

THE EFFECT OF SUPRAPHYSIOLOGICAL DOSES OF VITAMIN E ON PERFORMANCE OF BROILER BREEDERS FLOCK

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Abstract: The effect of supplementary vitamin E levels on the performance of broiler breeder flocks was studied. A completely randomized design with four treatments (100, 500, 1000, or 1500 IU vitamin E/kg) and three replicates per treatment was used. Each replicate included seven females and one male broiler breeder. Rearing conditions, lighting, temperature, humidity, amount of feed, and the amount of other nutrients in the diet were equal for all treatment groups and according to specifications of the management guide for broiler production. Eggs from each replicate were collected up to six times daily for nine weeks. Every three days, eggs were transferred to a hatchery and their characteristics were determined. The results showed 5- to 15-fold Vitamin E levels over the recommended daily dose had significant negative effects on hatchability and related parameters as well as on herd economic index ($P < 0.05$).

Key words: broiler breeder; hen; tocopherol; reproductive; performance

Introduction

Vitamin E has been shown to be an essential vitamin in the diet of poultry (1). Vitamin E, if given in sufficient amount in the poultry diet, can be stored in the body and distributed throughout different tissues and organs (2). In the past, there have been some reports on the vitamin requirements of broiler breeders (3, 4). However, genetic, management practice and environmental improvements with broiler breeder flocks has resulted in alteration of their vitamin

requirements (5). Reports about the amount of vitamin requirements for broiler breeder are available (3, 4), but the vitamin formulation is no longer adequate for the actual broiler breeder flocks. (1). There are reports on role of vitamins on reproductive performance of broiler breeder hen and roosters (6, 7, 8, 9, 10). Based on most important findings it seems that absorption of vitamin E is facilitated by dietary fat, intestinal bile and pancreatic lipase, and enters the lacteals for transport. The main pathway of its excretion is through defecation. The main role of this vitamin is as an antioxidant, preventing the formation of peroxides. Vitamin E is protective for vitamin A and carotenoids in some tissues, e.g. gastrointestinal

tract. The requirement of vitamin E increases whenever unsaturated fats are supplemented in poultry diet. Since there are different amounts of unsaturated fats added to commercial breeder broiler diets, the requirement of vitamin E can change based on fat contents (11). More research is needed in order to determine the requirement of vitamin E for the broiler breeder hen and rooster under different commercial conditions.

Vitamin E was recently shown to have antioxidant properties, protecting of cell membranes in both intra- and extracellular spaces (12). In the absence of sufficient vitamin E, breakdown of cell structure occurs, due to the formation of hydroperoxides from unsaturated fatty acids. There is a recent report on the positive effects of extra doses of this vitamin on performance, hatching process, and chick quality in broiler breeder flocks (5). The objective of this experiment was to evaluate the effect of supraphysiological concentration levels of vitamin E on the reproductive performance of broiler breeder hens.

Materials and methods

A total of 96 Ross-308 broiler breeders (84 hens and 12 roosters), aged between 61 and 69 weeks, were randomly assigned to four treatment groups. The birds were selected at the end of their production cycle, because it was expected that doses of vitamin E above standard recommendations would improve their performance and inhibit a decline in egg production. The observation period was nine weeks. Hens and roosters weighed, on average, 4.24 ± 0.1 and 4.96 ± 0.1 kg, respectively. Mean body weight for all replicates was the same at the start of the trial. There were three replicates per treatment with seven hens and one rooster.

The experimental facility was surrounded with fences and nets, and the cages ($2.0 \times 1.5 \times 1.0$ m) were placed on the ground, in a row, and each cage had one door to the outside. In each cage, there were nests for hens, one for the rooster and a two-floor egg-laying trap. A nipple system, in which water was supplied from a central repository, was created around the cages. In preparation for the trial, the poultry facility was cleaned, rinsed and disinfected. Poultry facilities had thermostatically controlled curtains and cross-ventilation. The lighting schedule consisted 16:8 h light:dark during the period of 61 to 69 weeks of the tests.

