

# SELECTION OF PUBLISHED PAPERS PRESENTED IN ANIMAL NUTRITION MEETINGS IN 2016

Innovation & Applied Science  
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# Effect of serum concentration of beta-carotene at AI on productive and reproductive parameters in lactating holstein cows

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The objective of this study was to determine the effect of beta-carotene concentration in serum at the moment of artificial insemination (AI) on Holstein cows. A total of 497 lactating dairy cows were enrolled. All animals were assigned to a timed AI protocol (CIDR+ estradiol benzoate+GnRH-7d-PGF-2d-CIDR-out+PGF+ECP-2d-timed AI). Blood samples and body condition score were collected at the moment of AI. The serum B-carotene was quantified in a single step denaturation and extraction into a solvent, followed by measurement using a portable spectrophotometer (iCheck; BioAnalyt, GmbH, Teltow, Germany). Milk production and herd health records were collected for the entire experimental period, and pregnancy diagnosis performed by ultrasound 31 d post-AI. Data was analyzed using the MIXED and GLIMMIX procedures of SAS. Animals with BCS  $\leq 2.75$  had lower ( $P < 0.01$ ) concentration of B-Carotene compared with cows with BCS  $\geq 3.0$  ( $3.82 \pm 0.09 \mu\text{g/ml}$  and  $4.16 \pm 0.06 \mu\text{g/ml}$ , respectively). Multiparous cows had greater concentration of B-Carotene compared with primiparous ( $P < 0.01$ ). The concentration of B-carotene at fixed-TAI was greater in cows with at least one disease episode between parturition and timed AI compared with healthy animals ( $3.95 \pm 0.12 \mu\text{g/ml}$  vs.  $5.12 \pm 0.46 \mu\text{g/ml}$ ). There was no correlation between milk production and concentration of B-carotene ( $r < 0.01$ ), but a quadratic correlation between pregnancy per AI and concentration of B-carotene ( $P = 0.03$ ) was found. When serum B-carotene was categorized as low ( $< 3.0 \mu\text{g/ml}$ ), intermediate ( $\geq 3.0 - < 6.0 \mu\text{g/ml}$ ) and high  $\geq 6.0 \mu\text{g/ml}$ , cows with intermediate concentrations were more fertile than the other two categories (29.0%; 38.9% and 22.6%, respectively;  $P = 0.05$ ). In conclusion, the concentration of beta-carotene was affected by BCS, parity, incidence of diseases. Animals with intermediate concentrations in serum had greater pregnancy per AI, suggesting a possible use as a marker for fertility in lactating dairy cows.

**Keywords:** betacarotene, fertility, pregnancy per AI.

# Effects of essential oils and exogenous enzyme in low starch diets for finishing feedlot cattle

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**RONOZYME** RumiStar<sup>™</sup>

The objective of this study was to evaluate the effects of the combination of essential oils (Crina® Ruminants) and  $\alpha$ -amylase (Ronozyme® RumiStar™) on performance of Nelore bulls finished in feedlot. One hundred twelve Nelore bulls (initial BW = 349 kg  $\pm$  33) were fed during 90 d with diets containing 54.5% ground corn, 8.5% sugarcane bagasse, 16% soybean hulls, 12% whole cottonseed, 5% soybean meal, 3% minerals and vitamin supplement and 1% urea. Animals were blocked based on initial BW and randomly allocated in 14 pens. Treatments were: MON (Sodium Monensin, Tortuga® – 26 mg/kg DM) or CRINA-RUM (Crina® Ruminants, DSM®, 90 mg/kg DM and Ronozyme® RumiStar™, DSM®, 560 mg/ kg DM). Response variables included: final body weight (FBW); dry matter intake (DMI), average daily gain (ADG), feed efficiency (G:F), hot carcass weight (HCW) and dressing percentage (dressing, %). Pen was considered the experimental unit. The data were analyzed using PROC MIXED of SAS and means were compared by Tukey test considering the block as random effect and treatments as fixed effects. Animals fed with CRINA-RUM had 9.9% greater DMI (10.30 vs. 9.28 kg;  $P < 0.001$ ) and a tendency for greater FBW (529 vs. 523 kg;  $P = 0.07$ ) compared with animals fed MON, respectively. There was no effect of treatments on ADG (1.65 and 1.72 kg, for MON and CRINA-RUM respectively,  $P = 0.14$ ). Animals fed MON had greater G:F compared with CRINA-RUM (0.178 vs. 0.166,  $P < 0.01$ ). The combination of essential oils and  $\alpha$ -amylase increased HCW and dressing percentage. Animals fed CRINA-RUM had 6.4 kg more carcass compared with MON (298.2 vs. 291.8 kg respectively,  $P = 0.015$ ) and dressing percentage were 56.3 vs 55.8% for CRINA-RUM and MON respectively ( $P < 0.01$ ). In conclusion, the use of essential oil combined with  $\alpha$ -amylase improved intake, carcass dressing and weight in animals fed low starch diets combined with coproducts and can be an alternative to monensin.

**Keywords:** beef, coproducts, starch



# Effects of essential oils and exogenous enzyme in feedlot finishing cattle diets high in flint corn ground at different particle sizes

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**RONOZYME® RumiStar™**

The objective of this study was to evaluate the interaction between two feed additives – MON (Sodium Monensin, Tortuga®) vs. CRINA-RUM (the combination of essential oils - Crina® Ruminants, DSM® and  $\alpha$ -amylase - Ronozyme® RumiStar™) and two different ground flint corn particle sizes - ground corn (GC = 1.82 mm average particle size) vs. coarsely ground corn (CGC = 2.53 mm average particle size) on performance of finishing Nellore bulls. Two hundred fifty-six Nellore bulls (initial BW = 360 kg  $\pm$  38) were fed during 99 days with diets containing 82.5% ground corn (1.82 or 2.53 mm), 8.5% sugarcane bagasse, 5% soybean meal, 3% minerals-vitamins supplement and 1% urea. Animals were blocked based on initial BW and randomly allocated in 48 pens. Treatments were: GC + MON (1.82 mm ground corn and sodium monensin - 26 mg/kg DM), GC + CRINA-RUM (1.82 mm ground corn and the combination of essential oils - 90 mg/kg DM +  $\alpha$ -amylase - 560 mg/ kg DM), CGC + MON (2.53 mm ground corn and sodium monensin - 26 mg/kg DM) and CGC + CRINA-RUM (2.53 mm ground corn and the combination of essential oils - 90 mg/kg DM +  $\alpha$ -amylase - 560 mg/ kg DM). The data were analyzed using PROC MIXED of SAS in a 2 x 2 factorial arrangement (2 ground corn particle sizes and 2 feed additives). Pen was considered the experimental unit. No effect of treatment ( $P > 0.05$ ) was observed for final BW. Animals fed CGC (2.53-mm) showed a tendency to greater average daily gain (ADG;  $P = 0.08$ ) than animals fed GC (1.82 mm) – 1.60 and 1.50 kg, respectively. Effect of additive was also observed for DMI. Sodium Monensin (MON) decreased ( $P = 0.013$ ) DMI compared to the combination of essential oils and  $\alpha$ -amylase (CRINA-RUM) – 8.70 and 9.34 kg respectively. No effects of treatment ( $P > 0.05$ ) were observed on feed efficiency (G:F) and dressing percentage. There was an interaction effect ( $P = 0.02$ ) between ground corn particle size and feed additives for hot carcass weight (HCW). Animals fed CGC diets and CRINA-RUM presented 11.5 kg greater HCW ( $P < 0.05$ ) compared to animals fed CGC and MON - 295.2 and 283.7 kg, respectively. On the other hand, no effects ( $P > 0.05$ ) of additives were observed for HWC on GC diets. The CRINA-RUM combination for finishing cattle fed flint CGC diets increases HCW and can be an effective substitute for sodium monensin.

**Keywords:** beef, carcass, starch

# Effects of essential oils and exogenous enzyme in feedlot finishing diets high in flint ground corn at different particle sizes during the adaptation period

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**Keywords:** beef, Nellore, starch

# Effects of essential oils and exogenous enzymes on intake, digestibility and rumen fermentation in finishing Nellore cattle

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**RONOZYME® RumiStar™**

The objective of this trial was to evaluate the combination of essential oils and exogenous enzymes on intake, digestibility and ruminal fermentation in finishing Nellore cattle. Five Nellore steers ( $427 \pm 52$  kg BW) were fed isonitrogenous and isocaloric diets containing 82.5% corn, 8.5% sugarcane bagasse, 5% soybean meal, 3% mineral and vitamin supplement and 1% urea. The treatments were MON (Sodium Monensin, Tortuga® – 26 mg/kg DM), CRINA (Essential Oils: Crina® Ruminants, DSM® – 90 mg/kg DM), CRINA+MON (90 and 26 mg/kg DM, respectively), CRINA+RUM (CRINA +  $\alpha$ -amylase: Ronozyme® RumiStar™, DSM® – 90 and 560 mg/kg DM, respectively) and CRINA+RUM+P (CRINA+RUM+Protease: Ronozyme® Proact™, DSM® – 90; 560 and 840 mg/kg DM, respectively). Experimental design used was a 5 x 5 Latin square. The 20-d experimental periods consisted of 15-d for adaptation followed by 5-d for collections. Data were analyzed using the PROC MIXED of SAS and means were compared by Tukey test considering animal and period as random effects and treatments as fixed effects. Cattle fed CRINA+RUM presented greater ( $P < 0.01$ ) dry matter (DM) and total nutrient digestible (TND) intakes compared to MON (9.77 vs. 7.69 kg and 7.73 vs. 5.89 kg, respectively). CRINA increased ( $P = 0.02$ ) total crude protein (CP) digestibility compared with MON (74.9% vs. 65.3% respectively). The combination of CRINA+RUM+P also increased ( $P < 0.01$ ) total CP and the total carbohydrate digestibility in comparison with MON (75.0% vs. 65.3% and 91.0% vs. 84.8% respectively). Total starch digested (kg) was greater ( $P < 0.05$ ) for cattle fed CRINA+RUM in comparison with MON (5.44 kg vs. 4.19 kg respectively), although no difference ( $P = 0.12$ ) in fecal starch was observed between the treatments. No difference in total NDF ( $P = 0.73$ ) and EE ( $P = 0.60$ ) digestibilities, ruminal pH ( $P = 0.84$ ) and molar concentration of acetate ( $P = 0.14$ ) were observed among the treatments. Animals fed CRINA+RUM presented greater molar concentration of propionate ( $P = 0.02$ ) and lower acetate-to-propionate ratio ( $P = 0.04$ ), compared with CRINA+RUM+P (41.5 vs. 27.7 mM and 1.48 vs. 2.2, respectively). The ruminal ammonia-nitrogen was lower ( $P = 0.05$ ) for animals fed CRINA+RUM in comparison with CRINA+MON (12.4 vs. 20.26 mg dL<sup>-1</sup>). In conclusion, the utilization of essential oils and their combination with amylase increases the DM and TDN intakes and the amount of starch digested in the total tract compared with sodium monensin, presenting minor effects on fermentation parameters.

**Keywords:** amylase, protease, starch



**PORKEXPO 2016**  
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**Foz do Iguaçu, BR**



# Apparent and standardized ileal digestibility of protein and amino acids in diets with soybean meal and added protease

**RONOZYME® ProAct**

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## Introduction

As a result of its nutritional characteristics, soybean meal is the main protein ingredient used to feed pigs. This dependence, however, can become a problem when soybean prices are high, as this will have a direct influence of production costs. As a result, the search for alternatives to overcome large variations in grains prices is increasing. One way to improve the efficient utilization of soybean meal is to add enzymes and thus it is possible to reduce its inclusion in the diets. Proteases can be used in animal feeds to improve protein and amino acids digestibility, contributing to improve the grains utilization. Post-weaning is an important period when enzymes can be added to pig diets. In this phase, the animals digestive system is not fully developed and they go through a transition period, from liquid to solid feeding. In this way, supplying enzymes can ensure a better use of soybean meal and reduce gastrointestinal problems. Besides that, it also helps to reduce excreta resulting in less environmental impact (3). Considering these factors, the objective was to evaluate the effect of adding protease on the digestibility of protein and amino acids of soybean meal.

## Material and methods

Eight pigs (BW 53.5 ± 4.36 kg) in growth phase were used. All animals underwent a surgical procedure to implant a T-cannula in the ileum according to the technique described by Donkoh et al. (2). After recovering from the surgical procedure, the animals were randomly allocated in blocks with four treatments, two replicates per period in three periods. Animals were blocked based on time and each animal was considered as an experimental unit. The periods had a six-day duration, five days for adaptation to the experimental diets and 24 hours for ileal digesta collection. The treatments were: a protein free diet (PFD) to evaluate the endogenous loss of protein and amino acids, PFD + 15000 PROT/kg protease (PFDP) to determine the enzyme effect on the endogenous loss of protein and amino acids, a diet with soybean meal (SBM), and a diet with soybean meal with added protease (SBM + Protease) (15000 PROT/kg). As an indicator of digesta, all diets received 1% acid insoluble ash as a digesta marker. During the experimental period, the animals were housed in concrete stalls with individual drinkers located in a room with clay tile roof and glass tilting windows. Each animal was placed in a stall. The stalls and the room were cleaned every day. The apparent and standardized ileal digestibility of protein and amino acids were calculated as reported by Sakomura & Rostagno (4). Parameters were analysed using SAEG statistical software (Statistical and Genetic Analysis System), UFV (2000). The Student Newman Keuls test was used to compare means at a level of significance of 5%.

## Material and methods

Eight pigs (BW 53.5 ± 4.36 kg) in growth phase were used. All animals underwent a surgical procedure to implant a T-cannula in the ileum according to the technique described by Donkoh et al. (2). After recovering from the surgical procedure, the animals were randomly allocated in blocks with four treatments, two replicates per period in three periods. Animals were blocked based on time and each animal was considered as an experimental unit. The periods had a six-day duration, five days for adaptation to the experimental diets and 24 hours for ileal digesta collection.

The treatments were: a protein free diet (PFD) to evaluate the endogenous loss of protein and amino acids, PFD + 15000 PROT/kg protease (PFDP) to determine the enzyme effect on the endogenous loss of protein and amino acids, a diet with soybean meal (SBM), and a diet with soybean meal with added protease (SBM + Protease) (15000 PROT/kg). As an indicator of digesta, all diets received 1% acid insoluble ash as a digesta marker. During the experimental period, the animals were housed in concrete stalls with individual drinkers located in a room with clay tile roof and glass tilting windows. Each animal was placed in a stall. The stalls and the room were cleaned every day. The apparent and standardized ileal digestibility of protein and amino acids were calculated as reported by Sakomura & Rostagno (4). Parameters were analysed using SAEG statistical software (Statistical and Genetic Analysis System), UFV (2000). The Student Newman Keuls test was used to compare means at a level of significance of 5%.

