energy densities at 90 and 80%, respectively). The last 3 d, total excreta were collected and in an additional group of chicks the endogenous excretion of Lys was determined. At the end, birds were killed to determine the protein and Lys content and retention. Chicks killed at the beginning were used to correct for initial protein and Lys content. Results were subjected to ANOVA. The daily Lys intake and excretion was similar among dietary treatments, but the TFDLys was lowest (P < 0.01) in T3 (61.0%) intermediate in T2 (67.3%) and highest in T1 (71.0%). In summary, chicks fed a diet with higher Lys and ME content (T3) had lower TFDLys and ELys for protein deposition compared with chicks fed a diet with lower Lys and energy content (T1); also chicks fed a diet with a lower Lys content but higher ME showed lower ELys for protein deposition.

Key Words: broiler, feed cost, lysine, methionine, meat yield

134 Feeding broiler diets formulated with varying crude protein restrictions with l-valine and l-isoleucine supplementation. D. J. A. Miranda*,1, S. L. Vieira1, H. S. Cemin1, H. V. Rios1, and E. T. Nogueira2,1Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, 2Ajinomoto Bioquimica, Sao Paulo, SP, Brazil.

The objective of this study was to compare 4 corn-soy feeding programs (PRG) formulated with or without a minimum in crude protein (CP) and with or without supplementation of l-Val and l-Ile. A total of 4,800 one-day-old Cobb 500 male broiler chicks was placed in 96 floor pens, 25 birds each, 9.0 birds/m2. The study was replicated twice in time. From pre starter to finishing the feeding programs to 21d were: PRG 1, CP restricted to a minimum (22.4, 21.1, 19.8, 18.4% for each phase) with AA to Lys ratios only set for TSAA (0.72) and Thr (0.65); PRG 2, CP was not restricted while minimum ratios of AA to Lys were extended to Val (0.77) and Ile (0.67); PRG 3, as PRG 2 with l-Val added; PRG 4 as PRG 3 with l-Ile added; totaling 4 treatments with 48 replicates. From 22 to 42d, each PRG was subdivided in 4 PRG having the same rational as it was done to 21d, where each of the 4 PRG began receiving all 4 PRG for grower and finisher phases. Analysis of variance was conducted with 4 treatments to 21d and as completely randomized design using a 4 × 4 factorial arrangement (4 PRG from 1 to 21 d and 4 PRG from 22 to 42 d) with a total of 16 treatments and 12 replicates. Data were analyzed using the PROC MIXED procedure of SAS, considering the housing as a random effect. At 21 d, BWG was improved for PRG 2, 3.
and 4, while FCR was better for PRG 2. No interactions between the PRG used 1 to 21 d and 22 to 42 d were observed on growth performance; however, PRG 2 led to the best FCR from 22 to 42 d and from 1 to 42 d, but without statistical difference from PRG 3 and 4. Birds fed PGR 1 from 1 to 42 d showed the lowest BWG and the highest FCR without statistical differences from PGR 2 and 3 and PGR 3 and 4, respectively. Feed intake was higher for PRG 4 but the BWG and FCR were similar compared with PGR 2 which showed the greater growth performance results. Supplementation with l-Val and l-Ile, in diets without maintaining a minimum CP allowed growth performance similar to that of diets supplemented with the usually available AA synthetic sources of Met, Lys and Thr having a higher CP.

**Key Words:** amino acid, broiler, l-isoleucine, l-valine

### 135 Broiler responses to feeds formulated with minimum crude protein restrictions using supplemental l-valine and l-isoleucine. D. J. A. Miranda*, S. L. Vieira1, R. F. A. Cruz1, H. V. Rios1, and E. T. Nogueira2, 1Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil, 2Ajinomoto Biolatina, São Paulo, SP, Brazil.

The objective of this study was to compare 4 corn-soy feeding programs formulated with or without crude protein (CP) restrictions supplemented with or without l-Val and l-Ile, and using different digestible (dig) Lys levels. Diets were formulated using Brazilian industry standards for dig Lys or with a 5% increase. A total of 1,800 one-day-old slow feathering Cobb × Cobb 500 male broiler chicks was placed on 72 floor pens; 25 birds per pen, 9 birds/m². Feeding programs (PRG) were as follows: PRG 1: CP was restricted to a minimum (22.4, 21.1, 19.8, 18.4% for pre starter, starter, grower, and finisher phases, respectively) with AA to Lys ratios set only for TSAA (0.72) and Thr (0.65); PRG 2: CP was not restricted, whereas minimum ratios were also extended to Val (0.77) and Ile (0.67); PRG 3: restrictions were as in PRG 2 but with l-Val added; PRG 4: restrictions were as in PRG 3, but with l-Ile added. For each phase, feeds had formulated dig Lys as 1.324%, 1.217%, 1.095% and 1.006% or 5% higher. A completely randomized 4 × 2 factorial of 4 PRG and 2 dig Lys was used. No interaction was found between PRG and dig Lys, with one exception for BWG and FCR from 36 to 43 d with birds fed PRG 2 demonstrating improvements in BWG and FCR when fed the 5% increasing in dig Lys. Cumulative BWG and FCR at 35 and 43 d and in each individual feeding phases showed broilers from PRG 2 having the best BWG and FCR; however, mean separations using Tukey showed no difference from birds fed PRG 1 and 3 dig Lys, with one exception for BWG and FCR from 36 to 43 d with PRG 1 dig Lys. Feed intake was higher for PRG 4 but the BWG and FCR were similar compared with PGR 2 which showed the greater growth performance results. Supplementation with l-Val and l-Ile, in diets without maintaining a minimum CP allowed growth performance similar to that of diets supplemented with the usually available AA synthetic sources of Met, Lys and Thr having a higher CP.

