Determination of the nutrient composition and metabolizable energy of new ingredients are essential for their use in feed formulation. Insects are considered promising sources of animal origin ingredients for poultry diets. The objectives of this study were to determine the nutrient composition and the apparent metabolizable energy corrected for nitrogen (AMEn) of tenebrio (Tenebrio molitor) meal (TM) for broiler chickens.

Forty-eight 21-d-old male broilers of commercial strain were weighted and placed over 12 metabolic cages (0.70 × 0.66 m) equipped with one galvanized trough feeder at the front and a linear drinker at the back in a completely randomized design. Each treatment was composed of 6 replicates (cages) of 4 birds assigned into 2 assay diets: a control diet, based on corn and soybean meal to meet nutritional requirements, and an experimental diet subsequently formulated by replacing 300 g/kg (wt/wt) of the control diet with TM. The adaptation period lasted 7 d. Feed and water were available ad libitum. Total excreta samples were collected from d 28 to d 32, twice a day (morning and afternoon) on metal trays covered with plastic material, weighted and stored at -20°C for further analysis. Feed intake was measured per cage and 1% ferric oxide was added to the diets on the first and last day of the collection to identify precisely excreta from the test period. TM was analyzed for dry matter (DM), crude protein (CP), gross energy (GE), ether extract (EE), crude fiber (CF), calcium, phosphorus, and fatty acids. Samples of the diets, and excreta were analyzed for DM, nitrogen (N), and GE. The apparent total-tract digestibility coefficient (ATTDC) of nutrients and AMEn were calculated based on the analytical results. TM used in this study contains 50.0% CP, 6,366 kcal/kg GE, 29.7% EE, 3.8% CF, 0.07% calcium, and 0.54% phosphorus, as fed basis. Regarding fatty acids profile, TM is a rich source of oleic 45.4%, linoleic 26.2%, and palmitic acid 15.4%, showing also good content of stearic 2.3%, palmitoleic 1.9%, and linolenic acid 1.1%. The ATTDC of DM, N, and GE of TM were 70.2%, 37.3%, and 79.6%, respectively. Calculated AMEn was 5,004 kcal/kg DM, indicating that TM has higher metabolizable energy value compared with common animal and vegetable food origin sources as other insect larvae meals already published in literature. The values of nutritional composition and AMEn of TM determined in this study might be applied as a guide for poultry feed formulation using this ingredient. Acknowledgment: FAPESP for the research grant (No. 2017/05423–8) and MS scholarship (No 2017/19751–7).

Key Words: insect meal, Tenebrio molitor, metabolizability, energy, broilers

We studied the influence of the nutritive value (AMEn, SID Lys, and Ca) of diets fed to pullets from 15 to 26 wk of age, on productive performance, egg quality, and tibia mineral content of brown egg-laying hens from 27 to 62 wk of age. Five feeding strategies were used. Three of them differed in the nutrient content of the diet fed from 15 to 18 wk of age: A) a pullet diet (2,700 kcal AMEn/kg, 0.61% SID Lys, and 1.0% Ca), B) a pre-lay diet (2,750 kcal AMEn/kg, 0.78% SID Lys, and 2.5% Ca), and C) a layer diet (2,750 kcal AMEn/kg, 0.78% SID Lys, and 3.8% Ca), respectively. The other 2 feed strategies (D and E) consisted in feeding the hens from 15 to 26 wk of age a diet low in energy (2,615 kcal AMEn/kg) and high in SID Lys (0.82%) diet with a medium or a high level of Ca (2.5 vs. 3.8%, respectively). After 18 wk (diets A, B, and C) or 27 wk (diets D and E) of age all the hens received the C layer diet to 62 wk of age. Each treatment was replicated 18 times and the experimental unit was an enriched cage with 10 hens for all traits. The experiment lasted for 12 periods of 4 wk each. Hen performance (egg production, egg mass, FCR, BW gain, and mortality) was controlled by replicate by period and cumulatively. Percentage of shell-less, broken, and dirty eggs were determined in all eggs produced. Egg quality, including Haugh units, shell thickness, shell strength, and shell weights in absolute (g) and in relative (%) terms, were determined by replicate in 8 eggs chosen at random for the last 2 d of each of the 12 periods. At 62 wk of age, one hen from 8 of the replicates per treatment was selected at random and sacrificed. The ash, Ca, and P content of these tibiae were determined. Data were analyzed as a completely randomized design with feeding strategy as main effect using the MIXED procedure of SAS. The Tukey test was used to make pairwise comparisons to separate treatment means. Feeding strategy did not affect any of the productive performance traits studied, except egg weight that tended (P = 0.079) to be greater in hens that were fed the high energy diets during the pre-peak period. Cumulatively, all shell quality variables studied were better (P < 0.05) in hens fed the 3.8% Ca diets during the experimental period than in hens fed 2.5% Ca or less, but Haugh units were not affected. At 62 wk of age the pre-peak feeding strategy did not affect the ash, Ca, or P content of the tibia. In summary, the use of a layer diet with 3.8% Ca from 15 wk of age onward, might improve shell quality traits during the entire egg cycle, without showing any negative effect on egg production.