## Results and discussion

The apparent ileal digestibility coefficient (AIDC) of protein was not influenced by adding protease. This result corroborates the findings of Barros et al. (1), but is different from the observations of Nery et al. (3). AIDC of threonine was higher when protease was added to soybean meal. However, AIDC of methionine was lower when protease was added. The results may have been influenced by the protease concentration, age of the animals, and the methodology that was used. The standardized ileal digestibility coefficients (SIDC) of threonine and valine were higher when protease was added to SBM when endogenous loss was based on PFD. SIDCs were also higher for protein, methionine + cysteine, threonine, and valine for SBM + protease when the endogenous loss was calculated based on inclusion of PFDP. The SIDC values for protein, methionine + cysteine, and threonine were higher when the endogenous loss was calculated based on PFDP inclusion compared to SIDC values, when endogenous loss was based on PFD. With these results it is perceived that inclusion of enzymes increases endogenous loss of protein and major amino acids. However, further studies are needed to better understand the effect of protease on endogenous loss. The results obtained in the present study confirm that adding enzymes can improve protein and major amino acids digestibility, resulting in a better use of soybean meal helping to reduce production costs.

## Conclusion

The inclusion of protease in diets with soybean meal increased protein and some essential amino acids digestibility, as methionine + cysteine, threonine and valine.

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**Key words:** Digesta; Enzymes; Nutrition; Pigs.

**Table 1.** Apparent ileal digestibility coefficient and standardized ileal digestibility coefficient of soybean meal protein and amino acids with protease.

Nutrients	AIDC%		P Value	SIDC%			p-value
	SBM	SBM + Protease		SBM	SBM + Protease using PFD	SBM + Protease using PFDP	
Protein	75,38	75,44	NS	90,96b	91,43b	93,13a	0,0001
Lysine	84,27	83,51	NS	92,65	91,88	93,50	NS
Methionine	88,88a	86,99b	0,002	98,72a	96,84b	99,09a	0,0001
Met + Cys	85,42	85,51	NS	96,30b	96,40b	98,00a	0,006
Threonine	71,10b	74,03a	0,04	89,50c	92,43b	94,72a	0,001
Valine	71,96	73,67	NS	87,25b	89,89a	91,43a	0,003

AIDC - apparent ileal digestibility coefficient; SIDC - standardized ileal digestibility coefficient; SBM – soybean meal; PFD – protein-free diet; PFDP – protein-free diet with added protease.

A,b,c – averages with different letters in the same line are different by SNK Test ( $P < 0.05$ ).



# Nursery piglets fed with diets supplemented with amylase

**RONOZYME™ HiStarch**

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## Introduction

Although it is common practice in swine production to wean piglets at 21 days of age, their full development may be limited by certain factors such as insufficient endogenous enzyme secretion, low intestinal absorption capacity, low levels of biliary salt secretion, and reduced water and feed intake<sup>(2)</sup>. During the weaning period, the transition from nursing to a solid diet represents a major milestone because it may eventually lead to gastrointestinal disorders which, in turn, may result in physiological or pathological changes that can negatively affect mortality and performance rates. Therefore, it is crucial that piglets receive ingredients and additives to promote a better feed digestibility, thereby minimizing digestive problems and poor nutrient absorption<sup>(4)</sup>. Some studies have shown that the use of exogenous enzymes in swine diets promotes the digestibility of nutrients, reducing malabsorption problems and the bacterial proliferation in the intestines of piglets<sup>(1)</sup>. Starch is the main carbohydrate found in cereals, and it can meet up to 65% of the total dietary energy requirements. Even small improvements in starch digestibility can greatly affect energy values and, consequently, reduce formulation costs. Satisfactory feed efficiency is difficult to achieve, not only because of the low levels of amylase secretion seen in piglets but also due to the way in which starch is found in cereals (amylose: amylopectin ratio). In view of the exposed, dietary supplementation with exogenous amylase may lead to better nutritional and performance results. The objective of this experiment was to study the effects of dietary supplementation with  $\alpha$ -amylase on the piglets performance.

## Material and methods

The experiment was conducted at DSM Innovation and Applied Science Center in the city of Mairinque, state of São Paulo. Sixty male piglets weaned at 21 days of age and weighing, in average,  $5.790 \pm 0.753$  kg were distributed according to a randomized block design, with two treatments and 10 replicates with three animals each. The two experimental treatments were control diet (CD) and CD + 80 KNU/kg of  $\alpha$ -amylase (CD+A). The feed were formulated with corn and soybean meal to meet the minimum requirements recommended by ROSTAGNO et al. (2011) Diets were fed during the experiment in 3 phase: 1) Pre-starter 1 (21 to 35 days of age), 2) Pre-starter 2 (36 to 49 days of age), and 3) Starter (50 to 63 days of age). All experimental feeds were identical, except for the addition of amylase (on top). The daily feed intake (DFI), daily weight gain (DWG), and feed conversion rate (FCR) were measured at 35, 49, and 63 days of age. The data were submitted to variance analysis and when significant were compared by the F test using the General Linear Model procedure (SAS version 9.4).

## Results and discussion

Table 1 shows the results obtained at the three different stages of the experiment. There were no interaction between the block factor and treatment. At 35 days of age, the piglets that were fed CD+A presented a higher DFI ( $P < 0.05$ ). For the other parameters evaluated in this phase there was no significant difference ( $P > 0.05$ ). An increase in feed intake throughout the first 14 days is desirable as this stage is usually characterized by lower feed intake and low digestibility, resulting in energy deficiency and as a consequence to lower weight and incidence of diarrhea, leading to economic loss and higher mortality rates<sup>(6;7;8)</sup>. At 49 days of age there was no effect of the dietary treatments on the animals' performance. At the end of the experiment, the 63-day old piglets fed with  $\alpha$ -amylase-supplemented diets presented a better feed conversion rate ( $P = 0.094$ ). Piovesan et al (2011) did not find significant differences favoring the addition of  $\alpha$ -amylase in terms of improving the performance of nursery piglets.

They did see, however, an increase in the availability of both digestible and metabolizable energy. The authors believe that the energy provided by the experimental diets was sufficient to meet the nutritional requirements, the caloric increment obtained by addition of the enzyme did not change the performance. There are only a few studies on the use of amylase in piglets in the scientific literature. Attempts have been made to extrapolate and find carbohydrases in the form of complexes. Adeola & Cowieson (2011) have reported that the findings from experiments using carbohydrases are inconsistent due to differences in the type and amount of cereals used, the animals age, the degree of the limiting nutrient deficiency, and the space for the enzyme to act.

### Conclusion

The addition of 80 KNU of amylase to piglet diets improves their performance during the nursery phase.

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**Key words:** Enzyme; Carbohydrase; Nutrition; Swine.

**Table 1.** Performance of piglets with and without amylase supplement.

	<b>Weight (kg)</b>	<b>ADG (kg)</b>	<b>DFI (kg)</b>	<b>FCR (kg:kg)</b>
<b>35 days of age</b>				
Control diet	7.481	0.121	0.178	1.483
Control diet + 80 KNU/kg	7.488	0.121	0.206	1.444
Probability	0.974	0.975	0.039	0.728
<b>49 days of age</b>				
Control diet	13.507	0.276	0.428	1.446
Control diet + 80 KNU/kg	13.337	0.270	0.477	1.382
Probability	0.707	0.415	0.483	0.767
<b>63 days of age</b>				
Control diet	21.344	0.370	0.586	1.585
Control diet + 80 KNU/kg	21.883	0.379	0.574	1.515
Probability	0.541	0.561	0.607	0.094

# Effect of 25-hydroxycholecalciferol on severity of osteochondrosis in finishing pigs



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## Introduction

Osteochondrosis (OC) is defined as a local disturbance in the process of endochondral ossification (10), and it is important cause of lameness in pigs (5). It is also related to leg weakness and premature culling of pigs (2, 4), which justify the necessity of studies to prevent this disease. The primary lesion is an ischemic necrosis of growth cartilage due to premature cessation of blood supply to the cartilage canal (11). The use of substances to improve bone and cartilage strengthening has been suggested in growing pigs to prevent OC (9). The 25-hydroxycholecalciferol (25-OH-D<sub>3</sub>) is a cholecalciferol metabolite commercially available that has been reported to mitigate the incidence and severity of OC (9). In broilers, this molecule can improve phosphorus (P) utilization and reduces abnormalities in cartilage vascularization (4). It is also associated with calcium (Ca) absorption from the intestinal tract and maintenance of plasma Ca concentration and can improve cartilage and bone metabolism, promoting bone formation (7). The objective of this study was to measure the effect of dietary supplementation of 25-OH-D<sub>3</sub> to sows and their progeny on incidence and severity of OC in finishing pigs.

## Materials and methods

The study was performed using 57 multiparous sows from two distinct commercial bloodlines and in their progeny, in a commercial farm located in the state of Paraná, Brazil. This study was approved by the Animal Use Ethics Committee (CEUA/protocol number 04/2015) of Paraná Federal University – Palotina. Sows were housed in individual pens. They had ad libitum access to water in float bowls drinkers in front of the pen. The gestation diet was provided twice a day (approximately 2 kg/sow) during a complete reproductive cycle (weaning to estrus interval, gestation and lactation). Piglets were housed in elevated floor pens equipped with a nipple drinker and two-space feeder and had free access to the water and feed. Growing and finishing pigs were housed in a concrete flooring pens equipped with a nipple drinker and two-space feeder having free access to water and feed. The sows received two dietary treatments: basal level (LV) of vitamins according to (8) or basal level of vitamins according to OVN® (DSM Nutritional Products, Brazil) supplemented with 50 µg 25OH-D<sub>3</sub> (HyD®, DSM Nutritional Products, Brazil) per kg of feed (OVN). The piglets born from these sows were weaned at 21 days of age (6 ± 1 kg of body weight) and sorted to two dietary treatments: basal level of vitamins according to (8) (Control) and basal level of vitamins added with 50 µg 25-OH-D<sub>3</sub>/kg feed (HyD®). The piglets were weighed at five different ages (21, 65, 85, 135, and 159 days of age). The average daily gain (ADG), feed intake, and feed conversion were measured at: nursery phase (6 to 25kg), growing I (25 to 40kg), growing II (40 to 90kg) and finishing phase (90kg to approximately 100- 110kg). Blood samples were collected from Control (n=39) and HyD® (n=43) pigs one day before slaughtering in order to measure 25-OH-D<sub>3</sub> plasma concentration. After slaughtering, the surfaces of medial and distal condyle on humerus were macroscopically examined in order to check OC lesions according to (5). The pigs were weighed and housed randomly into two diets according to the sows diet, in a factorial design (2 x 2 x 2 x 2). The factors were: piglets sex (male and female), genetic bloodline (A and B), sow treatment (LV and OVN) and piglets treatment (Control and HyD®). Data were analyzed with repeated measures mixed model. Osteochondrosis scores and average daily gain were analyzed using Pearson procedure of Statistical Analysis System software (SAS 9.0, Cary, NC) (significant results when p<0.05).

## Results and discussion

Dietary supplementation of vitamins did not affect the frequency and severity of OC lesions in the progeny. It was not observed difference in progeny from sows receiving LV or OVN treatments. Pigs receiving dietary supplementation of HyD® had a significant higher plasma concentration of 25-OH-D<sub>3</sub> (80.559 ± 18.674 ng/ml) than the Control group (37.215 ± 22.96 ng/ml) (p<0.0001), achieving plasma levels similar to outdoor raised pigs (12). The measurement of 25-OH-D<sub>3</sub> in plasma is a good indicator of the vitamin D status in animals, and is the most important form of vitamin D in plasma which is available to be converted in the other forms of vitamin D metabolites according to the body needs (3). Supplementation with 25-OH-D<sub>3</sub> during nursery, growing and finishing phases did not affect the animals' weight gain. The final weight of Control group and HyD® group was 109.53 and 110.06 kg, respectively (p> 0.05). It was previously reported that 28% of boars can have OC in humeral condyle (6). This study observed that the frequency of OC was 30.67% in Control group and 23.89% in HyD® group (p=0.167). The lesion score of OC was influenced (p=0.0368) by piglets treatment. Control group showed the frequency of score 3 lesion of 9.82% and HyD® group of 4.44%. These results are in agreement with (9) that showed reduction in severity (and also in frequency) of OC in pigs fed diet supplemented with 25-OH-D<sub>3</sub>.

## Conclusion

The present study showed that supplementing 25-OH-D<sub>3</sub> (HyD®) during nursery, growing and finishing phase reduces severity of OC and improves 25-OH-D<sub>3</sub> plasma concentration, without effect on performance.

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**Key words:** Arthritis; D vitamin; Performance.

# **Poultry Science Association 1st Latin American Scientific Conference**

## **Campinas, São Paulo, Brazil**



# Effects of canthaxanthin and 25-hydroxycholecalciferol on broilers meat physical and chemical characteristics.

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The purpose of this study was to evaluate the effect of MaxiChick and its active ingredients, canthaxanthin combined with 25-hydroxycholecalciferol (25-OH-D<sub>3</sub>) in broilers feed on the physico-chemical characteristics of the meat. Two experiments were made to evaluate the effects on male and female chicks: 1500 and 1680 male and female one-day old Cobb-500 broilers were used, distributed in a completely randomized design, with 2 treatments of 15 replicates of 50 birds each for male chicks and 56 birds each for female chicks. Male broilers were raised during 42 d and female broilers during 43 d. Treatments were: T<sub>1</sub>: Control Diet and T<sub>2</sub>: Control Diet + 0.1% MaxiChick until 21 d of age. Samples for breast meat physical and chemical characteristics' measurement were harvested at 28 and 43 d of age in female chicks and 42 d of age in male chicks. Three birds with average weight per replicate were selected. Variables measured were: pH, color (L\*, a\* and b\*), water-holding capacity, sheare force and cook loss. Leg color pigmentation levels were evaluated in 6 birds per replicate, at 42 d of age in male chicks and 43 d in female chicks. Data were subjected to ANOVA. Significant results (P < 0.05) were observed in yellow color strength (b\*) in breast meat of male broilers supplemented with MaxiChick (7.76 vs. 7.06) and in leg color pigmentation in male broilers evaluated at 42 d of age (4.68 vs. 3.11). In female chicks, significant results (P < 0.05) were observed in red color strength (a\*) (3.26 vs. 2.83) and yellow (b\*) (6.48 vs. 5.70) in breast meat of birds evaluated at 28 d of age supplemented with MaxiChick. No differences were observed at the other variables. It is therefore concluded that the addition of MaxiChick to the diet, based on Canthaxanthin and 25hydroxycholecalciferol (25-OH-D<sub>3</sub>), had a direct influence on color, with differentiated results among sexes. Better pigmentation of meat results in greater acceptance of the product by the consumer market.

