Effects of Feeding Methods (Feed vs. Water) of Vitamin E on Growth Performance and Meat Quality of Broilers

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ABSTRACT : This research was conducted to compare the effects of vitamin E (VE) when supplemented in either feed or water on the performance and meat quality of broilers. For a six-week feeding trial, a total of 330 broiler chicks were allotted to five treatments. The treatments were 1) 0 ppm VE, 2) 10 ppm VE in feed, 3) 20 ppm VE in feed, 4) 5 ppm VE in water and 5) 10 ppm VE in water. During the starter phase (0-3 weeks) chicks on non-supplemented groups grew slower ($p<0.05$) than the supplemented ones and the same trend was followed during the finisher (4-6 weeks) and overall period (0-6 weeks). The feed intake was significantly higher in feed supplemented groups as compared with water-supplemented groups and at higher levels as compared with lower levels of supplementation. The nutrient digestibility studies conducted after 15 and 35 days on the feeding trial showed that the digestibility of all nutrients was significantly ($p<0.05$) higher in supplemented groups than the non-supplemented one. The dressing percentage was higher in supplemented groups, when fed in feed and at higher levels when compared with their respective counterparts. Similar trends were noticed with respect to bone resistance. The calcium and phosphorus contents in tibia were also significantly ($p<0.05$) higher in supplemented, feed fed groups at higher levels than other groups. The TBARS values measured after 5 and 10 days of storage, which reflect the degree of oxidation, showed significantly lower levels in supplemented diets. The plasma and muscle vitamin E levels also showed a positive linear correlation with the levels supplemented both in feed and water. Overall it can be inferred that supplementation of VE was beneficial and there was not much difference observed when fed either in feed or water at the levels measured in the present study. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 9 : 1260-1265)***

Key Words : Broiler, Vitamin E, Bone, Carcass

INTRODUCTION

Broilers are under continual stress due to fast growth rate, pathogens and the ever-changing environmental conditions in the broiler houses (McCorkle and Glick, 1980). It is a well established that supplementation of vitamin E has some protective role under such stressful conditions. Commercially available vitamin E (VE) as alpha -tocopherol in broiler diets has become obligatory in most feed formulations these days as the tocopherols have protective anti-oxidant roles in biological membranes (Jacobsen et al., 1995). VE requirement of broiler chicks, (NRC, 1994) is 10 IU per kilogram diet but there are many research reports available showing a higher allowance of VE to be beneficial (Mazija et al., 1992; McIlory et al., 1993; Haq et al., 1996), with effects such as improved growth and immunity. VE supplementation of the diets of meat-producing animals effectively elevates muscle VE levels and lowers the susceptibility of muscle to lipid oxidation and the onset of flavour defects (Monahan et al., 1992; Guidera et al., 1997; Mitsumoto et al., 1998; Lee et al., 2003).

VE is mostly supplemented in feed but also in water in broiler production. There are few reports available where the direct comparison of feeding methods (feed vs. water) was made with respect to any micronutrient supplementation. The main objective of the present study was to compare the effects of VE on performance and meat quality when supplemented in either feed or water to broilers.

MATERIALS AND METHODS

Three hundred and thirty commercial four day-old Ross broiler chicks, average 56.16 g body weight, were raised for a 6 week period in a room with rice hull litter material, under controlled temperature till first week, and air ventilation. The pen size was 2.0 m×2.0 m. The day-old chicks were reared with a commercial starter diet for three days followed by respective experimental diets. The room temperature was not controlled except during the first week (22-30°C) because it was summer in Korea (June-August). Chicks had *ad libitum* access to diets and water.

Basal diets (mash type) were formulated to contain 22.4 and 20.26% crude protein for starter (0-3 week) and finisher (4-6 week), respectively, as shown in Table 1. The treatments were (1) 0 ppm, (2) 10 ppm VE in feed, (3) 20 ppm VE in feed, (4) 5 ppm VE in water and (5) 10 ppm VE in water. Vitamin E was used as Medivita E™, which is a vitamin E-polyethylene glycol complex produced by LG Life Sciences (Seoul, Korea). This company has developed Medivita E™ in powder form, which has to be added in feed, as well as in liquid form, which has to be supplemented in water. These levels of VE in feed and

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Received January 5, 2004; Accepted April 2, 2004

