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Effect of the Supplementation of Vitamins and Organic Minerals on the Performance of Broilers under Heat Stress¹

■ Author(s)

Laganá C²

Ribeiro AML³

Kessler AM³

Kratz LR⁴

Pinheiro CC⁴

¹ Part of the thesis presented by the first author to Universidade Federal do Rio Grande do Sul as one of the requisites to obtain the title of Ph.D. in Animal Science.

² Researcher APTA Regional/PRDTA Leste Paulista.

³ Assistant Professor, Dep. Zootecnia - UFRGS- Porto Alegre - RS.

⁴ Laboratório de Ensino Zootecnico - UFRGS- Porto Alegre - RS.

■ Mail Address

C Laganá

Caixa Postal 01

13.910-000. Monte Alegre do Sul, SP, Brasil

E-mail: christine@apta regional.sp.gov.br

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ABSTRACT

The objective of this experiment was to evaluate the effect of diet supplementation with vitamins C and E and organic minerals Zn and Se on the performance of 1 to 35 day-old broilers from, kept under cyclic heat stress (25 to 32°C). Four levels of vitamin-mineral supplementation were used (T1-control diet (60/30 IU of vit E for starter and growing diet, respectively, zero vit. C, 80 ppm of inorganic Zn, 0.3 ppm of inorganic Se); T2-control diet + 100 UI vit E and 300 ppm vit C/kg; T3-control diet + 40 ppm Zn and 0,3 ppm Se/kg; T4-control diet + T2 and T3 levels) and two environments - thermoneutral and cyclic heat stress (TN and HS) from 14 to 35 days of age. In the period when part of the birds was submitted to HS, from 14 to 35 days, it was observed lower feed intake (FI) and better feed conversion (FC) for HS birds receiving supplementation compared to the group without supplementation. Evaluating the total period, all the types of supplementation provided lower FI and better FC than the control treatment, but not affected weight gain (WG). The supplementation of vitamins C and E and/or organic minerals Zn and Se improved the performance of birds due to a lower FI resulting in better FC, independently on the environment.

Introduction

Environmental temperature can be considered one of the main physical factors that influence broiler performance, as it has an important effect on feed intake (Cerniglia *et al.*, 1983 e Teeter *et al.*, 1984). This has a direct effect on weight gain and feed conversion ratio, and it is considered as a type of stress. Research studies have often showed that stressed birds require higher vitamin and mineral supply (Coelho & McNaughton, 1995, Miltenburg, 1999 e El-Boushy, 1988) due to changes in metabolism, to a decrease in feed intake, and to reduced vitamin stability. However, this does not mean that the mere supplementation of vitamins solves problems caused by heat stress (HS) (Ribeiro & Laganá, 2002). However, few studies were carried out to determine the requirements and the availability of these nutrients under hot conditions.

Vitamins C and E present important metabolic interactions: vitamin C enhances vitamin E antioxidant activity by reducing tocopheroxyl radicals into the active form of vitamin E (Jacob, 1995), or by sparing available vitamin E (Retsky & Frei, 1995).

Many studies have been carried out on the use of organic trace minerals, as these present higher bioavailability, and are transported more easily and stored for longer periods of time than its inorganic counterparts (Maiorka & Macari, 2002). Among trace minerals, selenium (Se) has important functions, such as antioxidant, component of enzymes



against pathogens. In addition, Se is required for normal pancreatic functions (Macpherson, 1994; Combs & Combs, 1986), including digestive enzyme secretion, thereby improving nutrient digestibility and consequently, performance. Zinc (Zn) is important due to its role in the normal function of the immune system, and its association to enzymes that are essential to maintain the integrity of cells involved in the immune response (Dardenne *et al.*, 1985). Zn is a cofactor of many essential enzymes, such as lactate dehydrogenase, alkaline phosphatase, and carbonic anhydrase (Maiorka & Macari, 2002). Zn requirements probably increase during exposure to HS conditions.

Aiming at finding alternatives to reduce heat stress problems in broilers, the objective of the present study was to evaluate the effects of the dietary supplementation of vitamin C and vitamin E and (or) organic zinc and selenium added together (vitamins and minerals) on the performance of broilers submitted to cyclic heat stress (25-32°C) from 14 to 35 days of age.

MATERIALS AND METHODS

A total number of 468 day-old male Ross 308 broilers was used. Birds were reared in metal cages with 31±1°C initial temperature, which was gradually decreased to 24±1°C on day 14. Six birds per cage were randomly distributed into four treatments, according to vitamin and/or trace mineral supplementation: T1 – control diet (80 ppm inorganic Zn; 0,3 ppm inorganic Se; 60 IU/kg vitamin E, included in the vitamin-mineral premix); T2 – vitamin supplementation (100 IU vit. E and 300 ppm vit. C/kg feed); T3 – organic trace mineral supplementation (40 ppm Zn and 0.3 ppm Se/kg feed); and T4 – vitamin and mineral supplementation at the same levels of T2 + T3.

Vitamin E was supplemented as dl- μ tocopherol acetate (Roche®), and vitamin C as ascorbic acid (Roche®). Zinc and selenium were supplemented in an organic form (Zinpro®).