**Key Words:** Vitamin D, color, nutrition, pigmentation, meat quality

# Performance of broilers fed with canthaxanthin and 25-hydroxycholecalciferol.



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The purpose of this study was to evaluate the effect of MaxiChick and its active ingredients, canthaxanthin combined with 25-hydroxycholecalciferol (25-OH-D<sub>3</sub>) in broilers feed. Two experiments were made to evaluate the effects on male and female chicks: 1500 and 1680 male and female one-day old Cobb-500 broilers were used, distributed in a completely randomized design, with 2 treatments of 15 replicates of 50 birds each for male chicks and 56 birds each for female chicks. Male broilers were raised during 42 d and female broilers during 43 d. Treatments were: T1: Control Diet and T2: Control Diet + 0.1% MaxiChick until 21 d of age. Parameters measured on a weekly basis were: weight gain (WG), feed consumption (FC) and feed conversion rate (FCR). At 42 d of age, 6 male broilers were selected, with an average weight by replicate, for further slaughter and measurement of cuts and carcass yield. Female broilers were evaluated at 28 d of age for carcass yield, and at 43 d of age for cuts and carcass yield. Six birds were selected by replicate, with the same average weight. Data were subjected to ANOVA. Male broilers fed with MaxiChick showed a significantly higher ( $P < 0.05$ ) BW at 14 and 21 d of age (551g vs 544g) (1072g vs 1055g) in respect of those fed with control diet. As far as female broilers, significant results ( $P < 0.05$ ) were found for breast yield at 43 d of age in those birds supplemented with MaxiChick (41.16% vs 40.44%). It is therefore concluded that the addition of the commercial product MaxiChick, based on Canthaxanthin and 25-hydroxycholecalciferol (25-OH-D<sub>3</sub>), has different effects on male and female birds, probably due to growth speed. In male chicks, benefits were found during the initial phase with better weight gain values until diet supplementation; whereas in females, for the same period, there was a significant contribution for breast yield at 43 d of age.

**Key Words:** vitamin D, feed conversion rate, weight gain, nutrition, carcass yield



# Quality of eggs in Brazil: correlations between parameters evaluated.

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The objective was to know the quality of eggs produced in Brazil and check some parameters of both internal as external quality: weight, albumen height, Haugh Unit, yolk color, eggshell thickness and resistance. This type of analysis can be a useful tool for the producer in monitoring the quality of the eggs; in addition, the continuous measurement of parameters of eggs may show an improvement in the quality. Therefore, samples were taken from eggs directly from farms in different regions of Brazil (different farming systems, management, climate, nutrition, age and breed), totaling 25 farms and 19,468 eggs analyzed from August 2012 to June 2015. Eggs were analyzed by Nabel Digital Egg Tester DET6000 and correlation analysis between the measured parameters was analyzed using the SAS statistical software. The results show that the highest correlation coefficient was 0.98 observed between albumen height parameter and Haugh unit, which was expected, because it uses the measure albumen height to calculate Haugh unit. Moderate negative correlation was observed between the age of layers and eggshell resistance ( $P = -0.41$ ) and moderate positive between eggshell resistance and eggshell thickness ( $P = 0.49$ ). The other correlations were considered weak. This study evaluated the quality of eggs in different regions of Brazil and the correlations between parameters that are important in assessing the freshness and eggshell quality.

**Key Words:** egg, quality, correlation, Brazil

# Effect of vitamin and mineral diet supplementation on oxidation and shelf life of broiler meat.

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The consumption of meat can be ensured through a tasty, nutritious and safety meat supply for the consumers. The aim of this trial was to assess the effect of supplementation of commercial diets for broilers with optimized vitamin levels and a more bioavailable mineral source on the oxidation and shelf life of broiler meat. Eighteen hundred Cobb Slow-feathering male- chicks were housed in a completely randomized design following a factorial scheme  $2 \times 2$  [Optimal vitamin Nutrition, OVN vs commercial levels and mineral sources-inorganic and carbon-aminophospho-chelate (CAP)], adding up to 4 treatments and 9 replicates. The optimized vitamin levels followed the recommendations of the Optimum Vitamin Nutrition Guidelines (OVN, DSM) with a metabolite of the vitamin D<sub>3</sub>, 25 (OH) D<sub>3</sub> (69mg/kg of feed). At 42 d of age, 30 birds/treatment were slaughtered and samples of thighs and drumsticks were collected for further freezing. After 10 and 40 d of freezing, 10-g samples were taken for analysis of substances reactive to thiobarbituric acid (TBARS), obtained by the amount of malondialdehyde (MDA). Data were submitted to variance analysis. There was an interaction ( $P < 0.05$ ) between vitamin levels and mineral sources for MDA concentration (mg/sample kg) in the thigh meat, frozen for 10 d. According to the unfolding of the interaction, supplementation of OVN levels associated with CAP mineral source (0.45 mg/kg) resulted in a lower MDA, index that shows higher oxidative stability, when associated with inorganic source. (0.70 mg/kg). For 40 d of freezing, it was not found difference ( $P < 0.05$ ) between OVN supplementation and control, regardless of the mineral source used. Due to the high level of polyunsaturated fatty acids (PUFA), there is a greater susceptibility of poultry meat suffering oxidative processes than pork and beef, especially regarding lipid oxidation. The supplementation of broiler diets with optimized levels of vitamins and a more bioavailable mineral source can contribute to maintain the original flavor of the product and increase shelf life of the meat, decreasing the range of lipid oxidation.

**Key Words:** trace mineral, costumer, TBARS, flavor, fatty acid

# Efficacy of vitamin and mineral supplementation on meat quality and skin resistance of broilers.

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The aim of this work was to evaluate the effect of supplementation of commercial diets for broilers with optimized vitamin nutritional levels (OVN, DSM Nutritional Products) and a more bioavailable mineral source on the quality of broiler meat. Eighteen hundred Cobb Slow-malechicks were divided into a completely randomized design following a factorial scheme  $2 \times 2$  (vitamin levels-commercial and optimized vs mineral sources-inorganic and carbon-aminophospho-chelate (CAP)), 4 treatments and 9 replicates. The optimized vitamin followed the guidelines of Optimum Vitamin Nutrition DSM and a metabolite of vitamin D<sub>3</sub>, 25 (OH) D<sub>3</sub> was added. At 42 d of age, 30 birds/treatment were slaughtered and the breasts submitted to different analyses. The skin of the thighs was removed and underwent assessments for breaking strength and elasticity. The tests were performed through a fixing device for shearing test and adjusted to a texturometer. Data were submitted to analyses of variance. The breast meat drip loss of birds fed with optimal vitamin levels was lower ( $P < 0.05$ ) when compared with the loss observed in the birds fed with commercial vitamin levels, regardless of trace mineral source. Regarding the shear strength, difference was not observed ( $P > 0.05$ ); however, the replacement of inorganic mineral by CAP resulted in less elastic muscular tissue ( $P < 0.05$ ) with higher softness, which provides breaking with lower resistance of the muscle fibers. About breaking strength and elasticity of the skin, the opposite effect was noted. The skin of the birds supplemented with CAP was more resistant to rupture considering a p value of 0.091. The resistance of the skin presents a significant variability (CV: 27.82%) due to the heterogeneous constituents of the cutaneous tissue and the intrinsic test conditions. The elasticity was similar ( $P > 0.05$ ) among the treatments. The optimal vitamin levels can play an important role in reducing meat drip loss by decreasing the negative effects of oxidation. More bioavailable mineral sources may bring extra benefits to improve broilers skin and meat quality.

**Key Words:** trace mineral, vitamin D, skin resistance, drip loss

# Effect of dietary supplementation of optimized vitamin levels and trace mineral sources on the Black Bone syndrome occurrence in broilers.

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Broilers have grown so fast that their bones have shown low levels of mineralization. As a result, it allows the extravasation of the medullary content on the bone surface, which alters the color of the meat. This effect is very clear especially after cooking, and, due to the darker aspect of the bone, it has been classified as the black bone syndrome. The aim of this study was to assess the effect of optimized vitamin levels and trace mineral sources on the occurrence of black bone syndrome in broilers. 1,800 Cobb Slow-male-chicks were divided into a completely randomized design of 2 × 2 factorial scheme: Optimal Vitamin Nutrition (DSM Nutritional Products recommendations) vs commercial levels and mineral sources: inorganic vs carbon-aminophospho-chelate (CAP), adding up to 4 treatments and 9 replicates. To evaluate the black bone syndrome, after 42 d the right tibia of 30 birds/treatment was cooled for further lengthwise measurements of lightness, redness and yellowness indexes using a colorimeter Minolta. The left tibias of the birds were frozen for 60 d, thawed and submitted to the same measurements. Then, they were roasted and reassessed. Data were submitted to ANOVA. Diets supplemented with CAP mineral source showed higher ( $P < 0.05$ ) yellowness index and lightness values in the adjacent muscle tissue of fresh and chilled tibias when compared with diets with inorganic mineral, regardless of the vitamin levels. It was not found interaction between treatments ( $P > 0.05$ ). Inorganic mineral supplementation resulted in higher ( $P < 0.05$ ) redness index (2.52) compared with CAP (1.70). This result indicates that supplementation with CAP may have contributed to the mineralization and lower porosity of the bones, which limited the extravasation of blood in the adjacent muscle tissue of the tibia. The minerals supplemented under more bioavailable sources, besides offering greater stability, bring benefits from a biochemical protection that can occur when they are employed in the diet. Thus, they are considered an important strategy to improve bone quality in broilers.

**Key Words:** trace mineral, bone porosity, lightness

# Trace mineral sources on duodenal mucosal repair of broilers challenged with *Eimeria* sp.

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The aim of this study was to assess the effect of carbon-amino-phospho-chelate as a mineral source on duodenal mucosa repair of broilers challenged with *Eimeria* sp. In this trial, 640 Cobb Slow-male-chicks, at 21 d of age, were divided into a completely randomized design following a 2 × 2 factorial scheme (inorganic mineral source or carbon-amino-phospho-chelate (CAP) vs challenge or not), totaling 4 treatments with 16 replicates of 10 birds each. The challenged group received commercial vaccine containing oocysts of *Eimeria* sp. in the crop, and the dose was 20 times above the dose recommended by the manufacturer (80,000 oocysts). At 28 d of age, 32 birds/treatment were slaughtered to collect duodenal fragments. The fragments were submitted to histological procedures. Length and width of the villi, and depth and width of the crypts were measured. Next, the villus:crypt ratio as well as the absorption surface area were calculated. Crypts were counted and divided by the number of villi to calculate the villi:crypts ratio. Data were submitted to factorial ANOVA. There was a significant interaction between the mineral source and the enteric challenge for length and width of the villi and crypt depth. The enteric challenge in birds supplemented with an inorganic mineral source reduced ( $P < 0.05$ ) drastically the villus length (769  $\mu\text{m}$ ), while the replacement by CAP mineral kept the same length of villi observed for control animals (1,077  $\mu\text{m}$ ). The inclusion of CAP minerals in enteric challenging led to an increase ( $P < 0.05$ ) in the villus width when compared with control birds. For the crypt depth in a challenging situation, the supplementation of CAP minerals resulted in increased ( $P < 0.05$ ) depth. As a result, it indicates higher proliferative capacity compared with the inorganic source. CAP supplementation, regardless of enteric challenge, reveals greater ( $P < 0.05$ ) villus:crypt ratio and absorption area in comparison to the inorganic source. Diets supplemented with CAP mineral source can contribute to regeneration and proliferation of the intestinal mucosa of broilers when submitted to challenging enteric conditions.

**Key Words:** villus length, trace mineral, cell proliferation

# Effect of supplementation of Vitamin E on productive parameters of laying hens.

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The objective of this study was to evaluate the effect of supplementation of Vitamin E on productive parameters of laying hens. The experiment was carried out at Poultry Science Laboratory of the Federal University of Santa Maria, with 128 laying hens of Novogen Brown lineage (40 to 55 wk of age). A completely randomized design was used with 2 treatments, 8 replicates of 8 laying hens each. The treatments were: DC, negative control diet; and DVitE, diet with addition of 200 mg/kg of vitamin E (acetate dl- $\alpha$ -tocopherol). The parameters evaluated were laying rate (LR), body weight (BW), daily feed intake (DFI), feed conversion per dozen eggs (FCR/DZ), feed conversion per egg mass (FCR/EM), egg weight (EW) and egg mass (EM). The laying rate and egg weight were calculated weekly for each replicate. All variables were performed at the end of each period (28 d). All data were subject to ANOVA (ANOVA) using the SAS statistical program. Laying hens fed with DVitE showed better results for LR ( $P = 0.0309$ ), EM ( $P = 0.0378$ ), FCR/DZ ( $P = 0.0289$ ) and FCR/EM ( $P = 0.0878$ ). The variables DFI, BW and EW showed no differences among the treatments ( $P > 0.10$ ). Supplementation of Vitamin E provides a positive effect on egg production, egg mass, conversion per dozen and egg mass, demonstrating to be an excellent additive used in diets of laying hens.