**Key Words:** amino acid, broiler, l-isoleucine, l-valine


An experiment was conducted to determine the effect of differing digestible amino acid (DAA) concentrations on productive parameters and feathering of broiler breeders. Ross 708 pullets and Ross males were reared according to 2011 Ross body weight standard. At 22 weeks of age, birds were randomly assigned to pens in a curtain sided building with 3 treatments replicated 12 times each (70 hens with 7 males per pen). The treatments were identical in nutrient content except for DAA. Treatment A was based on 2013 Aviagen Ross 708 nutrition specifications. Treatment B was identical to treatment A except for a 10% increase in DAA. Treatment C was based on model estimated DAA requirements (Hurwitz and Bornstein, 1973). All diets were formulated to meet Ross 708 Parent Stock Nutrition Specifications for all nutrients except for changes in DAA levels. During the production phase all birds were fed to their estimated dietary energy needs. Beginning at 25 wk of age, hens were fed on an energy allocation schedule such that peak feed energy amounts were attained at 27 wk, 3 d (approximately 60% production). There were no significant treatment effects on egg production or mortality. Average egg weights for treatment C were significantly lower ($P < 0.05$) when compared with treatments A and B, from 41 weeks until the end of the trial. Average hatch percentage of eggs from treatment C was significantly lower ($P < 0.05$) when compared with treatment B for wk 57 to 59. Hens of treatment C exhibited poorer feathering from wk 41 until the end of the trial. Results of this trial indicate how DAA levels can affect fertility, hatchability, egg weight, and feathering.

**Key Words:** broiler, breeder, feathering, amino acid

### 137 The response to meat ducks to dietary energy and protein. Q. F. Zeng*, P. Cherry2, A. Doster3, R. Murdoch4, O. Adeola5, and T. J. Applegate1, 1Institute of Animal Nutrition, Sichuan Agricultural University, Chengdu, Sichuan, China, 2Lincoln, United Kingdom, 3Maple Leaf Farms, Leesburg, IN, 4Animal Science Department, Purdue University, West Lafayette, IN.

A study was conducted to determine the influence of dietary energy and protein concentrations on growth performance and carcass traits of Pekin ducks from 15 to 35d of age. In experiment (Exp) 1, 15-d-old ducks were randomly assigned to 3 dietary ME (11.8, 12.8, and 13.8 MJ/kg) and 3 CP concentrations (15, 17 and 19%) in a 3 × 3 factorial arrangement (6 replicate pens; 66 ducks per pen). Carcass characteristics were evaluated on d 28, 32 and 35. In Exp 2, 15-d-old ducks were randomly allotted to the 9 dietary groups (6 replicate pens; 6 ducks/replicate). For Exp 2, diets from Exp 1 were remixed with 0.5% chromic oxide as a digestibility marker. Excreta were collected from d 17 to 19, and ileal digesta was collected on 19d to determine AME and amino acid digestibility. In Exp 1, there were interactions ($P < 0.05$) between dietary ME and CP on BW gain and feed intake, wherein BW gain increased more to increasing dietary CP as dietary ME increased. However, feed intake was only influenced by dietary CP at 11.8 MJ of ME/kg and not 12.8 or 13.8 MJ/kg. As dietary CP increased from 15 to 19%, breast meat yield increased by 10.8% whereas breast skin and fat decreased by 9.89% on d 35 ($P < 0.0001$). Conversely, increasing ME from 11.8 to 13.8 MJ/kg increased dressing percent, breast skin and fat, but decreased breast meat yield on d 35 ($P < 0.01$). In Exp 2, the determined AMEn for diets formulated to contain 11.8, 12.8, or 13.8 MJ ME/kg were 11.66, 12.68, or 13.75 MJ/kg, respectively; determined standardized ileal digestible Lys were 0.95, 1.00, or 1.21% for diets formulated to contain 15, 17, or 19% CP, respectively. These results provide a framework for subsequent modeling of amino acid and energy inputs and the corresponding outputs of growth performance and carcass components.

**Key Words:** carcass traits, crude protein level, duck, metabolizable energy level, nutrient utilization

### 138 Withdrawn