On day 14, 272 birds (four birds per cage) were selected at random, and distributed into 68 cages, measuring 0.90 m², located in two different environments: thermoneutral (TNE) and heat stress (HSE), with eight replicates per supplementation type in HSE, and nine replicates per supplementation type in TNE.

to 25°C daily, whereas TNE involved daily temperatures of 21 to 25°C. Air relative humidity was kept at 70% in both environments.

Birds were fed *ad libitum* the starter diet from 1 to 21 days of age, and the grower diet from 22 to 35 days of age (Table 1). The only difference in the diet premix between the two phases was the level of vitamin E, which was 60 IU and 30 IU, for the starter and grower diets, respectively. Other supplementation levels were kept equal in both phases.

Table 1 - Nutritional and ingredient composition of starter and grower control diets for broilers during the experimental period.

	Starter diet (1-21days)	Grower diet (22-35days)
Ingredients		
Corn	56,88	60,61
Soybean meal (46CP)	36,08	31,61
Soybean Oil	2,78	3,67
Limestone	1,43	1,39
Dicalcium phosphate	1,80	1,68
Salt	0,47	0,47
Vitamin premix ¹	0,05	0,05
Mineral premix ²	0,10	0,10
Hidroxy analogue (88%)	0,23	0,25
Choline	0,03	0,03
Coccidiostat	0,025	0,05
Nutritional levels		
ME (kcal/kg)	3000	3100
CP (%)	21,5	19,50
Ca	1,0	0,95
P avail	0,45	0,42
Lys	1,25	1,14
Met+Cys	0,90	0,83
Zn (ppm)	80	80
Se (ppm)	0,3	0,3
Vit E (mg/kg)	60	30

1- Levels calculated based in Rostagno *et al.* (2000). 2 - Vitamin mix (content per kg/product): Vit.A. 10.000 IU; Vit D3 3.000 IU; Vit E 60 mg; Vit K3 3 mg; Vit B1 3 mg; Vit. B2 8 mg; Vit B6 4 mg; Vit B12 0,014 mg; Pantothenic Acid 20 mg; Niacin 50 mg; Folic Acid 2 mg; Biotin 0,15 mg. 3 - Mineral mix (content per kg/product): Fe 40 mg; Zn 80 mg; Mn 80 mg; Cu 10 mg; I 0,7 mg; Se 0,3 mg. 4 - Utilized bioequivalence.

Weight gain, feed intake, and feed conversion ratio were weekly determined until the end of the experimental period (35 days).

Data were submitted to analysis of variance using the GLM (General Linear Models) procedures of SAS (2001) software package. LSMeans test was used to compare treatment means.

RESULTS AND DISCUSSION

Performance results of the period the birds were kept under thermoneutral conditions (1-14 days of age)



However, there were significant differences in feed conversion ratio ($p < 0.05$), which was better in birds receiving vitamin-mineral supplementation as compared to those fed the control diet or receiving only vitamin supplementation. The treatment with only mineral supplementation was intermediate.

Table 2 - Effect of supplementation type (vitamin and/or mineral) on body weight (BW), weight gain (WG), feed intake (FI), feed conversion ratio (FCR) of 1 to 14 d-old broilers.

Type of supplementation	BW(kg)	WG(kg)	FI (kg)	FCR(kg/kg)
T1 (control)	0.412	0.368	0.480	1.306 ^b
T2 (control + vit)	0.407	0.363	0.476	1.316 ^b
T3 (control + min)	0.409	0.366	0.470	1.287 ^{ab}
T4 (control+vit+min)	0.427	0.383	0.480	1.256 ^a
p	0.18	0.20	0.68	0.05
CV (%)	6.9	7.74	6.17	5.09

1 - Means in the same column with no common superscript are significantly different.

From 14 to 35 days, there was no interaction between environment and diet on the measured parameters. As shown in Table 3, there was a highly significant effect ($p < 0.0001$) of environment on average weight on day 35. Birds kept in the HSE presented 7.6% lower weight as compared to those in TNE, which is explained by a reduction in feed intake. Ribeiro *et al.* (2001) found 9% lower weight when submitting broilers to cyclic heat stress, but for a longer period of time (21 to 56 days).

Table 3 - Effect of environment (HS and TN) and type of supplementation (vitamin and/or mineral) on body weight (BW), weight gain (WG), feed intake (FI), feed conversion ratio (FCR) of 14 to 35 d-old broilers.

Environment	BW (kg)	WG (kg)	FI (kg)	FCR(kg/kg)
HS	2,052 ^b	1.63	2,75 ^b	1,69 ^a
TN	2,208 ^a	1.78	2,95 ^a	1,66 ^b
p	<0.0001	0.0001	<0.0001	0.05
Type of supplementation	BW (kg)	WG (kg)	FI (kg)	FCR(kg/kg)
T1 (control)	2.123	1.71	2.93 ^a	1.719 ^b
T2 (control + vit)	2.146	1.72	2.83 ^b	1.641 ^a
T3 (control + min)	2.114	1.69	2.82 ^b	1.665 ^a
T4 (control+vit+min)	2.137	1.71	2.82 ^b	1.668 ^a
p	0.73	0.69	0.002	0.01
CV (%)	4.0	4.6	3.3	4.1

1 - Means in the same column with no common superscript are significantly different.