The four levels of vitamin E were 100 (Control), 500 (Treatment 2), 1000 (Treatment 3) and 1500 (Treatment 4) IU vitamin E/kg diet. 100 IU vitamin E/kg in the diet represents the recommended concentration of vitamin E. The effect of the doses was evaluated for 63 days. A standard broiler breeder's diet (2800 kcal of ME/kg and 14.5% CP for female and 2700 kcal of ME/kg and 13.5% CP for male) was fed to meet or exceed broiler breeder nutrient requirements (13). Feed was provided ad libitum and feed intake calculated weekly by difference between the quantities fed and left over. The ingredient composition and the energy content of the diet were kept similar for all the groups (Table 1).

Weekly egg production, egg counts, and egg weights per pen were recorded. Eggs were manually collected, weighted, and incubated at a commercial hatchery. At the hatchery, they were candled by a trained operator for eggshell defects and screened at day 12 for unhatched eggs. Unhatched and hatched eggs were sorted out, counted and weighted (hatchable produced egg number, hatchable total egg weight, hatchable egg weight average, dirty egg number, hatchable total egg weight at transfer incubator to hatcher, hatchable egg weight average at transfer incubator to hatcher, egg loss weight).

At the end of incubation, the number of live healthy chicks was counted ("chicks produced") and eggs weighed (total chick weight and mean chick weight). "Chick yield" was the percentage of initial eggs from which live chicks hatched (number of eggs hatched/number of initial eggs). "Percent hatchability: was calculated from eggs yielding live chicks (number of eggs hatched/number of fertile eggs). "Economic index" was calculated as sum of the weekly chick number and half of the dirty eggs.

Statistical analysis was performed with SPSS (14). For statistical analysis, the replicate chicken pen was considered as the experimental unit. Data were subjected to a mixed linear model, with replicates as random factors, treatment as fixed factors and performance parameters as dependent variables. A completely randomized design, with four treatments and three replicates per treatment, was used. Alternatively, Kruskal-Wallis test was used. If both tests were significant, subsequent Pairwise testing was conducted using Bonferroni's method. Data between 0-0.5, or percentages between 0-30 were transformed into $x^{0.5}+0.5$.

Results

Neither hen nor rooster weights differed significantly among the treatment groups at the beginning and at the end of the trial. Hens produced 1.82 dirty eggs/hen in the Control group, whereas in Treatment 4 only 0.81 dirty eggs/hen were produced ($p=0.013$) (Table 2). The percentage of egg loss weight differed significantly ($p=0.052$) between the Control group and Treatment 4. Hens produced 16.71 chicks/hen in the Control group, whereas in Treatment 4 only 7.05 chicks/hen were produced ($p=0.023$). Hens in the Control group

produced 1103.81 g total chick weight, which was significantly superior ($p=0.003$) compared to 756.21 g, 783.76 g and 387.28 g in Treatments 2, 3, and 4 respectively. The hatchability percentage was significantly lower in Treatment 4 (35.58%) compared to the other groups. The economical index confirmed the significantly inferior results ($p=0.008$) reported for Treatment 4 (7.45).

Other traits were not significantly affected by the treatments. Briefly, hens in Treatment 3 had the greatest number hatchable eggs, hatchable total egg weight, hatchable total egg weight at transfer from incubator to hatchery,

Table 1: Experimental diets fed to broiler breeder hens and roosters

| | Hens | Roosters |
|---|-------|----------|
| Ingredients, % | | |
| Maize | 69.64 | 66 |
| Soybean meal (44% protein) | 18 | 11 |
| Wheat bran | 2.47 | 18.37 |
| Vitamin and Mineral premix | 0.5 | 0.5 |
| Calcium carbonate | 6.5 | 1.5 |
| Oysters shell | 0.5 | 0.5 |
| Dicalcium phosphate | 1.4 | 1.4 |
| DL-methionine | 0.4 | 0.08 |
| L-lysine HCL | 0.01 | 0.07 |
| Salt | 0.2 | 0.2 |
| Sodium bicarbonate | 0.15 | 0.15 |
| Natuzyne P | 0.03 | 0.03 |
| Toxin binder | 0.1 | 0.1 |
| Formycine Gold | 0.1 | 0.1 |
| Calculated analysis | | |
| Metabolizable energy, kcal kg ⁻¹ | 2800 | 2700 |
| Crude protein, % | 14.0 | 13.5 |
| Calcium, % | 3.0 | 1.1 |
| Available Phosphorus, % | 0.4 | 0.4 |
| Sodium, % | 0.16 | 0.16 |
| Chloride, % | 0.16 | 0.18 |
| Lysine, % | 0.6 | 0.6 |
| Methionine, % | 0.033 | 0.3 |
| Ether extract, % | 2.9 | 3.15 |
| Fibre, % | 2.9 | 4.2 |
| Linoleic acid, % | 1.65 | 1.8 |