**Key Words:** feed additive, production performance, feed conversion, laying hen

# Meta-analysis of effect of canthaxanthin on the quality production of broiler breeds and laying hens.



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The aim of this study was to evaluate, by meta-analysis, the effect of canthaxanthin in diets of broiler breeders and layers on production and quality of eggs. For this purpose were examined data of researches conducted between the years 2008 to 2015 of the Poultry Laboratory of the Federal University of Santa Maria (UFSM). The experiments involved 1292 hens, totaling 844 broiler breeders (Cobb 500) and 448 laying hens (Isa Brown and Novogen). Broiler breeders were placed in an open-sided house, divided into pens consist of 6 nests. Each pen was equipped with an automatic drinker, one tube feeders to females, and a trough-type feeder to the roosters. Laying hens were placed in experimental facilities equipped with metal cages with Nipple drinker and feeder. All data were derived from hens feed with corn and soybean meal, and adding 6mg/kg canthaxanthin (CAROPHYLL Red 10%, DSM Nutritional Products). Variables analyzed were: egg production (EP), egg yolk, albumen and shell weight, egg specific gravity (SG) and yolk color. Data were evaluated weekly to 3 eggs by replicate coming from broiler breeders and laying hens. Variables analyzed to egg incubation in the experiments that involved broiler breeders were hatchability of fertile eggs (HF), hatchability of total eggs (HT) and fertility of eggs (F). Data were subjected to proc mixed and means compared a level of 5% significance. Statistical procedures were performed using the SAS software. Broiler breeders and laying hens fed with diets supplemented with canthaxanthin showed highest EP ( $P = 0.0003$ ). Egg weight ( $P = 0.6923$ ), yolk ( $P = 0.7878$ ), albumen ( $P = 0.3317$ ) and shell weight ( $P = 0.3317$ ) did not differ between treatments. The SG was highest in eggs of hens fed without the supplementation of canthaxanthin in the diet ( $P = 0.0099$ ). Egg yolk color was highest in eggs from hens fed with canthaxanthin in the diet ( $P < 0.0001$ ). The HF, HT and F were highest in eggs from hens fed with 6mg/kg of canthaxanthin in the diet ( $P < 0.0001$ ). The addition of canthaxanthin in broiler breeders and layers showed a positive effect on production and egg quality.

**Key Words:** feed additive, egg production, yolk color, hatchability, fertility

# Internal egg quality from laying hens fed corn-based diet with the addition of canthaxanthin.



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The aim of this study was to evaluate the effects of canthaxanthin on corn-based diets and its effects on hens' internal egg quality. It was used 320 ISA Brown hens from 20 to 48 wk of age, distributed in a completely randomized design with 2 treatments, 10 replicates of 16 birds each one. Treatments were: NC negative control diet and CTX diet with the addition of 6mg/kg canthaxanthin (Carophyll Red 10%, DSM Nutritional Products). The parameters analyzed were: Haugh unit (HU), yolk index (YI), egg weight (EW), yolk and albumen percentage (%Y and %A), mg of total carotenoids/kg of yolk (C), yolk color (YC), vitelline membrane resistance (VMR) and lipid oxidation (TBARS). To determine internal quality 3 eggs were selected per repetition according to EW (within an interval for variance of 2.5%). To determine yolk carotenoids concentration a kit containing a portable photometer iCheck was used. Data were submitted to ANOVA ( $P < 0.10$ ). Statistical procedures were performed using SAS software. Canthaxanthin supplementation presented higher C in yolk (23.43) ( $P < 0.001$ ), HU (90.79) ( $P = 0.10$ ) and YC (12.6) ( $P < 0.001$ ), compared with NC (14.72, 89.79 and 5.7). No differences were observed between treatments for EW, %Y, %A, YI, VMR and TBARS ( $P > 0.10$ ). Canthaxanthin supplementation in corn-based diets is beneficial to the improvement of some internal quality parameters of eggs, such as concentration of carotenoids in yolk, Haugh unit and Yolk index.

**Key Words:** corn, carotenoid, vitelline membrane, lipid oxidation



# Effects of corn-based diets supplemented with canthaxanthin on performance and egg quality of laying hen.



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The aim of this study was to evaluate the effects of corn-based diets, with or without the addition of canthaxanthin, on the productive and qualitative parameters of laying hen eggs. It was used 320 Isa Brown hens (20 to 48 wk of age) in a completely randomized design with 2 treatments, 10 replicates of 16 birds each one. Treatments were: a Negative Control (NC) and other it the addition of 6mg/kg canthaxanthin (CTX, Carophyll Red 10%, DSM Nutritional Products). Performance was evaluated considering the productive parameters: laying rate (LR), body weight (BW), daily feed intake (DFI), feed conversion per dozen eggs (FCR/DZ), feed conversion per egg mass (FCR/EM), egg weight (EW) and egg mass (EM). Egg qualitative parameters were: yolk color (YC), specific gravity (SG) and albumen pH (pH). YolkFan DSM was used to measure egg yolk color in a 1 to 15 scale, 1 – light yellow and 15 – dark orange. Data were submitted to ANOVA ( $P < 0.10$ ). Statistical procedures were performed using SAS software. Birds fed CTX diet showed better results for LR (88.21%) ( $P = 0.0205$ ) and higher BW (1703g) ( $P = 0.0634$ ) than NC diet (84,82% and 1669g). Canthaxanthin supplementation also increased YC (12.6) ( $P < 0.0001$ ), presented better EM (22.23 kg) ( $P = 0.0679$ ) and FCR/DZ (1.39) ( $P = 0.1004$ ) compared with NC. DFI, FCR/EM, EW, SG and pH did not showed differences between treatments ( $P > 0.10$ ). Canthaxanthin supplementation improved laying rate, yolk pigmentation, egg mass and feed conversion rate per dozen eggs.

**Key Words:** feed additive, carotenoid, laying rate, egg yolk

# Effect of canthaxanthin supplementation on internal egg quality of laying hens and storage at different temperatures.



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The aim of this study was to evaluate the effects of canthaxanthin (CTX) supplementation on internal egg quality of laying hens, storage at room temperature or refrigerated. We used 2,400 eggs, distributed in randomized design with a 2 × 2 factorial arrangement [supplementation 0 or 6 mg of CTX (CAROPHYLL Red 10%, DSM Nutritional Products)/kg diet; 2 types of storage: room temperature (25°C) or refrigerated (4°C)], with 10 replicates of 60 eggs each. The eggs were stored for 0, 7, 14, 21, and 28 d (d). The parameters analyzed were: egg weight (EW), yolk and albumen percentage (%Y and %A), yolk index (YI), Haugh unit (HU), vitelline membrane resistance (VMR), lipid oxidation (TBARS), and milligrams of total carotenoids per kilogram of yolk (C). To determine internal quality, 3 eggs were selected per repetition according to EW (within an interval for variance of 2.5%). To determine the C we used an iCheck portable photometer, VMR was measured by a TA.XT Texture Analyzer 123, and TBARS measured the amount of thiobarbituric acid-reactive substances. All the data were subjected to ANOVA. Tukey's test was used for significant interaction at the 10% level. Statistical procedures were performed using SAS software. In the interactions study only was observed that storage eggs at 4°C from hens fed with different diets had higher YI to 21 d (P = 0.0601) and 28 d (P = 0.0738) than eggs stored at 25°C. Hens fed with 6 mg CTX/kg of diet had highest C in all storage periods (P < 0.10), VMR at 21 d (P = 0.0918), HU at 0 d (P = 0.0335) and lowest %A at 14 d (P = 0.0564) and 21 d (P = 0.0405). However, hens fed with 0 mg/kg CTX had highest YI to 0 d (P = 0.0086). Eggs stored at 4°C had highest HU from 7 to 28 d (P < 0.10), YI and lowest TBARS at 7 to 14 d (P < 0.10). Eggs from hens fed with 6 mg CTX/kg of diet, stored at refrigerated temperature (4°C) had better shelf life.

**Key Words:** corn, carotenoid, refrigerated, yolk index

# Energy and nutrient utilization of broiler chickens fed corn-soybean meal and corn based diets supplemented with xylanase.



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The objective of this study was to evaluate the effects of different supplementation levels of an exogenous  $\beta$ -xylanase on energy utilization and nutrient digestibility of broiler chickens fed corn-soybean meal diets. A total of 480 one-day-old male Cobb 500 chicks was distributed using a completely randomized design, with 10 treatments, 8 repetitions, and 6 broilers per experimental unit. Birds were fed a common starter diet to 14 d. From 14 to 25 d, birds were fed 2 experimental basal diets in a  $2 \times 5$  factorial arrangement of a conventional corn/soy-based basal diet (CS) and the basal diet (CN) where 40% was displaced by corn. These diets were supplemented with 0, 50, 100, 150, and 200 mg/kg of a fungal  $\beta$ -xylanase units (FXU/kg). Samples of feed, excreta, and ileal digesta were analyzed for determination of ileal digestible energy (IDE), metabolizable energy, and total-tract retention of protein and lipid. The CS diets had higher ( $P < 0.05$ ) energy utilization and nutrient digestibility when compared with the CN diets. AMEn and IDE were improved ( $P < 0.05$ ) by 192 and 145 kcal/kg, respectively when diets were supplemented with 100 FXU/kg xylanase. The xylanase added to the CN diet led to quadratic increases ( $P < 0.05$ ) in IDE ( $Y = -0.014x^2 + 2.570x + 3.155$ ;  $r^2 = 0.60$ ) and in AMEn ( $Y = -0.016x^2 + 3.982x + 3.155$ ;  $r^2 = 0.68$ ). Crude protein digestibility and AMEn were linearly increased ( $P < 0.05$ ) when xylanase was added to the CN diet. In conclusion, energy utilization, digestibility of crude protein and dry matter increased with xylanase supplementation in cornsoy-based diets. When xylanase was tested in the CS diet, 92 and 124 FXU/kg maximized the energy release effect; however, the maximum energy response in the CN diet was not achieved until 200 FXU/kg.

**Key Words:** broiler, corn, digestibility, metabolizable energy, xylanase

# Dehydrated cassava starch residue in the feed of broilers from 21 to 42 days supplemented or not with carbohydrases.

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The dehydrated cassava starch residue (*Manihot esculenta* crantz; DCSR) can be used as an energetic ingredient for non ruminants. For being a fibrous ingredient, carbohydrases enzymes can be used to improve the feed value. In view of this, the study aimed to evaluate the effect of different levels of DCSR with or without the carbohydrases supplementation on performance and carcass characteristics of broilers from 21 to 42 d. 950 male broilers were assigned in a completely randomized  $2 \times 5$  factorial arrangement, composed of the supplementation or not of carbohydrases enzymes (amylase - Ronozyme A, 400 g ton<sup>-1</sup>; xylanase - Ronozyme VP, 200 g ton<sup>-1</sup>;  $\beta$  glucanase - Ronozyme WX2000, 50 g ton<sup>-1</sup>) and 5 levels of inclusion of DCSR (0, 2.5, 5.0, 7.5, and 10%), resulting in 10 treatments with 5 replicates. At 42 d of age, the performance parameters (weight gain - WG, feed intake - FI and feed:gain - F:G) were evaluated. To determine the carcass characteristics (carcass yield and portion yield - whole breast, thigh, and legs with their skin and bones) 2 birds per pen were selected and slaughtered. Data were submitted to ANOVA to verify main effects of the studied factors and their interactions. Means were compared by the F test ( $P < 0.05$ ). When a significant ( $P < 0.05$ ) main effect of dietary DCSR level was detected, a regression analysis was then performed. There was a significant interaction ( $P < 0.05$ ) between DCSR level/enzyme supplementation on F:G during the period from 21 to 42 d of age. The F:G linearly increased ( $P < 0.05$ ) in the birds fed the non-enzyme supplemented diet. For breast yield, there was a significant interaction ( $P < 0.05$ ) between DCSR level/enzyme supplementation, with a quadratic response ( $P < 0.05$ ) and highest and lowest value estimated at 4.06% and 5.76% for non-supplemented and supplemented treatment, respectively. There was no interaction ( $P > 0.05$ ) between the studied factors to the other variables. The DCSR diet inclusion impaired broiler performance and carcass characteristics, however, enzyme supplementation was able to maintain the F:G.

# Effects of full fat soybean meal source and protease on standard amino acids digestibility in broilers.

**RONOZYME<sup>®</sup> ProAct**

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A study was conducted to evaluate the effects of an exogenous protease on amino acids digestibility in 9 different full fat soybean meal (FFSB) in Brazil. A total of 1,120 males, Cobb 500, 24 d old chicks were allocated in metabolic cages. The experiment was a factorial arrangement with 9 × 2 (FFSB x protease inclusion – 0 and 15,000 PROT/kg feed - RONOZYMEProAct, DSM Nutritional Products), plus a Protein Free Diet (PFD) with and without protease. There were 20 experimental diets (treatments), with 8 replicates and 7 birds each. The design was conducted in 2 blocks with 4 replicates per treatment in each block, under the same conditions just separated by time. PFD was formulated to determine the amino acid endogenous losses, while in the rest of the diets, 40% of the starch was replaced with a soybean product, according to the treatment. Protease was added on top. For all diets, 1% of acid insoluble ash was added as an indigestible marker. At 28 d of age, all birds were euthanized by cervical dislocation to collect ileal content. Data were submitted to ANOVA, and means were compared by Tukey test (P < 0.05). It was observed interaction (P < 0.05) between FFSB and protease to standard Met digestibility. The sample number 8 of FFSB (36.33% CP and 0.502% total Met) with or without protease supplementation showed lower Met digestibility when compared with other FFSB. The different sources of FFSB differ amino acid digestibility (P < 0.05). Supplementation with protease led to improvements in the standard of amino acid digestibility (P < 0.05). Protease increases +1.75% Lys, +5.98% Thr, +3.01% Met, +4.62% TAAS, +4.29% Val, +2.96% Ile, +2.77% Leu, +2.53% total aas, +2.3% essential aas, +1.98% no-essential aas, and +3.04% CP. Protease supplementation improves the digestibility of amino acids in different FFSB.

**Key Words:** protease, protein free diet, soybean, vegetal protein

# Effect of enzyme blend in diets on performance of broiler chickens.

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A study was conducted to examine the effects of enzymes blend (EB) in a diet with reduction of nutrients on performance of chickens. A total of 900 chicks, males SF-COBB 500, were fed 6 dietary treatments of 8–21 d old. Positive control diet (PC) had 21.2% CP, 3,050 kcal/kg AME, 0.84% Ca, 0.40% aP, 1.22% DLys, 0.88% DMet+Cys, 0.79% DThr and 0.24% DTrp, however, negative control diet (NC) had 2.55% of reduction of AME (–80 kcal/kg), CP (–0.54%), DLys (–0.03%), DMet+Cys (–0.02%), DThr (–0.02%), Ca (–0.02%), aP (0.01%) and 3.75% of reduction of DTrp (–0.009%), NC+EB1 (15,000 PROT/kg of protease + 80 KNU/kg amylase + 1,000 FYT/kg phytase), NC+EB2 (15,000 PROT/kg protease + 80 KNU/kg amylase + 2,500 FYT/kg phytase), NC+EB3 (15,000 PROT/kg protease + 80 KNU/kg amylase + 1,000 FYT/kg phytase + 100 FXU/kg xylanase), and NC+EB4 (15,000 PROT/kg protease + 80 KNU/kg amylase + 2,500 FYT/kg phytase + 100 FXU/kg xylanase) were arranged in completely randomized design, each of 6 treatments had 10 replicates of 15 chicks. The chicks group fed PC, NC+EB1, NC+EB2, NC+EB3, NC+EB4 had, respectively better WG (911.20a, 910.95a, 894.90a, 902.04a, 915.50a, and 860.95b g) and FCR (1.171b, 1.186b, 1.207b, 1.190b, 1.168b and 1.266a g/g) compared NC ( $P < 0.01$ ). However, chicks group fed NC diet supplemented with all EB presented same performance of chicks group fed PC diet ( $P > 0.05$ ). The supplementation with protease, amylase, phytase and xylanase of diets based on corn-soybean meal with reduction mean of 2.5% in AME, CP, EAA, Ca and aP improves broiler performance.