A 6.8% reduction was found for feed intake ($p < 0.0001$). Therefore, the environment also influenced weight gain ($p < 0.0001$), which was 8.4% higher in TNE as compared to HSE, as well as feed conversion ratio.

compared to the present experiment (Oliveira Neto *et al.*, 2000; Lana *et al.*, 2000; Bertechini *et al.*, 1991). As the experimental period ended when birds were 35 days of age, the negative impact of the environment was lower, as the heavier the bird, the more difficult it is to dissipate heat. In addition, cyclic heat stress seems to be less harmful to the birds than chronic heat stress (Bonnet *et al.*, 1997).

Supplementation type did not influence bird weight or weight gain ($p < 0.73$ and $p < 0.69$, respectively). In fact, literature data are conflicting as to mineral supplementation and performance. Bartlett & Smith (2003), testing different dietary zinc levels (32, 40, and 100 ppm), concluded that zinc did not interfere with the performance of 42-day-old broilers under cyclic heat stress (23.9 to 35°C). Ferket & Qhreshi (1992) showed that the supplementation of a vitamin complex (B-complex, A, D, and E vitamins) in drinking water of broilers submitted to heat stress improved weight gain and feed conversion ratio. Hegazy & Adachi (2000) observed a significant improvement in weight gain and feed conversion ratio of birds infected with Salmonella, or Salmonella and aflatoxin, and fed diets containing Zn (60ppm), and Zn+Se (60ppm+1ppm, respectively). However, diets containing only Se (1ppm) reduced performance. On the other hand, the performance of birds not submitted to challenge was not affected by the type of supplementation.

Type of supplementation influenced feed intake ($p < 0.002$). Birds receiving supplementation, independent of type, had lower feed intake. Therefore, supplementation yielded better feed conversion ratio than the control diet ($p < 0.01$). There are only a few studies on this subject, but some authors observed better feed conversion ratio, particularly in layers (Lee *et al.*, 1999; Vathana *et al.*, 2002) and quails (Sahin & Kucuk, 2001).

When the entire experimental period was taken into account (Table 4), no interaction between environment and diet was observed. However, environment had a negative impact on weight gain, feed intake, and feed conversion ratio of birds submitted to HSE ($p < 0.0001$).

During this period, the results were the same as to those observed during the grower period as to supplementation type. There was no influence on weight gain ($p < 0.74$), but feed intake was affected ($p < 0.003$), with lower feed intake of supplemented birds as compared to those fed the control diet. FCR of supplemented birds was also better ($p < 0.003$),



The initial hypothesis that heat stress could intensify a marginal vitamin and mineral deficiency, or increase the requirements of these nutrients, was not confirmed, as no interactions were found between these factors. However, there was a beneficial effect of vitamin and mineral supplementation, but there is no direct explanation for the reduction in feed intake in literature. Improvement in nutrient digestibility promoted by some of these minerals and vitamins, and their interrelationships (Sahin & Kucuk, 2001; Macpherson, 1994; Combs & Combs, 1986) could improve the efficiency of the use of these nutrients, and therefore, decrease feed intake. According to Thompson & Scott (1970), all elements of the antioxidant system efficiently interact. This interaction probably starts at nutrient absorption level, and continues throughout their metabolism.

Taking into consideration the better feed conversion ratio promoted by all types of dietary supplementation, and the lower cost of mineral supplementation as compared to vitamin supplementation, the cost-benefit of supplementing only trace minerals would be higher. This advantage could be obtained both in hot and cold seasons.

Table 4 - Effect of environment (HS and TN) and of type of supplementation (vitamin and/or mineral) on weight gain (WG), feed intake (FI), feed conversion ratio (FCR) of 1 to 35 day-old broilers.

	WG (kg)	FI (kg)	FCR (kg/kg)
Environment			
HS	2.01 ^b	3.225 ^b	1.604 ^a
TN	2.16 ^a	3.425 ^a	1.581 ^b
p	<0.0001	<0.0001	<0.0001
Type of supplementation			
T1 (control)	2.08	3.40 ^a	1.639 ^b
T2 (control + vit)	2.10	3.30 ^b	1.573 ^a
T3 (control + min)	2.07	3.28 ^b	1.589 ^a
T4 (control+vit+min)	2.09	3.28 ^b	1.569 ^a
p	0.74	0.003	<0.003
CV (%)	4.3	3.1	2.8

1 - Means in the same column with no common superscript are significantly different.

CONCLUSIONS

The supplementation of vitamins E and C and of the organic trace minerals Zn and Se did not influence weight gain of broilers reared in thermoneutral or heat stress environment. However, performance was improved, promoting lower feed intake, which resulted in better feed conversion ratio, independent of environmental temperature. Due to cost considerations,

supplementation should be used instead of vitamin-mineral supplementation.

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