¹ Supplied per kilogram of feed - Vitamin A: 12500 IU; vitamin D₃: 1250 IU; vitamin E: 18 IU; vitamin K₃: 3.7 mg; thiamine: 1.8 mg; riboflavin: 6.6 mg; calcium pantothenate: 10 mg; niacin: 37.5 mg; pyridoxine: 32.5 mg; vitamin B12: 2.5 mg; Mn: 50 mg; Zn: 37.5 mg; Fe: 25 mg; Cu: 7.5 mg.

Table 2: Effects of vitamin E on reproductive performance of Ross broiler breeder hens during the trial

| | Hatchable produced egg number (N/female broiler breeder) | Hatchable total egg weight (g/female broiler breeder) | Hatchable egg weight average (g/egg) | Dirty egg (n/female broiler breeder) | Hatchable total egg weight at transfer incubator to hatcher (g/female broiler breeder) | Hatchable egg weight average at transfer incubator to hatcher (g/egg) | Egg loss weight (%) | Produced chick (N/female broiler breeder) | Total chick weight (g/female broiler breeder) | Chick weight average (g/chick) | Chick yield (%) | Hatchability (%) | Economic index ** |
|---------|--|---|--------------------------------------|--------------------------------------|--|---|---------------------|---|---|--------------------------------|-----------------|---------------------|--------------------|
| 100 | 21.96 | 2230.68 | 71.81 | 1.82 ^a | 2035.93 | 63.63 | 11.37 ^a | 16.71 ^a | 1103.81 ^a | 48.72 | 67.82 | 75.67 ^a | 17.63 ^a |
| 500 | 20.48 | 1928.57 | 72.27 | 1.19 ^{ab} | 2042.86 | 64.98 | 10.09 ^b | 13.38 ^a | 756.21 ^b | 48.65 | 67.36 | 67.36 ^{ab} | 13.98 ^a |
| 1000 | 22.95 | 2314.67 | 70.04 | 1.19 ^{ab} | 2369.05 | 62.73 | 10.43 ^{ab} | 13.14 ^a | 783.76 ^b | 48.08 | 68.69 | 56.39 ^b | 13.74 ^a |
| 1500 | 22.95 | 2220.76 | 70.94 | 0.81 ^b | 2193.90 | 64.19 | 9.51 ^b | 7.05 ^b | 387.28 ^c | 47.71 | 67.32 | 35.58 ^c | 7.45 ^b |
| SEM | 2.270 | 253.994 | 0.949 | 0.427 | 234.396 | 0.723 | 0.476 | 1.640 | 85.188 | 0.966 | 0.712 | 4.344 | 1.474 |
| P-Value | 0.839 | 0.743 | 0.434 | 0.013 | 0.672 | 0.199 | 0.052 | 0.023 | 0.003 | 0.895 | 0.528 | 0.001 | 0.008 |

Values within the same column followed by different superscript letters differ significantly (P<0.05). SEM: Standard Error of Means. * = % relative to standard catalogue; ^a = chick + 1/2 dirty egg

and chick yield compared to other treatments, but these were not significantly different from the other treatments. Hens in Treatment 2 had only a numerically greater mean hatchable egg weight and hatchable egg weight at transfer from incubator to egg hatcher, compared to other treatments. Finally, the Control group had the highest chick weight average compared to other treatments, but again the difference was not statistically significant (Table 2).

