Metabolism and Nutrition: Vitamins and Minerals

177 A Review of Vitamin Recommendations in Broiler Breeders Hugo Romero-Sanchez*[1], Dinabandhu Joardar[2] [1]*Novus International, , Wake Forest, North Carolina, United States;* [2]*Cargill, Animal Nutrition, Elk River, Minnesota, United States*

Vitamins are nutritional organic elements essential for development, growth, and metabolism of cells in small quantities. Vitamins are well deposited into eggs and deficiencies under commercial conditions rarely occur; however, there is an increasing interest in studying the role of high vitamin supplementation in broiler breeders to improve breeder and broiler performance. This review reports the recommendations for dietary supplementation of vitamins from various organizations that reflect practical conditions of the broiler breeders in different regions under practical husbandry conditions. Vitamin recommendations differ between organizations, genetic lines, and premixes suppliers. Difference depends on the literature review, practical experience and reflects type of diet. Recommendations for wheat diets tend to be higher than for corn diets, and recently Aviagen (2022) have increased vitamin recommendations to reflect the genetic improvement in feed conversion and growth rate. Since vitamins are required in low amounts, their cost in the feed represents a low percentage (1-2%), that might justify an increment in supplementation, to overcome fluctuations in environmental temperatures, diseases, stress, biological variations, diet composition, bioavailability and nutrient interactions. However, the cost of fortifying the ration with vitamins should be weighed against the breeder and progeny performance and health. Some vitamins have been studied more extensively than others, and for example dietary recommendations of vitamin E have increased to improve semen quality and fertility, while natural antioxidants might partially replace the need for those high levels. On the other hand, different metabolites of vitamin D have shown to improve calcium absorption, breeder, and progeny performance. As intake and utilization of vitamins from feedstuffs are unpredictable due to variable content, bioavailability, and feed processing it is safer to cover the entire vitamin requirement of poultry through dietary supplementation, and the practical levels should be determined according with biological and economic reasons.

178 Effects of vitamin D source on egg production and quality in end-of-cycle laying hens Doug Korver*[2], Kathrin Buehler[1], Jan Dirk Van der Klis[1], Emmanuel Opoku-Yeboah[2] [1]*Herbonis Animal Health GmbH, , Augst, BL, Switzerland;* [2]*University of Alberta, Agricultural, Food & Nutritional Science, Edmonton, Alberta, Canada*

Laying cycles in excess of 100 weeks require nutritional support to maintain egg production, hen health and shell quality. Lohmann Brown (**LB**) and White (**LW**) hens (n=336/strain) were housed in battery cages with 4 hens/cage; treatments were evenly distributed among 7 identical rooms. Experimental diets were: **Control** (2,500 IU vitamin D_3/kg feed), **25OHD** (Control plus 62.5 µg 25-OH vitamin D_3/kg feed (DSM Nutritional Products) or **PAN** (Control plus 1 µg 1,25-$(OH)_2$ vitamin D_3/kg feed as Panbonis (Herbonis Animal Health GmbH)) fed from 74 to 106 weeks of age. The basal diet provided 3.75% Ca and 0.40% available P (**avP**) from 74 to 83, and 3.80% Ca and 0.27% avP from 84 to 106 weeks. All diets contained phytase (1,000 FYT/kg feed, Ronozyme HiPhos GT, DSM Nutritional Products). From 84 to 106 weeks, diets were devoid of added inorganic P. Measurements were body weights at 8-week intervals, feed intake and feed conversion ratio (g feed/g egg), egg production during each 4-week period, and shell quality at 4-week intervals. Data were analyzed as a two-way ANOVA, based on strain and diet. Differences were considered significant at $P \leq 0.05$. LW hens had lower body weight throughout the trial, but a greater feed disappearance due to increased feed wastage. From 75 to 106 weeks, egg production of LW was greater than that of LB hens (84.07% vs 72.83%, respectively; SEM = 1.13%). In spite of feed wastage, LW hens had 5 to 15% lower FCR from 75 to 106 weeks, with the strain disparity increasing with age. Diet did not affect any of the preceding measures. Despite being smaller, LW laid larger eggs than LB hens at most ages. Both PAN and 25OHD reduced egg weight in LW hens, but each increased egg weight relative to the control in LB hens at 92 weeks; at 77 weeks this interaction was nearly significant (P = 0.06). PAN increased shell thickness at 78 weeks relative to 25OHD; at 87 weeks, specific gravity was nearly significantly decreased by PAN in LB, but there was no effect in LW hens (P = 0.06). Although there was no strain effect, PAN and 25OHD each nearly increased (P = 0.08) shell strength at 78 weeks. At 91 weeks, each treatment reduced shell strength relative to the control. LB had greater Ca digestibility than LW hens at 84 weeks (64.4% vs 49.1%, respectively, SEM = 4.6%), but there was no strain effect at 106 weeks. Ca digestibility was not affected by diet. LW had greater performance traits than LB hens, although there were infrequent strain differences in response to the vitamin D sources. Neither PAN nor 25OHD had a clear beneficial effect in end-of-cycle laying hens. Removal of supplemental inorganic P did not appear to have a detrimental effect in LW; the effect of removal was less clear on LB hens.