Key Words: calcium level, external egg quality, laying hens, pre-peak feeding

We studied the influence of the source and level of digestible phosphorus (DP) in the diet on performance and egg quality traits of brown laying hens from 64 to 76 weeks of age. P. Hernández1, A. F. de Juan1, G. Fondevil1, J. Ben Mabrouk1, J. Garcia2, R. Scappaticcio2, and Gonzalo Mateos1, 1UPM, Madrid, Madrid, Spain, 2Camar Agroalimentaria S.L., Toledo, Spain.

We studied the influence of the source and level of digestible phosphorus (dP) in the diet on performance and egg quality traits of brown hens from 64 to 76 wk of age. The diets were based on corn and soybean meal and all contained 4.0% Ca. The design was completely randomized with 8 treatments arranged as a 2×4 factorial with 2 sources of P [monocalcium phosphate (MCP) and calcined bone phosphate (CBP)] and 4 levels of dP (0.27, 0.31, 0.35, and 0.39%) as main effects. Each treatment was replicated 14 times and the experimental unit was an enriched cage with 6 hens. The experiment lasted for 12 wk (3 periods of 4 wk each). Egg production and hen mortality were recorded daily. Feed intake (FI) and BW of the hens were determined by period and cumulatively. Egg weight was estimated by period by weighing all the eggs produced the last day of each week on trial. From these data, ADFI, egg mass, feed conversion ratio (FCR), and BW gain (BWG) were calculated by period.
and cumulatively. Egg quality traits, including Haugh Units and shell resistance to breakage, were determined per cage in 8 eggs collected at random the last 2 d of each experimental period. In addition, the percentage of dirty, broken, and shell-less eggs was recorded in all eggs produced. Data were analyzed as a completely randomized design with source of P and level of dP of the feed as main effects, and the interaction between them was also analyzed. In addition, the effect of the level of dP on the different variables studied was partitioned into linear (L) and quadratic (Q) components. No interactions between main effects were detected for any of the traits studied and therefore, only main effects are presented. Neither source of P nor level of dP affected any of the productive traits studied, except BWG that increased (L; \( P < 0.05 \)) as the level of dP of the diet increased. An increase in dP of the diet from 0.27 to 0.39% tended to reduce (L, \( P = 0.077 \); Q, \( P = 0.058 \)) shell resistance to breakage. Haugh units decreased linearly (\( P < 0.01 \)) as the level of dP increased. The percentage of non-sealable eggs (dirty, broken, and shell-less eggs) was higher in hens fed CBP than in hens fed MCP (\( P < 0.05 \)). In conclusion, from 64 to 76 wk of age, hens require no more than 0.27% dP in the diet for optimal egg production and egg quality. An excess of dP (\( \geq 0.39\% \)) might reduce shell quality. Hens responded similarly to both sources of P but the percentage of non-sealable eggs increased with the use of calcined bone phosphate.