Discussion

Next to the cost of feeding, the major benchmark for a broiler breeding farm is the number of chicks produced per hen. Furthermore, these chicks must be of optimal weight for successful future meat production. Thus, presuming management conditions are optimal, the total number of chicks delivered per hen for rearing and the total weights of these of chicks per hen are two important parameters. Hens supplemented with a normal level of vitamin E in their ration (control) produced 16.71 chicks per hen, which was better than that of hens fed with overdoses. Furthermore, the total weight of all chicks produced per hen of the Control group was significantly more than that of the three treatment groups and resulted in a better economic index. Since mean chick weight was around 48 grams, the high numbers of chicks produced in the control group was the major success factor.

The numbers of hatched chicks per hen depend on the numbers of eggs laid, as well as on the numbers of eggs that are fertilized by the roosters. Thus, health is important for both parents.

One explanation for the increased production of chicks per hen could be due to increased egg production per hen, but the number of hatchable eggs per treatment group was not significantly different. Thus, in our studies, egg production was not significantly affected by excessive vitamin E level in the feed.

More important for hatchability is the quality of the hatchable and fertilized eggs per hen. It appears that above normal doses of vitamin E did not affect egg production per se, but dramatically decreased hatchability.

Other research did not find positive effects of high levels of vitamin E supplementation on chick yield and weight in laying breeders (3). Yet

another study showed that a deficiency of vitamin E lead to impairment of the reproductive organs, such as degeneration of the seminiferous tubules, degenerative spermatogonia and testicular damage (15). Vitamin E as a free radical scavenger can prevent the oxidation of readily oxidized substances. The potential of vitamin E to act as a lipid-based radical chain-breaking agent and protect against free-radical attack is considered fundamental to its effects in biological systems such as broiler breeders (16). Apparently, the expected beneficial antioxidant activity of larger than normal doses of vitamin E compromises the development of the chicken embryo, resulting in poor hatchability. Negative effects of “hyperdoses” of vitamin E have been linked to impairment of absorption of vitamins A and D3. Furthermore, weak bone calcification was observed when birds received “hyperdoses” of vitamin E, and body weight decreased after an increase of dietary vitamin E (17). At “hyperdoses” of vitamin E, there was decreased pigmentation of the shanks, feet and beak and waxy feathers. There are similar studies about positive effects of optimum doses and negative effects of “hyperdoses” of vitamin E (18, 19, 20, 21, 22).

Our results may be explained by findings of meta-analyses of clinical studies in man that showed that supplementation of vitamin E as antioxidants did not result in the presumed health benefit, but was rather associated with increased mortality (22). The conclusion of this trial is that the vitamin E levels of 100 IU/kg, as currently advised in broiler breeder production, should not be increased.

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UČINEK SUPRAFIZIOLOŠKIH ODMERKOV VITAMINA E NA PRIRAŠČANJE VZREJNIH BROJLERJSKIH JAT

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Povzetek: V študiji smo raziskovali učinek dodajanja vitamina E na hitrost prirasta v vzrejnih brojlerskih jatah. Študija je bila zasnovana naključno s štirimi koncentracijami dodatka (100, 500, 1000 ali 1500 i.e. vitamina E/kg telesne mase) in tremi ponovitvami tretiranja za vsako koncentracijo dodanega vitamina E. Vsaka ponovitev je vključevala sedem samic in enega brojlerskega samca. Pogoji reje, razsvetljava, temperatura, vlaga, količina krme in količina drugih hranilnih snovi v prehrani so bili enaki za vse poskusne skupine in v skladu s specifikacijami reje pitovnih piščancev. Jajca iz vsake ponovitve tretiranja po skupinah so bila zbrana do šestkrat dnevno devet tednov. Vsake tri dni so bila jajca prenesena v valilnico, kjer smo določili njihove značilnosti. Rezultati so pokazali da so imele 5- do 15-kratne vrednosti vitamina E nad priporočenim dnevnim odmerkom značilno negativne učinke na sposobnost valjenja in sorodnih parametrov, kakor tudi na na čredni gospodarski indeks ($P < 0,05$).

Ključne besede: brojlerji; kokoš; vitamin E; razmnoževanje