179 Would correlative elemental imaging explain the assimilation of essential trace elements in eggshell? Iris Valido[23], Rosa Mary Lopez Alvarez[2], Florent Penen[12], Maria Angels Subirana[2], Stéphane Faucher[4], Pascale Sénéchal[4], Peter Moonen[4], Sandra Mounicou[2], Alessandra Monteiro*[1], Dirk Schaumloeffel[2] [1]*Animine, , Meythet, , France;* [2]*CNRS, Université de Pau et des Pays de l'Adour, IPREM UMR 5254, , Pau, , France;* [3]*Universitat Autònoma de Barcelona, Centre GTS, Departament de Química, , Barcelona, , Spain;* [4]*CNRS, Université de Pau et des Pays de l'Adour, DMEX IPRA FR 2952, , Pau, , France*

Broken eggs represent an important source of economic loss for the egg industry. Shell defects are even more often in old layer hens, which have eggs with a thinner shell. Trace mineral (TM) supplementation can help to improve the eggshell quality, thanks to the role of TM on shell formation. The objectives of this study were to evaluate the effect of TM supplementation on eggshell quality and understand how TM are incorporated into eggshell. 936 Leghorn layers (60 weeks of age) were distributed in three treatments with 12 replicates of 26 birds. Treatments were: negative control (NC) diet, without TM supplementation (54 ppm Zn, 60 ppm

Mn); Zn diet, NC + 90 ppm of Zn from HiZox; Mn diet, NC + 110 ppm of Mn from ManGrin (Animine, Annecy, France). After 20 weeks trial, eggs were collected and analyzed for fracture force, shell thickness and correlative imaging (X-ray tomography, Laser ablation LA-ICPMS, and NanoSIMS). Shell thickens was improved (P<0.05) by both Zn and Mn supplementation (0.35 mm) in comparison to NC (0.34 mm). However, fracture force was improved (P<0.05) when hens received Mn diet (37 N) than Zn or NC diets (35 N in average). Correlative imaging results (X-ray tomography and LA-ICPMS) showed that Mn and Zn are located in the outer membrane of the eggshell and in the cuticle, whereas Ca is mainly found in the palisade and mammillary layers. NanoSIMS images revealed that Ca in eggshell seems to be more present in Mn supplemented diets, which may be related to the impact of Mn on calcium-binding proteins, and would explain the better fracture force in these eggs. In conclusion, TM supplementation improves eggshell quality but the effect of Mn seems to be more important than Zn.

180 Supplementation of organic trace minerals of lysine maintains chickens' performance and reduces mineral excretion in feces compared to inorganic and organic sources of minerals. Tristan Chalvon-Demersay[1], Romain Bouvet[2], Josselin Le Cour Grandmaison*[1] [1]*METEX NOOVISTAGO, , Paris, Select One..., France;* [2]*ZOOTESTS, , Ploufragan, , France*