Table 1. Composition of basal diets

	Starter (0-3 wk)	Finisher (4-6 wk)
Ingredients (%)		
Corn	56.06	59.90
Soybean meal (44%)	22.44	20.76
Corn gluten meal	7.00	8.00
Fish meal	6.16	3.00
Animal fat	6.00	5.70
Tricalcium phosphate	0.92	1.12
Limestone	0.59	0.87
Vitamin premix[1]	0.10	0.10
Trace mineral premix[2]	0.20	0.20
Salt	0.25	0.25
L-lysine-HCl	-	0.03
DL-methionine (50%)	0.20	-
Choline chloride (25%)	0.08	0.07
Total	100.00	100.00
Chemical composition calculated (%)		
ME (kcal/kg)	3,200	3,200
CP	22.04	20.26
Ca	0.90	0.90
Avail. P	0.40	0.35
Lysine	1.14	1.00
Methionine	0.53	0.40
Methionine+cystine	0.90	0.75

[1] Supplied per kg diet: 9.000 IU vitamin A. 1.800 IU vitamin D_3. 1 mg vitamin B_1. 10 mg vitamin B_2, 4 mg vitamin B_6. 0.02 mg vitamin B_{12}. 1 mg vitamin K_3. 12 mg pantothenic acid, 30 mg niacin, 0.03 mg biotin. 0.5 mg folic acid, 3 mg ethoxyquin.

[2] Supplied per kg diet: 80 mg Fe, 80 mg Cu, 100 mg Zn, 120 mg Mn, 2 mg I, 0.1 mg Co, 0.2 mg Se.

water were compared using the rule of thumb that water intake is twice the intake of feed (Leeson and Summers, 1991).

For a digestibility trial, thirty chicks (6 birds per treatment) were allocated to individual cages to collect fecal samples. Starter and finisher diets containing 0.25% chromic oxide as an indigestible marker were given to chicks at the age of 15 and 35 days respectively. Fecal samples of each bird were collected on the 4th day after feeding the respective marked diets. Feces were dried in an air forced drying oven at 60°C for 3 days and then ground and stored for chemical analysis. Body weight gain and feed intake were recorded at weekly intervals. Proximate analysis of the samples was made according to the methods of AOAC (1990). Gross energy was measured with an adiabetic bomb calorimeter (Model 1241, Parr Instrument Co. Molin. IL). vitamin E with HPLC (Waters, Model 486, USA) and chromium with a spectrometer (Jasco Co. Model V-550. Japan).

At the end of the experiment, ten chicks per treatment were sacrificed. Blood samples were taken to analyze VE contents in plasma and muscle was also frozen till analysis. Chicken meat color was measured with a color difference meter (Yasuda Seiko Co. CR 310. Minolta. Japan) and compared with standard color values. Carcass traits like dressing percentage. breast meat and abdominal fat were also measured. Bone mineralisation was studied in terms of bone breaking strength of tibia. ash content and calcium and phosphorus content. For this both the tibia were freed of soft tissue. The dried (100°C. 3 h) bone samples were defatted in petroleum ether for 48 h. The right tibia of each bird was used to determine the breaking strength (EZ Test. Shimadzu. Japan). The ground breast meat was stored at 1°C for 10 days after slaughter to determine the thiobarbituric acid reactive substances (TBARS) as milligrams of malonaldehyde (MDA/kg) by the method of Sinnhubber and Yu (1977).

The data were analyzed using the General Linear Model and contrast procedure of SAS (1985). The data were compared in tables between supplemented and non-supplemented group. between feed and water as well as among higher and lower levels.

RESULTS AND DISCUSSION

Growth performance and nutrient digestibility

The supplemental effect of VE on the growth

Table 2. Effects of feeding methods (feed vs. water) of vitamin E on growth performance in broilers

	Control	Feed		Water		SE[1]	Contrasts[2]		
	0	10	20	5	10		1	2	3
Starter (0-3 week)									
Weight gain (g)	464[c]	515[ab]	527[a]	509[b]	520[ab]	6.24	0.0001	NS*	0.0395
Feed intake (g)	984	978	1,015	974	981	4.12	NS	0.0002	0.0001
FCR	2.12[a]	1.90[b]	1.93[b]	1.91[b]	1.89[b]	0.02	0.0001	NS	NS
Finisher (4-6 week)									
Weight gain (g)	917[c]	989[b]	1,004[a]	987[b]	992[b]	8.34	0.0001	0.0410	0.0058
Feed intake (g)	2,468[b]	2316[c]	2,493[a]	2,317[c]	2,321[c]	21.40	0.0001	0.0001	0.0001
FCR	2.69[a]	2.34[c]	2.48[b]	2.35[c]	2.34[c]	0.04	0.0001	0.0001	0.0001
Overall (0-6wk)									
Weight gain (g)	1,381[c]	1,504[b]	1,531[a]	1,496[b]	1,512[ab]	14.43	0.0001	NS	0.0091
Feed intake (g)	3,452[b]	3,294[c]	3,508[a]	3,291[c]	3,302[c]	24.67	0.0001	0.0001	0.0001
FCR	2.50[a]	2.19[c]	2.29[b]	2.20[c]	2.18[c]	0.03	0.0001	0.0006	0.0017

[a, b, c, d] Means of the same row with different superscripts significantly differ ($p<0.05$).