**Key Words:** corn, enzyme, nutrient reduction, soybean meal

# Digestibility of broiler chickens fed three different corn varieties and supplemented with carbohydrases.

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**RONOZYME** HiStarch

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A study was conducted to evaluate the effects of 3 different varieties of corn and 5 carbohydrase supplementations on energy and nutrient digestibility of broiler chickens. A total of 840 1-d-old Cobb 500 broiler chicks was placed in 60 battery cages. Seven birds per cage were randomly allocated and fed experimental diets from 16 to 24 d. Birds were distributed in a completely randomized design, using a factorial arrangement of 3 corn varieties (waxy, semi-hard, and semi-dent) and 5 carbohydrase combinations (no supplementation, amylase, xylanase, amylase + xylanase, and an enzymatic complex compound by xylanase and  $\beta$ -glucanase). The study was replicated twice over time. In the pre-experimental period, all birds were fed a common starter diet (3,050 of AME/kg; 21.7% CP, 1.05% Ca, and 0.53% Av. P). On d 16, birds received semipurified diets (95.91% of corn), formulated with 1,000 FYT of phytase, and celite at 1% was used as a marker. Total excreta collections were between 21 and 24 d, twice a day, to evaluate the total-tract retention of dry matter (DM), crude protein (CP), ether extract (EE), and apparent metabolizable energy corrected for balance of N (AMEn). At 24 d, all birds were slaughtered to collect ileal content and determine the ileal digestibility of DM (iDM), CP (iCP), EE (iEE), and ileal digestible energy (iDE). Data were subjected to ANOVA and means, when significant, were compared by Tukey test ( $P < 0.05$ ). Broilers fed diets supplemented with carbohydrases had higher AMEn and iDE compared with birds fed diets with no supplementation ( $P < 0.05$ ). No interactions between corn and carbohydrases were observed. Waxy corn had the lowest iEE among the varieties of corn ( $P < 0.05$ ). Results in this study indicated that the supplementation of carbohydrases ameliorated AMEn and iDE. Different corn varieties can implicate in different nutrients digestibility for broiler chickens.

**Key Words:** broiler, digestibility, corn, carbohydrase

# Effects of $\alpha$ -amylase and $\beta$ -xylanase supplementation on growth performance and metabolizable energy of broiler chickens fed corn-soy diets.

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An experiment was conducted to evaluate the effects of single or combined dietary supplementation of  $\alpha$ -amylase and  $\beta$ -xylanase on growth performance of broiler chickens fed corn-soy diets. A total of 1,800 slow feathering, Cobb × Cobb 500 male broilers were randomly distributed into 8 treatments with 9 replicates of 25 birds each. Broilers were fed starter (1 to 21 d) and finisher diets (22 to 40 d) with a positive control diet (PC, with 3050 and 3170 kcal/kg of AMEn, respectively); the other treatments were increases or reductions of 50 or 100 kcal/kg in AMEn (PC + 50, PC + 100, PC – 50 and PC – 100 kcal/kg). The PC – 100 kcal/kg was the negative control (NC). NC diet was supplemented with  $\alpha$ -amylase (80 kg-Novo  $\alpha$ -amylase units/kg),  $\beta$ -xylanase (100 fungal  $\beta$ -xylanase units/kg), and both enzymes combined at the same supplementation levels. Broilers fed the PC, PC + 50 and PC + 100 diets had lower FCR and higher BWG when compared with the NC diet ( $P < 0.05$ ). Regressing performance responses to AMEn levels showed only linear significant adjustments ( $P < 0.05$ ). These were equated and solved for X in linear equations at different enzyme supplementations. Corresponding AMEn estimates for BWG and FCR from 1 to 40 d were, respectively 98, 84, and 137 and 51, 27, and 43 kcal/kg for amylase,  $\beta$ -xylanase and amylase +  $\beta$ -xylanase. In conclusion, supplementing cornsoy diets with  $\alpha$ -amylase and  $\beta$ -xylanase led to increased dietary energy yields. Significant difference occurred in favor of  $\alpha$ -amylase when compared with  $\beta$ -xylanase supplementation whereas adding both enzymes in the same feed generated similar AMEn to the single addition of  $\alpha$ -amylase.

**Key Words:** amylase, broiler, metabolizable energy, performance, xylanase



# Corn replacement with sorghum and a combination of protease, xylanase, and phytase on nutrient and energy utilization by broiler chicken.

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**RONOZYME<sup>®</sup> ProAct**

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Sorghum can replace corn but due to factors such as kafirin, tannin and phytate, its nutrient and energy utilization by young broilers can be impaired, thus exogenous enzymes supplementation could alleviate these negative effects. An experiment was conducted to study the effect of corn replacement with sorghum and inclusion of a combination of exogenous protease, xylanase and phytase on nutrient and energy utilization by broiler at starter phase. A total of 150 male Cobb500 chicks were randomly assigned in a 3 × 2 factorial arrangement [0%, 50% and 100% replacement of corn with sorghum × inclusion or not of enzyme blend containing protease (200g/ton) xylanase (150g/ton) and phytase (100g/ton)] with 5 replicates cages and 5 birds per cage. Prior to initiation of experimental diets birds were fed a common starter diet based on corn and soybean meal. From 11 to 21 d birds were fed experimental diets and total excreta collection was performed from 16 to 21 d post-hatch. Data were analyzed using a 3 × 2 factorial arrangement followed by Tukey multiple comparison test with  $P < 0.05$  as significance level. There was interaction between level of corn replacement with sorghum and inclusion of exogenous enzymes on dry matter (DM) retention. Total replacement of corn with sorghum reduced DM retention however, enzyme supplementation increased the value of this parameter. Partial and total corn replacement with sorghum reduced nitrogen (N) retention. Including the enzyme blend increased N retention and AMEn in all diets. Although not significant, responsiveness of N retention to enzyme supplementation of birds fed diets containing sorghum tended to be higher (interaction P-value = 0.076) than those fed corn-based diets. It can be concluded that total replacement of corn with sorghum can be done if an enzymatic blend containing protease, xylanase and phytase is included to improve nutrient and energy utilization by broiler chicken at starter phase.

**Key Words:** carbohydrase, NSP-degrading enzyme, maize, nonstarch polysaccharide

# Growth performance, energy utilization, and starch digestibility of broiler chickens fed corn-soy diets supplemented with enzymes.

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A study was conducted to evaluate the effects of dietary  $\alpha$ -amylase and  $\beta$ -xylanase supplementation of corn-soybean meal basal diets formulated with or without supplemental phytase on growth performance, energy utilization and starch digestibility in broiler chickens. A total of 336 slow feathering, Cobb  $\times$  Cobb 500 male broilers were randomly distributed to 6 treatments having 8 replicates of 7 birds each. Birds were fed a common starter diet from 0 to 14 d (3,050 kcal/kg AMEn, 21.7% CP, 1.05% Ca, and 0.53% nPP). The experimental diets were provided afterward until 25 d. A 2  $\times$  3 factorial arrangement of 2 control diets (Basal = corn-soy diet without added phytase or PHY = corn-soy diet formulated with 1,000 phytase units/kg) and 3 carbohydrase supplementations (0, 80 kg-Novo  $\alpha$ -amylase units/kg, or 80 kg-Novo  $\alpha$ -amylase units/kg + 100 fungal  $\beta$ -xylanase units/kg) was used from 14 to 25 d. Excreta were collected from 21 to 24 d and all birds were euthanized at 25 d for jejunum and ileum content collection. Samples of feed, excreta, jejunal and ileal digesta were analyzed for determination of total-tract retention and ileal apparent digestibility. No interactions between diet and carbohydrase were observed. Broilers fed diets formulated with phytase or supplemented with amylase + xylanase had higher BWG and lower FCR ( $P < 0.05$ ) when compared with birds fed diets without carbohydrases. Relative to the basal diet, AMEn was increased ( $P < 0.01$ ) by 70 kcal/kg and 99 kcal/kg when birds were fed the diet supplemented with amylase and amylase + xylanase, respectively. Starch digestibility in the jejunum and ileum was increased ( $P < 0.05$ ) by 3.5% and 2.4% respectively when birds were fed the diet supplemented with amylase + xylanase. Results from this experiment show that corn-soy diets having phytase and supplemented with amylase and xylanase led to increased growth performance, AMEn, and starch digestibility in broilers. Furthermore, the efficacy of exogenous amylase and xylanase was independent of the presence of microbial phytase.

**Key Words:** amylase, broiler, metabolizable energy, starch, xylanase

# Effect of a high dose of phytase on broiler performance based on a 3-trial meta-analysis.

**RONOZYME® HiPhos**

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The objective of this study was to evaluate the effect of a high-dose inclusion of phytase (RONOZYME HiPhos GT, DSM Nutritional Products) on broiler performance. Three experiments were conducted between April 2015 and February 2016 in Brazil using meta-analysis. Corn/SBM diet (positive control diet, PC) were formulated to contain all nutrients, following the recommendations of the Brazilian Tables (2011). In all trials, a total of 3,300 slow-feathering, Cobb 500 male broilers were randomly distributed to 5 treatments (Trt) with 8 replicates (in 2 trials) and 12 replicates (in one trial). Treatments consisted of PC; negative control (NC) with Ca (-0.12% n = 1; -0.15% n = 2) and available P (aP) reduction (-0.14% n = 1; -0.15% n = 2); NC+1,000 FYT/kg feed; NC+2,000 FYT/kg feed; and NC+3,000 FYT/kg feed. Data were used in a meta-analysis conducted as a complete randomized design using the MIXED procedure of SAS (SAS Institute, 2002). The model included Trt (n = 5) as a fixed effect and trial (n = 3) as a random effect. Regressions were done on the effect of phytase levels (NC, NC+1,000, 2,000, and 3,000 FYT/kg) on performance measures. Feeding the PC and phytase supplementation Trts improved weight gain (WG) and adjusted feed conversion ratio (adjusted for 2.5 kg of body weight, FCRadj) (P < 0.0001) when compare with NC. Based on regression analysis, phytase increased WG up to an inclusion of 2,424 FYT/kg and 2,269 FYT/kg at 21 and 40 d, respectively ( $WG_{21d} = 795.79644 + 0.0625497x - 0.0000129x^2$ ;  $R^2 = 0.79$ ;  $WG_{40d} = 2533.018254 + 0.190604x - 0.000042x^2$ ;  $R^2 = 0.77$ ). As phytase increased, FCRadj improved up to an inclusion of 2,153 FYT/kg and 2,092 FYT/kg at 21 and 40 d, respectively ( $FCR_{21d} = 1.44082 - 0.000055982x + 0.000000013x^2$ ;  $R^2 = 0.57$ ;  $FCR_{40d} = 1.8461220266667 - 0.000075318x + 0.000000018x^2$ ;  $R^2 = 0.85$ ). In conclusion, the inclusion of a high dose (2,100 to 2,450 FYT/g) of the tested phytase resulted in improved performance over the NC, and same performance of PC.

**Key Words:** feed conversion ratio, feed cost, phosphorus, weight gain

# Effect of high inclusion rates of phytase on performance of broilers.



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The aim of this research was to evaluate the effect of phytase superdosing on broiler performance fed with diets containing 7% rice bran. A total 936 male broilers (Cobb) were distributed in a randomized experimental design with 4 treatments and 9 repetitions of 26 birds per experimental unit. The diets were: positive control (PC, formulated to meet or exceed bird nutritional requirements) without phytase; negative control (NC), reduction of 0.192% Ca and 0.175% avP levels when compared with PC diet; and NC diet supplemented with 750 or 1500 FTU/kg phytase. Water and feed were supplied ad libitum throughout the experimental period. Rice bran was included by 7% to increase phytate P levels in all diets. The evaluated parameters were feed intake (FI), feed conversion ratio (FCR) and body weight gain (BWG) determined at 1 to 42 d of age, whereas carcass (CY), breast (BY), thigh and drumstick yield (TDY) were determined in 2 birds per pen at 42 d of age. The results are shown in Table 1. The data were analyzed by ANOVA and Tukey test at 5% probability level. The inclusion of phytase in broiler diet provided higher FI compared with the NC. However, the PC achieved the same performance (BWG and FCR) of treatment with 1500 FTU/kg phytase, probably because of the P levels available in the diet (PC) were sufficient to meet the nutritional requirements of production animals. There was no effect ( $P > 0.05$ ) of phytase levels on CY, BY nor TDY. Therefore, the inclusion of high levels of phytase in diets containing 7% rice bran was efficient for the productive parameters.

**Key Words:** body weight, carcass yield, feed intake, phosphorus, phytate

**Table 1.** Effects of treatments feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR), carcass (CY), breast (BY), thigh and drumstick yield (TDY).

Treatment	FI (g)	BWG (g)	FCR	CY (%)	BY (%)	TDY (%)
CP	5.101a	2.982a	1,71c	79,71	36,10	24,82
CN	4.793b	2.734bc	1,75ab	78,58	37,07	28,29
CN+750	5.071a	2.874b	1,76a	79,34	36,21	28,06
CN+1500	5.013a	2.894ab	1,73bc	80,21	36,98	28,67
P-Value	<0,001	<0,00	<0,001	0,133	0,574	0,373
CV (%)	3,45	4,10	1,66	1,80	4,79	18,40

a–c Different letters in the columns differ by Tukey test at 5% probability.