Minerals (copper, zinc, manganese and iron) when they are supplied as inorganic form are associated with significant excretion in the environment and potential ecological damages. This urges to find ways to optimize their bioavailability. The aim of this study was therefore to compare the effects of iron (Fe), copper (Cu), zinc (Zn) and manganese (Mn) supplementation from different sources on performance and mineral excretion of broilers. Organic trace minerals (OTM) of lysine (Mizinate) were compared to inorganic sources or OTM of glycine (Glycinate). 1000 one day-old broilers (Ross 308) were randomly assigned to 5 treatments, each consisting of 10 pens. In the control treatment group (Control), minerals were provided with a full dose of trace minerals as sulfates or oxides : Cu, Fe, Zn and Mn at 12, 80, 60 and 85 ppm, respectively. In the Mizinate and Glycinate treatment groups, minerals were provided with a the same dose as organic trace minerals of lysine or glycine, respectively. In the last two treatment groups, ½ Mizinate and ½ Glycinate, minerals were provided at half the dose as organic trace minerals of lysine or glycine, respectively. Feed intake (FI), average daily gain (ADG) and feed conversion ratio (FCR) were monitored from d0 to d12 and from d0 to d35. At day 35, muscle and feces samples wereare collected and mineral content were measured by ICP-OES. Differences were tested by one-way ANOVA, followed by Tukey post-hoc test ($P < 0.05$). Performance did not differ across treatment from d0 to d12 or from d0 to d35 (P>0.05). In the feces, manganese and iron concentrations were significantly reduced in all treatment compared to the control group ($P < 0.05$) except for the Glycinate group. Mizinate and ½ Mizinate were associated with the lowest concentrations of manganese and iron in the feces. Zinc and copper concentrations were significnalty reduced only in ½ Mizinate and ½ Glycinate treatment groups compared to the control (P<0.01). In the muscle, only zinc and copper were detectable. Copper concentration did not vary across treatments (P>0.05). On the contrary, zinc concentration was significantly increased in the mizinate group compared to all groups (P<0.01). except the glycinate one where a trend could be observed ($P = 0.074$). In summary, this study suggests that OTM of lysine are an efficient source of minerals and are associated with improvement of mineral bioavailability marked by a reduction of mineral excretion in feces and an increased concentration in the muscle. Dose of minerals can be cut by half without impairing performance when minerals are provided as OTM of lysine or glycine. The metabolic fates of the four minerals still remain to be fully clarified.

181 Effects of different sources and levels of copper and manganese on immune responses for broilers chickens challenged with *E. coli* LPS Luigi A. Moreira*[1], Karolina Von Zuben Augusto[2], Priscila M. Groff-Urayama[3], Cassio Y. Oura[3], Fernanda Kaiser de Lima-Krenchinski[3], Tatiane Souza dos Santos[3], Paola Aparecida Damázio Rodrigues[3], Jéssica M. Cruvinel[3], Julianna Batistioli[3], Carolina Santos[3], José R. Sartori[3] [1]*Selko Feed Additive, Mineral Program, Amersfoort, Utrecht, Netherlands;* [2]*Selko Feed Additive, R&D, Campina, Sao Paulo, Brazil;* [3]*São Paulo State University (UNESP), Animal Breeding and Nutrition Dept., Botucatu, , Brazil*

In broiler nutrition copper and manganese are commercially available in organic, inorganic and hydroxychloride forms. The hydroxychloride form copper (IntelliBond® C - IBC) and manganese (IntelliBond® M- IBM) have emerged as a proven an alternative source of trace mineral supplementation and are known for their strong chemical bonds, which improves their stability in the diet and in gastrointestinal tract. Thus, the objective of the present study was to evaluate the effect of different sources and levels of Cu (Cu Sulfate monohydrate - CSM and IBC) and Mn (Mn sulfate monohydrate - MSM and IBM) on immune system parameters. A total of 1,920 1-d-old male Cobb chicks were allocated to eight dietary treatments in a 2x3+2 factorial arrangement. The factors were two levels of IBC (15 and 150 ppm) and three levels of IBM (40, 80 and,120 ppm) and two additional treatments that were the controls with sulfate source (15 ppm CSM + 80 ppm MSM and 150 ppm CSM + 120 ppm MSM), with 8 replicates of 30 birds each. The diets were based on corn and soybean meal according to the recommendations of each phase: pre-starter (d1-d7), starter (d8-d21), grower (d22-d35) using Rostagno et al. (2011) broiler nutritional recomendations. At 35 days of age 12 birds per treatment were selected and were subjected to abdominal inoculation with *E. coli* LPS. At 48 hours after the challenge, abdominal liquid was collected of the birds for determination of nitric oxide (NO) and hydrogen peroxide (H_20_2) production by macrophages (respiratory burst), activity of superoxide dismutase (SOD) in liver and white blood cells parameters were analyzed. ANOVA stadistical test was performed. Data were analyzed with Minitab® 18, and the means were compared by Tukey and Dunnett tests (P<0.05). Broilers fed diets containing 150 ppm IBC resulted in higher production of H_2O_2 and NO by macrophages (P=0.045). The supplementation level of 80 ppm IBM produced higher SOD activity, and nitric oxide production for broilers (P=0.025). Broilers supplemented with 80 and 120 ppm of IBM resulted in higher basophil count than those who received 40 ppm IBM. In review, broilers supplemented with hydroxychloride sources had higher enzyme SOD activity, NO and H_20_2 production when compared to sulfate sources.