**Key Words:** digestible phosphorus, calcined bone phosphate, egg quality, laying hen, monocalcium phosphate

### 401 Biostrong® 510 improves performance of laying hens just after peak production

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Just before peak production of laying hens, a rapid increase in nutrients is necessary since the birds must cover the requirement to grow to the adult body weight, to achieve peak of production and to get a rapid egg weight increase. From the start of lay until peak production, feed consumption should increase by about 40% to allow the birds to meet their requirements for egg production and growth. After peak production, feed intake is stabilized and in general increases no further. That is why another strategy can be used to increase nutrient availability in laying hens after peak production. Research has shown that the use of phytogenic feed additives, such as essential oils, pungent, and bitter substances stimulate digestive enzyme production and induce a higher secretion of bile acids. Essential oils are also used to enhance the activities of trypsin and amylase. In addition, quillaja saponins can act as a nutrient transporter. A study was undertaken to examine the effect of Biostrong® 510, a mixture of essential oils, pungent and bitter substances and quillaja saponins, on the production performance of laying hens after peak production (from 32 until 55 weeks). 375 Isa Brown laying hens are used in this trial, with 5 hens per pen and 25 repetitions per treatment. Three dietary treatments have been tested: 1) control feed before and after peak (CTR), 2) 150 g/t Biostrong® 510 added before and after peak (BSG), 3) control feed before peak and 150 g/t Biostrong® 510 added after the peak (CTR-BSG). At the start of the trial, BSG had 2% lower laying rate and +4 points FCR compared with CTR and CTR-BSG. This effect disappeared after 2 weeks. Egg weight, egg mass and laying rate increased as FCR decreased from 32 weeks onwards for both BSG and BSG-CTR compared with CTR. Until 40 weeks, the difference between CTR and BSG and CTR-BSG was small (~4 points FCR, +1.5% laying rate). After 40 weeks, this difference broadened with an increase of laying rate (+4%) and a clear decrease in FCR (~10 points) at wk 50. Considering the full period of 32–55 weeks, an increase of laying rate from 92.4% for CTR to 94.5% for CTR-BSG and to 94.6% for BSG and a decrease in FCR from 1.967 for CTR to 1.916 for CTR-BSG and to 1.918 for BSG was achieved. These results clearly indicate that laying hens take advantage of the extra nutrients that are released with the help of phytogenic feed additives.

**Key Words:** phytophagens, digestibility, laying hens, nutrient utilization, post-peak production

### 402 The effects of dietary rubber seed oil on hens laying performance, egg quality, and fatty acid content and composition and cholesterol content in yolks

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To evaluate the application of rubber see oil (RSO) in the production of n-3 polyunsaturated fatty acid enriched eggs, a dose-response experiment was conducted to evaluate the effects of dietary RSO levels on hens laying performance, egg quality, and fatty acid content and composition and cholesterol content in egg yolk. Three hundred and 60 30-week-old healthy Lohmann Brown laying hens, with similar laying rate and body weight, were randomly allotted to 5 groups (4 replicates, 18 birds/replicate) and fed 5 experimental diets (0, 1%, 2%, 4%, and 6% RSO) for 8 weeks. The results showed that the egg production and daily egg mass were increased in 4% RSO group (\( P < 0.05 \)), but egg weight, yolk percentage, egg shape index, albumen height, and the contents of dry matter, lipid, and protein in yolks were not influenced by dietary treatments (\( P > 0.05 \)). Yolk color was improved (\( P < 0.05 \)) while Haugh units after storing at room temperature for 6 d decreased (\( P < 0.05 \)) gradually with the increasing RSO levels. Total triglyceride and cholesterol contents of yolks were also reduced in RSO supplemental groups. The concentration of total n-3 PUFA in yolks increased (\( P < 0.001 \)) gradually, while n-6/n-3 ratio of yolks decreased (\( P < 0.001 \)) gradually with increasing RSO levels in diets. The enrichment of total n-3 PUFA and DNA in yolks showed a tendency that had a gradual increase and then reached a plateau during the feeding period, and more feeding days for the hens was needed to reach maximum enrichment at the low RSO levels. The 6% RSO group had highest DHA and total n-3 PUFA levels, reaching 353.74 mg DHA and 396.49 mg total n-3 PUFA per egg, respectively. In conclusion, dietary RSO supplementation enriched yolk with n-3 PUFA (especially DHA) and improved yolk color without adverse effects on performance and egg quality, and indicated the practical feasibility to produce n-3 PUFA-enriched eggs.

**Key Words:** N-3 polyunsaturated fatty acids, rubber seed oil, eggs, enrichment, cholesterol

### 402 Not Presented