# Levels of phytase on broiler performance and carcass characteristics.

**RONOZYME<sup>®</sup> HiPhos**

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The aim of this study was to evaluate broiler performance and carcass yield fed corn-soybean meal diets and supplemented with phytase. A total 880 broiler chick males Cobb 500 were randomly distributed in 5 treatments with 8 replicates and 22 birds each one. Treatments were a Positive control diet (PC); Negative control diet (–0.15% Ca and avP) (NC); NC + 1,000 FYT/kg feed (RONOZYME HiPhos GT, DSM Nutritional Products); NC + 2,000 FYT/kg feed; and NC + 3,000 FYT/kg feed. Feed intake (FI), body weight gain (WG) and adjusted feed conversion ratio (adjusted for 2.7 kg of body weight, FCRadj) were evaluated. Also, it were evaluated carcass yield and cuts (breast and thigh+drumstick), and abdominal fat percentage of 3 birds with average weight of experimental unit (±5%). Data were submitted to ANOVA, and means were compared by Tukey test ( $P < 0.05$ ). Regression equations were estimated ( $P < 0.05$ ) according to phytase levels and negative control diet. The phytase supplementation and PC improved the WG (2,610 g PC, 2,458 g, NC+1,000 FYT/kg, 2,668 g NC+2,000 FYT/kg, 2,669 g NC+3,000 FYT/kg) and FI, and FCRadj ( $P < 0.01$ ) (1,551 PC, 1,546 NC+1,000 FYT/kg; 1,538 NC+2,000 FYT/kg, 1,569 g:g NC+3,000 FYT/kg) compared with negative control (2,647 g WG, and 1.641 g:g FCRadj). The regression analysis showed linear effect to FI ( $FI_{42d} = 3913 + 0.102x$ ;  $R^2 = 0.34$ ), and quadratic effect to WG and FCRadj ( $WG_{42d} = 2464.2125 + 0.20828x - 0.00004750x^2$ ;  $R^2 = 0.50$ . Optimal level: 2,192 FYT/kg.  $FCR_{adj} = 1.63857 - 0.00011712 + 0.00000003159375x^2$ ;  $R^2 = 0.38$ . Optimal level: 1,834 FYT/kg). It was not observed any differences in treatments for carcass characteristics ( $P > 0.05$ ). In conclusion, the optimal phytase supplementation to improve broiler performance is higher than usual 1,000 FYT/g used by industry.

**Key Words:** breast yield, enzyme, mineral reduction, regression, weight gain

# Extra-phosphoric effect of phytase on broiler performance from 1 to 21 days.

**RONOZYME<sup>®</sup> HiPhos**

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The use of exogenous enzymes in non ruminant diets have been shown to be an important alternative in reducing the negative effects of anti-nutritional factors of food used in diets formulations. The inclusion of phytase in poultry diet has effective capacity to increase the availability and use of phytic phosphorus. The objective of this study was to evaluate the extraphosphoric effect of phytase on performance of broilers from 1 to 21 d old. 920 broiler chicks were assigned in a completed randomized design to 5 treatments (T1: positive control (PC) without phytase; T2: negative control (NC) (reduction of 0.12% Ca and 0.14% of P available); T3: NC + 1000 FYT/kg (RONOZYME HiPhos GT 100 ppm), T4: NC + 2000 FYT/kg (RONOZYME HiPhos GT 200 ppm); T5: NC + 3000 FYT/kg RONOZYME HiPhos GT 300 ppm). The variables analyzed were weight gain (WG), feed intake (FI) and feed:gain (FG). The data were submitted to ANOVA to compare means by Tukey ( $P < 0.05$ ), and subsequent regression analysis excluding T1 (0% phytase). The performance was better ( $P < 0.05$ ) for the PC treatment and those with phytase inclusion (1000, 2000, and 3000 FYT/kg) than for birds in the NC group. The WG showed a quadratic ( $P < 0.05$ ) response ( $WG = 797.398 + 0.0639312 \times \text{phytase} - 0.0000107528 \times \text{phytase}^2$ ;  $R^2 = 0.69$ ), estimating a value of 893 g of WG when using the level of 2973 FYT of phytase. There was a linear response in FI and FG according to increase in phytase inclusion ( $FI = 1187.58 + 0.026021 \times \text{phytase}$ ;  $R^2 = 0.35$ ;  $FG = 1.466959 + 0.0000230009 \times \text{phytase}$ ;  $R^2 = 0.29$ ). At 21 d of age, the phytase inclusion increased chicken performance remained similar to PC. The great phytase level from 1 to 21 d of age is 2973 FYT/kg of diet.

**Key Words:** exogenous enzyme, extra phosphoric effect, nutrition, phytate, poultry

# Levels of phytase on the digestibility of diets for broilers.



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The increase of Phy in diets can promote change in gut cell renewal increasing the production of mucins and the reduction in protein and energy digestibility once phytic acid it is considered anti nutritional factor more irritating to the mucous, however when we used the enzyme P these changes were minimized. The objective of the trial was to evaluate the apparent digestibility coefficients (ADC) of dry matter (DM), crude protein (CP) and gross energy (GE) in diets from broilers with high level of phytate P (Phyp) and supplement with superdosing of phytase (Phy), the use of concentration of sialic acid (SA) as indicator of gut health. It was used on 936 Cobb one-day-old male broilers, distributed in a completely randomized design, into 4 treatments, 9 replicates of 26 birds on each. Treatments comprised a positive control (PC), a negative control (NC) (no enzyme, and reduction of 0 – 192% Ca and 0 – 175% vP), NC+750 and NC+1500 FTU. All the diets had rice bran added at 7%. At 21st day, 12 birds per treatment were euthanized and ileal content sampled for analysis of DM, crude protein, gross energy and SA. The ADC and SA were compared by ANOVA ( $P < 0.05$ ), and the means compared by Tukey test at 5% of probability (Table 1). Using superdosing phytase the ADC of DM, was numerically higher than the other treatments (65%), and although not significantly, different. Birds fed with NC+1500 had better DM digestibility than PC and NC ( $P < 0.001$ ). The PhyP may also reduce the protein solubility, and it interacts with digestive enzymes also affecting the digestibility of others nutrients, among them energy.

**Key Words:** crude protein, digestibility energy, dry matter, phytase, superdosing

**Table 1.** Effects of the treatment on apparent digestibility coefficients ileal of dry matter (DM), crude protein (CP), digestible energy (DE) and concentration of sialic acid (SA) content ileal in broilers at d 21

Treatment	DM	CP	GE	SA
CP	60,63bc	77,71a	67,75bc	2,81b
CN	57,46c	73,15b	64,91c	2,90ab
CN+750	62,93ab	78,24a	68,53ab	2,83b
CN+1500	65,31a	79,62a	70,76a	3,13a
P-Value	< 0,001	< 0,001	< 0,001	< 0,001
CV <sup>1</sup>	6,25	4,05	4,47	10,18

<sup>1</sup>CV = coefficient of variation. a–c Different letters in the same column differ significantly by Tukey test ( $P < 0.05$ ).





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# Effect of trace minerals as carbo-amino-phospho-chelate on the performance and yield of broilers, a meta-analysis.

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## **Introduction.**

The use of trace minerals more bioavailable in the nutrition of broilers allows a better absorption of the minerals resulting in a better development of skeletal, immune, and antioxidant systems. The purpose of this study was to use a meta-analysis to evaluate the effect of a mineral preparation with higher biological value (carbo-amino-phospho-chelate - CAPC) on the performance and yield of broilers.

## **Material and Methods.**

Eight trials performed between 2008 and 2016 were selected. The diets were based on corn and soybean meal and were formulated to meet the minimum recommendations of Brazilian Tables. A total of 8158 male broiler chicks were used, Cobb, assigned to two treatments with 8 to 12 replicates per treatment. The treatments were: control diet supplemented with inorganic trace minerals as sulfates (Cu, 11.6; Fe, 60; Zn, 96; Mn, 88.7, and Se, 0.31 – average values as mg/kg diet), and control diet supplemented with CAPC (DSM Nutritional Products): Cu, 8.8; Fe, 50; Zn, 58.5; Mn, 62.5, and Se, 0.31 (average values as mg/kg diet). Performance and carcass characteristics were evaluated at 42 days of age. Eight trials were selected to evaluate carcass characteristics, but only five of them evaluated carcass yield, a total of 560 birds. The meta-analysis data underwent a totally random design and were analyzed by using the MIXED procedure of SAS (SAS Institute, 2002). The model included treatments as fixed effect and trials as random effect.

## **Results and Discussion.**

The weight gain of broilers fed CAPC was higher ( $P < 0.05$ ) when compared to those fed sulfates (Table 1). There was no difference ( $P > 0.05$ ) in feed intake and corrected feed conversion for the evaluated mineral sources. Carcass yield was higher ( $P < 0.01$ ) in broilers fed CAPC. There was no difference ( $P > 0.05$ ) between the sources effect on breast and thigh + drumstick yield.

## **Conclusion.**

The use of carbo-amino-phospho-chelate improves broilers performance as well as carcass yield. Supplementation of trace minerals micro minerals can be reduced without interference on performance when more bioavailable sources are used.

**Key Words:** Copper, mineral source, weight gain, zinc.

**Table 1.** Effects of different trace minerals sources and levels on performance and carcass yield of broilers at 42 days of age.

Treatment	WG, g	FI, g	cFC, g:g	CY, %	BY, %	TDY, %
Sulfate	2815 <sup>b</sup>	4562	1.56	77.04 <sup>b</sup>	37.41	30.03
Carbo-amino-phospho-chelate	2849 <sup>a</sup>	4612	1.54	77.60 <sup>a</sup>	37.48	29.84
P Value	0.0258	0.0825	0.4135	0.0026	0.6422	0.1712
CV, %	3.29	4.13	4.54	2.80	6.75	5.23

<sup>a,b</sup> are different based on F test. WG, weight gain; FI, feed intake, cFC feed conversion corrected for 2.7 kg BW; CY, carcass yield; BY, breast yield; TDY, thigh + drumstick yield.

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# Performance of european quail breeders supplemented with canthaxanthin and 25-OH-D<sub>3</sub>

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## Introduction

Carotenoids and vitamins are essential components in layers and breeders' nutrition. When added to feed, Carotenoids such as Canthaxanthin (Cx) reinforce the natural antioxidant capability of the bird's metabolism, fighting free radicals in tissues with a high concentration of polyunsaturated fatty acids, such as egg yolk, thus preventing oxidation (5). 25-OH-D<sub>3</sub> is essential to maintain calcium homeostasis, recycling both calcium and phosphorus in the bird's intestine, and has a fundamental role not only in egg shell formation (4) but also in production systems with low solar radiation incidence. The association of these nutrients has been studied in poultry production systems, especially breeders, to improve fertility and hatching (2). For that reason, the purpose of this study was to analyze the effects of Cx + 25-OH-D<sub>3</sub> association on the production yield of European quail breeders.

## Material and Methods

This essay used 240 European quail breeders at 24 weeks of age, randomly distributed in 5 treatments with six replications of 6 birds (2 male and 4 female) in each experimental unit. Experimental feed consisted of a control feed and 4 levels of canthaxanthin and 25-OH-D<sub>3</sub> addition, as follows: 0 (control feed), 3 (3 ppm Cx + 1.380 UI 25-OH-D<sub>3</sub>), 6 (6 ppm + 2.760 UI 25-OH-D<sub>3</sub>), 9 (9 ppm de Cx + 4.140 UI 25-OH-D<sub>3</sub>) and 12 (12 ppm Cx + 5.520 UI 25-OH-D<sub>3</sub>). Birds were given water and feed ad libitum and were analyzed during 5 productive cycles of 21 days. Production variables were: egg production (P%); feed consumption (FC), feed conversion ratio (FCR) kg/kg and kg/dozen) and egg mass (EM). Egg-laying indices were recorded daily and the feed was weighted once a week. The number of dead birds was considered in the final values correction. Data was submitted to ANOVA and orthogonal polynomial regression in PROC GLM of SAS 9.0, considering 5% probability.

## Results and Discussion

FC, FCR (kg/kg and kg/dozen) and EM were not affected by the supplementation level. Working with broiler breeders, Duarte et al. (1), found no effect of Cx and 25-OH-D<sub>3</sub> addition on egg production variables, egg-laying indices included. Rosa et al. (3) researched the addition of 6 ppm of canthaxanthin to the feed of 960 broiler breeders and 96 roosters and concluded it had no significant effect on egg laying rates. Garcia et al. (2) studied the effect of various levels of canthaxanthin addition on production parameters of 384 Hisex Brown layers and found no significant effect on egg-laying rates, FC, EM and FCR (kg/kg and kg/dozen). Study results on the yield of other production birds show that the association of Cx + 25-OH-D<sub>3</sub> does not affect production yield. The present results corroborate these findings; therefore, this association can also be used in European quail breeders with no harm to production.

## Conclusion

The addition of an association of Cx + 25-OH-D<sub>3</sub> showed no impact on the productive variables of European quail breeders between 24 and 35 years of age.

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**Table 1.** Feed consumption, egg laying indices, feed conversion ratio and egg mass of European quail breeders supplemented with canthaxanthin and 25-OH-D<sub>3</sub>.

Treatments	Feed consumption (g/bird/day)	Egg-Laying indices (%)	Feed Conversion Ratio (kg/kg)	Feed Conversion Ratio (kg/dz)	Egg mass (g/bird)
0	0.03	87.69	4.05	0.62	11.04
3	0.03	83.78	4.15	0.58	10.72
6	0.03	84.96	4.05	0.64	10.79
9	0.03	86.55	3.93	0.64	10.91
12	0.03	83.69	4.11	0.63	10.73
Mean	0.03	85.33	4.05	0.62	10.84
EP	0.00	6.32	1.19	0.05	0.86
Regression	NS	NS	NS	NS	NS



# Quality of eggs from european quail breeders supplemented with canthaxanthin + 25-OH-D<sub>3</sub> association

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## Introduction

The interest of the egg industry in using pigmenting nutrients has increased in the last years as there are different consumer niches and other possible benefits. Canthaxanthin (Cx) is a member of the carotenoid family that has important pigmentation effects on egg yolks, where it is deposited, and on liposoluble media where it acts as an antioxidant, removing free radicals, preventing nutrients oxidation (4). In the diets of breeder, the antioxidant and pigmentation effects of Cx have been associated with 25-hydroxycholecalciferol (25-OH-D<sub>3</sub>) due to its relationship with calcium and phosphorus that are essential for eggshell formation (3). Therefore, the objective of this trial was to evaluate the effects of different levels of the canthaxanthin and 25-OH-D<sub>3</sub> association on quality variables of European quail breeder eggs.

## Material and Methods

A total of 240 European quails 24-weeks old were used, distributed in a completely randomized design, with 5 treatments, 8 replicates and 6 birds per experimental unit (four females and two males). The experimental diets were a control feed and 4 levels of canthaxanthin and 25-OH-D<sub>3</sub> association: 0 (control), 3 (3 ppm Cx + 1,380 IU 25-OH-D<sub>3</sub>), 6 (6 ppm Cx + 2,760 IU 25-OH-D<sub>3</sub>), 9 (9 ppm Cx + 4,140 IU 25-OH-D<sub>3</sub>) and 12 (12 ppm Cx + 5,520 IU 25-OH-D<sub>3</sub>). Water and feed were provided ad libitum and breeders were evaluated in five 21-day production cycles. The characteristics evaluated in the last 3 days of each cycle were: egg weight, yolk weight, yolk index and Haugh unit. The yolk color was assessed by L\*, a\*, and b\* in the colorimeter, L\* value indicating luminosity, a\* the light reflectance between red and green, and b\* the light reflectance between yellow and blue. Data was analyzed by ANOVA and the orthogonal polynomials were unfolded by regression using Proc GLM of SAS 9.0, considering a 5% significance level.

## Results and Discussion

The mean data related to the analysis of egg quality variables as a function of the Cx + 25-OH-D<sub>3</sub> association levels are presented in Table 1. Haugh units, egg mean weights, yolk weights and yolk index were not influenced by the Cx + 25-OH-D<sub>3</sub> levels ( $P > 0.05$ ). In relation to yolk color, decreasing quadratic behavior was observed for values referring to L\* ( $Y = 60.70 - 1.61x + 0.081x^2$ ;  $R^2 = 0.99$ ) and increasing quadratic behavior for values referring to a\* ( $Y = -3.58 + 3.91x - 0.178x^2$ ;  $R^2 = 0.98$ ) as a function of the studied levels. L\* values decreased according to the supplemented level, suggesting that yolk color became darker. The a\* values indicated that by increasing the supplemented levels the red color became more intense in the egg yolks. These results are similar to those reported by Rocha et al. (2) in broiler breeders, concluding that egg yolks become darker by adding canthaxanthin. Adding 3 ppm Cx to the diet of Japanese quails, Moura et al. (1) reported a marked alteration in the yolk color. The higher deposit of carotenoids into the egg yolk assumes that there is a higher antioxidant protection level in the yolk of fertile eggs, which could possibly lead to better reproduction, embryonic development and hatching rates.

## Conclusion

Adding the Cx + 25-OH-D<sub>3</sub> association modifies the yolk color of fertile eggs, making them more reddish.

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**Table 1.** Egg weight (EW), yolk weight (YG), yolk index (YI), Haugh unit (HU) and egg yolk color (L\*, a\*, and b\*) of eggs from European quail breeders supplemented with canthaxanthin and 25-OH-D<sub>3</sub>.

Treatments	EW (g)	YW (g)	YI	HU	Egg yolk color		
					L*	a*	b*
0	12.87	3.99	0.46	87.57	60.76	-4.43	39.22
3	12.65	3.88	0.46	88.06	56.15	8.48	38.41
6	12.79	3.99	0.45	87.83	54.37	12.74	38.32
9	12.45	3.97	0.46	87.22	52.66	16.20	37.28
12	12.79	3.98	0.46	87.16	52.99	18.32	38.51
Mean	12.71	3.96	0.46	87.43	55.40	10.26	38.35
SE	1.78	0.14	0.01	3.70	2.97	3.56	3.33
Regression	NS	NS	NS	NS	Q	Q	NS

SE = standard error; NS = non-significant; L = effect of linear regression; Q = effect of quadratic regression.

# Optimized levels of vitamins and carbo-amino-phospho-chelate minerals increase meat yield and reduce fat in broilers

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## Introduction

Recent studies have shown that vitamins have a role in the main pathways leading to broilers' growth and muscular development (1,2,3,4). Supplementation with 25(OH)D<sub>3</sub> promotes the activity of Pectoralis Major satellite cells, which increases muscular yield through muscular fiber hyperplasia (1). Vignale et al. (2) have shown that Vitamin D participates in protein synthesis processes, via the mechanistic target of Rapamycin (mTOR). Supplementing these processes with Vitamin D (25(OH)D<sub>3</sub>) might change body composition and fat deposition in broilers (3). Transcription of a gene to cytosolic phospholipase is a process regulated by Vitamin E (4), which might potentially change the profile and composition of fatty acids and fat deposition. On the other hand, mineral sources with higher bioavailability not only represent greater stability and better absorption and use, but also less environmental impact. The aim of this study was to supplement broiler diets with optimal vitamin levels and mineral sources and assess the effect on meat yield.

## Material and Methods

A total of 1800 Cobb male broiler chicks were randomly assigned to a 2x2 factorial design (vitamin levels: commercial and optimal vitamin levels vs mineral sources: inorganic and carbo-amino-phospho-chelate), in 4 treatments with 9 replications of 50 birds each. Diets were isonutritive and vitamin and mineral premixes were included in 5 kg/ton doses, according to the experimental treatments. Vitamin D<sub>3</sub> metabolite 25(OH)D<sub>3</sub> was only added to the optimized vitamin premix. At 42 days of age a total of 240 birds were slaughtered (60 birds/treatment) to assess carcass and commercial cuts yields. Results were submitted to ANOVA (SAS software) with 5% significance.

## Results and discussion

Interaction was found for carcass weight (Table 1). Birds treated with commercial levels of vitamin supplemented diets associated to carbo-amino-phospho-chelate or inorganic mineral sources had higher absolute weight ( $P < 0.05$ ) and carcass weight (Table 2). On the other hand, supplementation with carbo-amino-phospho-chelate mineral sources resulted in higher breast weight and less abdominal fat deposition (Table 1). Considering nutritional strategies of supplementation with optimized vitamin and greater bioavailability mineral sources to increase muscle mass in poultry carcass generates relatively small gain – average 0.16 to 0.83% (1). Even so, a moderate increase in breast meat yield might represent a significant income to the broiler industry.

## Conclusion

Dietary supplementation with optimized levels of vitamin and carbo-amino-phospho-chelate mineral source increases meat yield and reduces abdominal fat in broilers.

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**Table 1.** Absolute weight and carcass yield at 42 days of age of broilers fed diets supplemented with various vitamin and mineral source levels.

	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Vitamins								
Commercial	2334,61	74,85	933,58 <sup>b</sup>	40,22 <sup>b</sup>	719,41	30,84	45,19	1,972 <sup>b</sup>
Optimized	2354,11	75,49	964,87 <sup>a</sup>	40,81 <sup>a</sup>	721,16	30,66	43,74	1,859 <sup>a</sup>
Minerals								
Inorganic	2332,00	75,22	937,26 <sup>b</sup>	40,65	717,09	30,79	45,41	1,971 <sup>b</sup>
Carbo-amino-phospho-chelate	2357,05	75,12	961,42 <sup>a</sup>	40,40	723,57	30,72	43,52	1,859 <sup>a</sup>
CV, %	7,52	5,43	9,79	5,46	8,67	5,86	27,45	28,07
Variance Analysis								
Vitamins	0.216	0.0685	0.011	0.0437	0.773	0.2618	0.3569	0.0332
Minerals	0.102	0.4915	0.050	0.3959	0.230	0.6605	0.2319	0.0174
V x M	0.026	0.0873	0.382	0.9127	0.075	0.6989	0.0752	0.0896

**Table 2.** Breakdown of vitamin levels vs mineral sources interaction on carcass weight

Minerals	Inorganic	Carbo-amino-phospho-chelate	P
Vitamins			
Commercial	2305.38 <sup>Bb</sup>	2364.75 <sup>Aa</sup>	0.0084
Optimized	2358.62 <sup>Aa</sup>	2349.59 <sup>Aa</sup>	0.6685
P	0.0143	0.4886	

Averages followed by different uppercase letters on columns and lowercase letters on rows are statistically different.

# Effect of feed supplementation with $\alpha$ -amylase and $\beta$ -xylanase on broilers performance and metabolizable energy

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## Introduction

Exogenous carbohydrases are enzymes that can be added to broilers' diet to improve their use of energy and nutrients. These enzymes can either act in the non-digestible fractions of ingredients or potentiate the action of endogenous enzymes. Using amylase and xylanase in corn-soy meal diets is a viable tool to improve production performance of broilers. The purpose of the present experiment was to assess the effect of one  $\alpha$ -amylase and one  $\beta$ -xylanase supplementation, either alone or in combination, on production performance of broilers.

## Material and Methods

1,800 Cobb x Cobb 500 broilers with one day of age were distributed in a completely random design of 8 treatments and 9 replications with 25 birds in each experimental unit. Diets were separated into 2 phases: initial (1 to 21 d) and final (22 – 40 d), with water and feed given ad libitum. Treatments were as follows: positive control (PC) with regular energy levels; 2 treatments with increased nAME (PC + 50 kcal/kg and PC + 100 kcal/kg); and 2 treatments with two levels of reduced energy (PC -50 kcal/kg, PC -100 kcal/kg); and 3 diets with enzyme supplementation (PC-100 kcal/kg supplemented with 80 kilo-Novo units of  $\alpha$ -amylase (KNU), 100 units of fungal  $\beta$ -xylanase (FXU) or 80 KNU of  $\alpha$ -amylase + 100 FXU of  $\beta$ -xylanase). Weight gain (WG), feed intake (FI) and feed conversion rate (FCR) corrected for weight of dead birds were recorded weekly. Data was submitted to Proc. GLM of SAS and significant means were submitted to Tukey test at 5% probability. Regression equations were estimated according to each dietary energy level and the energy equivalence of enzymes was calculated.

## Results and discussion

Broilers fed with PC + 100 kcal/kg resulted in higher weight gain ( $P < 0.05$ ) from 1 to 21d and 1 to 40d but did not differ from the positive control. Lower FCR was observed in both phases (1 to 21 d and 1 to 40 d) in broilers fed with PC, PC + 50 kcal/kg and PC + 100 kcal/kg, compared to birds receiving PC – 100 kcal/kg ( $P < 0.05$ ) diet. No significant difference was seen in weight gain (WG) and feed conversion rate (FCR) between the positive control (PC) diet and enzyme supplemented diets. On the whole period, birds on PC diet showed 5% lower feed conversion rate compared to birds fed with PC -100 kcal/kg without enzyme addition. This result is consistent with Sorbara et al. (1) findings, who reported 3.5% lower feed conversion rate than in the control feed group when compared to PC -100 kcal/kg. Regarding nAME throughout the whole period (from 1 to 40d) increases of 98, 84 and 112 kcal/kg were estimated for weight gain (WG), and 41, 26, 43 kcal/kg for feed conversion (FCR) in broiler diets containing amylase, xylanase and amylase + xylanase, respectively.

## Conclusion

Productivity was better in broilers receiving higher energy level diets. Diet supplementation of 80 KNU  $\alpha$ -amylase, 100 FXU fungal  $\beta$ -xylanase or 80 KNU  $\alpha$ -amylase + 100 FXU  $\beta$ -xylanase for NC resulted in 98, 84 and 112 kcal/kg for WG and 41, 26, 43 kcal/kg for FCR, respectively.

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**Table 1.** Effect of treatments on production performance of broilers from 1 to 40 d

Treatments	WG <sup>1</sup> , g	FCR <sup>2</sup>
NC (PC -100 kcal/kg)	2924ab	1.38bcd
PC -50 kcal/kg	2897b	1.42abcd
PC	2889b	1.45 <sup>a</sup>
PC+ 50 kcal/kg	2968ab	1.37 <sup>cd</sup>
PC + 100 kcal/kg	2983 <sup>a</sup>	1.36 <sup>d</sup>
NC + amylase	2931ab	1.43ab
NC + xylanase	2923ab	1.44 <sup>a</sup>
NC + amylase + xylanase	2950ab	1.43abc
EPM	8.021	0.006
Prob.	<0.036	<0.001

a-d Means in the same column followed by different letters are significantly different by Tukey test ( $p < 0.05$ )

1 Weight gain

2 Feed Conversion Rate corrected for dead birds weight

**Table 2.** Effect of treatments on production performance of broilers from 1 to 21 d and 22 to 40 d

Treatments	1 - 21 d		22 - 40 d	
	WG <sup>1</sup> , g		WG <sup>1</sup> , g	FCR <sup>2</sup>
NC (PC -100 kcal/kg)	1006ab	1.284ab	1919	1.484bc
PC -50 kcal/kg	995bc	1.299a	1913	1.518ab
PC	978c	1.316a	1912	1.535a
PC + 50 kcal/kg	1018ab	1.258bc	1936	1.467c
PC + 100 kcal/kg	1029a	1.232c	1952	1.453c
NC + amylase	995bc	1.299a	1940	1.516ab
NC + xylanase	998bc	1.302a	1932	1.532a
NC + amylase + xylanase	997bc	1.295a	1946	1.516ab
MSE (mean standard error)	2.604	0.004	6.178	0.004
Prob.	<0.001	<0.001	<0.005	<0.001

a-c Means in the same column followed by different letters are significantly different by Tukey test ( $p < 0.05$ )

1 Weight gain

2 Feed Conversion Rate corrected for dead birds weight

# Meat quality and color of slow-growing broilers fed with dehydrated cassava starch residue with or without added enzymes

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## Introduction

Demands for meat quality are increasing as the consumer is more careful about attributes related to the product quality. Thus, the inclusion of feedstuffs in birds' diets should always be done in a cautious manner to avoid alterations in the quality of the final product. This study was carried out to evaluate the effects of including dehydrated cassava starch residue (DVSR) in the feed of slow-growing broilers on the meat quality and color.

## Material and Methods

A total of 1,100 male, Label Rouge, day-old chicks were allocated in a completely randomized factorial arrangement 2 × 5 (with and without added enzymes and five levels of DVSR - 0; 2.5; 5.0; 7.5, and 10%), with five replicates and 22 birds per experimental unit. During the whole experimental period (63 days) the birds had access to feed and water ad libitum. Enzymes (xylanase, cellulase, amylase and β-glucanase) were added according to the manufacturer's recommendation and the DVSR nutritional value used in the diets formulation was obtained from a previous trial. Meat quality was evaluated in the breast muscle (Pectoralis major) of 10 birds per treatment. The breast meat color was measured 15 min post mortem. Components L\* (luminosity – from bright to dark), a\* (red/green intensity), and b\* (yellow/blue intensity) were expressed by the Cielab color system. Water holding capacity (WHC) was analyzed using the centrifugation method. To determine the weight loss by cooking (WLC), breast fillets were weighed, cooked and after a certain period the fillets were weighed again, thus providing the WLC. The shearing force (SF) was obtained by using the Brookfield CT3 Texture Analyzer. The data was submitted to ANOVA, regression analyses and means were compared by Tukey test ( $P < 0.05$ ), using the statistical program SAEG.

## Results and Discussion

There was no effect ( $P > 0.05$ ) of enzymes and DVSR inclusion on meat quality (Table 1). Interaction ( $P < 0.05$ ) was observed between the addition of enzymes and DVSR on the breast meat color intensity of a\* (Table 2). By unfolding the interaction, birds fed diet with enzymes and up to 5% of DVSR had lower a\* values than the birds that were fed the diet without enzymes. Increasing the DVSR level in the diet had a linear effect when no enzymes were supplemented and a quadratic effect of the diet with added enzymes, resulted in a lower a\* intensity at 4.06% of DVSR. A quadratic effect ( $P < 0.05$ ) on b\* intensity was found which was lower at 8.89% of DVSR inclusion. The influence observed of DVSR inclusion levels on colorimetry can be related to the lack of cassava pigments and its coproducts (1).

## Conclusion

Adding up to 10% of dehydrated cassava starch residue to the diet of slow-growing broilers does not interfere in the meat quality but modifies its pigmentation.

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**Table 1 .** Quality characteristics of breast meat from slow-growing broilers fed diets with different DVSR levels, with or without added enzymes.

	WLC (%)	WHC (%)	SF (kgf cm <sup>-2</sup> )
With	22.02	50.38	3.00
Without	21.24	51.35	3.40
Levels (%)			
0.0	20.82	50.38	3.04
2.5	22.10	51.35	3.11
5.0	21.51	51.57	2.76
7.5	21.98	51.52	3.77
10	21.72	49.66	3.32
Enzyme	NS	NS	NS
Level	NS	NS	NS
E x L	NS	NS	NS
CV%	14.43	5.66	27.93

WLC = weight loss by cooking; WHC = water holding capacity; SF = shear force; NS = non-significant by Tukey test (P<0.05).

**Table 2 .** Colorimetry of breast meat from slow-growing broilers fed diets with different DVSR levels, with or without added enzymes

	L*	a*		B*
With	46.37			2.66
Without	46.73			3.23
Levels (%)				
	Without		With	
0.0	46.27	2.60a	1.15b	4.29
2.5	47.79	2.06a	0.60b	3.21
5.0	46.75	2.41a	0.56b	2.75
7.5	46.48	1.67a	1.22a	2.65
10	45.46	1.28a	1.47a	2.38
Enzyme	NS	0.0001		NS
Level	NS	NS		NS
E x L	NS	0.002		NS
L <sup>1</sup> (0.0006) Q <sup>2</sup> (0.023)				
CV (%)	4.09	38.44		25.26

L\* = Luminosity; a\* = red/green intensity; b\* = yellow/blue intensity. <sup>1</sup>Y=2.61107+0.121480x; R<sup>2</sup>= 0.79. <sup>2</sup>Y=1.08468+0.212221x-0.0261181x<sup>2</sup>; R<sup>2</sup>= 0.83; minimum point: 4.06. <sup>3</sup>Y=4.21094+0.399510x-0.0224724x<sup>2</sup>; R<sup>2</sup>= 0.97; minimum point: 8.89. In the same line, means followed different lower case letters indicate statistical difference by Tukey test (P<0.05).



# Bone quality of broilers fed different mineral sources

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## Introduction

The poultry industry development has been accompanied by a higher incidence of bone disorders in high performance modern broilers (1). Thus, it became necessary to complement feeds with minerals to improve the birds bone structure, allowing them to reach their genetic potential without compromising the skeletal system. Minerals act as catalysts in many enzyme and hormone systems (2) and, as a result, they influence growth and bone development (3). The objective of this study was to assess broilers bone quality when fed different mineral sources in two recommendations.

## Material and Methods

The trial was performed at FMVZ/UNESP involving 2,304 Cobb broiler chicks. The adopted experimental design was completely randomized, 2x2 factorial being either inorganic mineral supplementation (Fe, Zn, Cu, Mn and Se) or Tortuga Minerals according to the genetic line (Cobb) recommendations (Fe: 40 mg; Mn: 100 mg; Zn: 100 mg; Cu: 15 mg; Se: 0.3 mg) or Tortuga Minerals (Fe: 44 mg; Mn: 56 mg; Zn: 44 mg; Cu: 8.6 mg; Se: 0.34 mg). Nutritional management was divided into four phases: pre-starter (1-7 days), starter (8-21 days), growth (22-35 days) and final (36-42 days). At 43 days of age, 240 birds (60 birds per treatment) were slaughtered using a method like the commercial slaughter and the drumsticks were removed. The drumsticks were frozen at -10°C for 30 days and were thawed in a refrigerator after this period. The right-side drumsticks were deboned and the distal portion of the tibias underwent colorimetric evaluation. These bones were weighed, dried in a forced ventilation oven at 105°C during 24h to determine the dry matter content. The resistance to breakage of these bones was determined using a Texture Analyser TA.XT Plus and a probe Blade Set HDP/BS, adapted to maintain a 5 cm span between the diaphyses. The left side drumsticks were cooked in an industrial oven until they reached an internal temperature of 95°C, and after cooling they were visually assessed to determine the darkening of meat adjacent to the bone (black bone syndrome).

## Results and Discussion

The use of different mineral sources and recommendations did not influence ( $p < 0.05$ ) luminosity, dry matter and bone resistance (Table 1). These characteristics are measures of bone quality, and bone resistance is mainly influenced by the amount and quality of mineral sources (4). Bone quality is influenced by the incidence of bone disorders and therefore the use of mineral sources was not efficacious in improving it, contrary to results obtained in a previous study (3). In the gross assessment of the broilers drumsticks using black bone syndrome scores (acceptable or unacceptable) no difference ( $p > 0.05$ ) was found between the treatments (Table 2). The intermediate black bone syndrome score was influenced by the mineral recommendation that was used ( $p = 0.0004$ ), with better results when Cobb's recommendation was followed with all mineral sources. It is known that the black bone syndrome can be influenced by nutrients such as Ca, P and vitamin D (5) and they are directly influenced by the availability of minerals as Fe, Mn, Zn and Cu, which can justify the results that were found.

**Table 1.** Dry matter (%), luminosity (L\*) and bone resistance (kgf) of broilers fed diets with organic or inorganic minerals, according to the genetic line or Tortuga nutritional recommendations.

Characteristic	Recommendation		Minerals	
	Cobb	Tortuga	Tortuga	Inorganic
L*	48.16	48.90	48.62	48.44
DM	52.00	51.73	52.16	51.56
BR	34.24	34.02	33.90	34.36
PROBABILITY				
Characteristic	M	R	M*R	CV (%)
L*	0.7411	0.1666	0.3668	8.47
DM	0.1519	0.5126	0.6669	30.10
BR	<u>0.8308</u>	0.8258	0.6536	22.97

L\* = luminosity; DM = dry matter; BR = bone resistance; M = mineral; R = recommendation; CV = coefficient of variation. Tukey test ( $p > 0.05$ ).

**Table 2.** Frequency of black bone syndrome (gross assessment) in the thighs of broilers fed diets with organic or inorganic minerals, according to the genetic line or Tortuga nutritional recommendations.

BBS	Recommendation		Minerals	
	Cobb	Tortuga	Tortuga	Inorganic
ACCEP	45.68	45.69	42.24	49.13
INTERMED	46.55b	49.14a	51.72	43.96
UNACCEP	7.76	5.17	6.03	6.89

### Conclusion

Bone quality was not influenced using Tortuga Minerals or inorganic minerals.

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# Mineral sources and breast meat quality of broilers

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## Introduction

The use of more bioavailable mineral sources in animal diets is becoming an important feature as they are better absorbed and less excreted to the environment. The total or partial replacement of inorganic minerals by more bioavailable sources in the diets of broilers can improve the carcass and meat quality as they provide higher resistance to the membrane and other cell structures (1). The objective of this study was to evaluate the breast meat quality of broilers fed Tortuga Minerals or inorganic minerals in two recommendations.

## Material e Methods

The trial was performed at FMVZ/UNESP involving 2,304 Cobb day-old broiler chicks. The adopted experimental design was completely randomized, 2x2 factorial being inorganic mineral supplementation (Fe, Zn, Cu, Mn and Se) or Tortuga Minerals according to the genetic line (Cobb) recommendations (Fe: 40 mg; Mn: 100 mg; Zn: 100 mg; Cu: 15 mg; Se: 0.3 mg) or Tortuga Minerals (Fe: 44 mg; Mn: 56 mg; Zn: 44 mg; Cu: 8.6 mg; Se: 0.34 mg). Nutritional management was divided into four phases: pre-starter (1-7 days), starter (8-21 days), growth (22-35 days) and final (36-42 days). At 43 days of age, 240 birds were slaughtered using a method like the commercial slaughter. On the day after slaughter, the left half of deboned breasts underwent the following evaluations: pH (digital penetration pHmeter), weight loss by cooking and water holding capacity (wrapped in filter paper, 2 g sample was under 10 kg pressure during 5 min and then weighed). The right half of 20 breasts per treatment underwent shelf-life evaluations (TBARS – index of lipid oxidation – reaction to malondialdehyde at 1, 90 and 180 days of storage).

## Results and Discussion

The water holding capacity and weight loss by cooking of breast meat were not influenced by the treatments ( $p > 0.05$ , Table 1). pH was influenced only by the mineral source, the highest values obtained in the meat of broilers fed with Tortuga Minerals. Although there was a difference in this characteristic, it should be stressed that the values are within the normal range in all treatments (1, 2, 3, 4). In the TBARS evaluation, it was found that results had the same behavior for the 1- and 90-day periods, with no interaction between the treatments ( $p > 0.05$ ). There was only an isolated effect of the mineral source with lower results for the inorganic minerals. However, the effects were no longer found ( $p < 0.05$ ) after 180 days storage, suggesting that the mineral source has an effect limited to lower storage period (Table 2).

## Conclusion

The use of more bioavailable minerals (Minerais Tortuga) did not improve the quality of broiler breast meat.

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**Table 1.** Quality of broiler breast meat.

Recommendation	Minerals		Mean
	Tortuga	Inorganic	
pH			
Cobb	5.75	5.67	5.71
Tortuga	5.74	5.65	5.69
Mean	5.74a	5.66b	
Water holding capacity (%)			
Cobb	35.42	35.85	35.63
Tortuga	35.17	36.60	35.88
Mean	35.29	36.22	
Weight loss by cooking (%)			
Cobb	30.94	30.59	30.76
Tortuga	31.25	30.44	30.84
Mean	31.09	30.51	

Means followed by followed different letters in the same line are different by Tukey test ( $P < 0.05$ ).

**Table 2.** Malondialdehyde (MDA) concentrations in broiler breast meat.

Recommendations	Minerals		Mean
	Tortuga	Inorganic	
TBARS – one day			
Cobb	0.38	0.35	0.36
Tortuga	0.38	0.33	0.35
Mean	0.38a	0.34b	
TBARS – 90 days			
Cobb	0.76	0.55	0.65
Tortuga	0.81	0.59	0.70
Mean	0.78a	0.57b	
TBARS –180 days			
Cobb	1.19	1.17	1.18
Tortuga	1.25	1.22	1.23
Mean	1.22	1.19	

# Mineral sources and broilers performance

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## Introduction

Minerals are involved in a wide variety of physiological processes, so they become essential for bird's growth (1). Total replacement of inorganic minerals by more bioavailable mineral source can provide better nutritional support for broilers, improving their performance, and decreasing the excretion of pollutants into the environment. The objective of this study was to evaluate performance and carcass yield of broilers fed two mineral sources in two recommendations.

## Material and Methods

The trial was performed at the FMVZ/UNESP involving 2,304 Cobb day-old broiler chicks. The adopted experimental design was completely randomized, 2x2 factorial the mineral supplementation (Fe, Zn, Cu, Mn and Se) being either Mineraiis Tortuga or inorganic minerals according to the genetic line (Cobb) recommendations (Fe: 40 mg; Mn: 100 mg; Zn: 100 mg; Cu: 15 mg; Se: 0.3 mg) or Tortuga Minerals recommendations (Fe: 44 mg; Mn: 56 mg; Zn: 44 mg; Cu: 8.6 mg; Se: 0.34 mg). Nutritional management was divided into four phases: pre-starter (1-7 days), starter (8-21 days), growth (22-35 days) and final (36-42 days). At 43 days of age, 240 birds (60 birds per treatment) were slaughtered using a method similar to the commercial slaughter and carcass, breast and fat yields were calculating.

## Results and Discussion

Feed consumption and weight gain were higher in broilers fed Mineraiis Tortuga (Table 1). Production efficiency, however, showed that the use of Mineraiis Tortuga is quite interesting. Minerals from more bioavailable sources are better absorbed and distributed in the body of broilers, leading to better production performance (2). Thus, the use of these minerals is beneficial, providing less environmental contamination (3). Breast yield was also influenced by the nutritional recommendation that was used, with better results for the Cobb recommendation.

## Conclusion

The use of more bioavailable minerals as Mineraiis Tortuga was beneficial for the birds, as productive efficiency and carcass and breast yield were better in the birds fed with this mineral source.

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**Table 1.** Performance of broilers in the 1 to 42 days of age period.

	FCR (%)	WG (G)	Adjusted FCR 2.8 kg	Productivity
	Minerals			
Tortuga	4581a	3043a	1.429	452.56a
Inorganic	4149b	2816b	1.455	436.62b
	Recommendation			
Cobb	4,414	2904	1.434	451.38
Tortuga	4,316	2955	1.450	437.80
	Probability			
Minerals (M)	<0.0001	0.0008	0.2390	0.0498
Recommendation (R)	0.3327	0.3020	0.4679	0.2342
M x R	0.3191	0.5000	0.9863	0.3057
CV (%)	9.21	8.20	5.20	8.92

For each source of variation, means followed by uppercase letters in columns and lowercase in lines are different by Tukey test ( $p < 0.05$ ).

**Table 2.** Carcass, abdominal fat, and breast yield of broilers.

	CY (%)	AbF (G)	BY (%)
	Minerals		
Tortuga	74.88a	1.69b	41.36 <sup>a</sup>
Inorganic	73.82b	1.87a	40.48b
	Recommendation		
Cobb	74.87	1.74	41.17A
Tortuga	73.83	1.81	40.67B
	Probability		
Minerals (M)	0.2100	0.3357	0.0355
Recommendation (R)	0.0004	0.0125	0.0004
M x R	0.2617	0.8890	0.3445
CV (%)	4.67	31.00	4.71

CY = carcass yield; AbF = abdominal fat; BY = breast yield. Means followed by uppercase letters in columns and lowercase in lines are different by Tukey test ( $p < 0.05$ ).