[1] Pooled standard errors. [2] 1: non-supplement vs. supplement, 2: feed vs. water. 3: low vs. high. * Not significant ($p>0.05$).

Table 3. Weekly water consumption in groups fed Vitamin E in water and feed: water ratio in starter phase (0-3 weeks)

Vitamin E	Water consumption (kg)				Feed consumption (kg)		Feed:Water
	1st week	2nd week	3rd week	Total	Per bird	Per group (n=66)	
5 ppm	20	40	60	120	0.974	64.28	1:1.87
10 ppm	20	40	60	120	0.981	64.75	1:1.85

Table 4. Effects of feeding methods (feed vs. water) of vitamin E on nutrient digestibility (%) in broilers

	Control	Feed		Water		SE[1]	Contrasts[2]		
	0	10	20	5	10		1	2	3
Starter (0-3 wk) :									
Gross energy	70.01[c]	71.52[b]	73.00[a]	71.13[b]	72.43[a]	0.29	0.0001	0.050	0.0001
Crude protein	71.18[d]	72.46[bc]	73.73[a]	71.97[c]	72.87[b]	0.24	0.0001	0.0021	0.0001
Ether extract	72.85[b]	73.82[a]	73.86[a]	73.86[a]	73.84[a]	0.11	0.0001	NS*	NS
Finisher (4-6 wk) :									
Gross energy	70.82[c]	74.18[a]	73.41[b]	73.91[ab]	74.32[a]	0.35	0.0001	NS	NS
Crude protein	70.71[c]	72.28[b]	73.16[a]	72.11[b]	72.31[b]	0.22	0.0001	0.0221	0.0163
Ether extract	70.32[b]	71.59[a]	71.18[a]	71.43[a]	71.56[a]	0.15	0.0001	NS	NS

[a, b, c, d] Means of the same row with different superscripts significantly differ ($p<0.05$).

[1] Pooled standard errors. [2] 1: non-supplement vs. supplement. 2: feed vs. water, 3: low vs. high. * Not significant ($p>0.05$).

performance of broilers was recorded at 0-3 weeks and 4-6 weeks intervals and presented in Table 2. Data revealed that there was increased ($p<0.05$) weight gain when VE was supplemented either in feed or in water as compared with un-supplemented at all phases of measurement. The weight gain was significantly ($p<0.05$) higher only in the finisher phase in feed supplemented diet when compared with water, and at higher levels as compared with lower one, at all levels of measurements. This showed a trend that as the level of VE was increased in the diet or water the weight gain was increased. During the starter phase though, there was no significant difference in the feed intake between supplemented and un-supplemented groups but higher gains was noted in the supplemented diets. Significant changes in body weight during the starter phase may be because of poor immune status of the bird at an early age and the role of VE in improving immunity. The benefits in performance due to high dietary concentration of VE would only be observed in the presence of free radical attack on the immune system (Franchini et al., 1988; Rice and Kennedy, 1988). The summer and growth stress may have triggered increased production of lipid free radicals and hence better growth was found in the supplemented groups as compared with un-supplemented ones. Contrary to our findings, Sheehy et al. (1991) did not find significant improvement in weight gain even after supplementing VE up to 180 mg/kg diet. Significantly higher feed intake was noted in 20 ppm VE fed in feed groups as compared with other groups at finisher and overall study followed by 0 ppm, 10 ppm in water, 10 ppm in feed and the least in 5 ppm in water treatment group. Significantly higher feed intake was noted in feed fed groups as compared with water fed groups and at higher levels than the lower levels. Feed conversion efficiency was improved following VE supplementation in the diet and through water. The same trend was noticed during finisher and overall study. Guo et al. (2001) recorded that supplementation of VE at 0, 5, 10, 50, 100 mg/kg for 0-3 weeks broiler chicks did not influence feed intake, but tended to improve growth and feed utilization. When compared between water and feed, significantly ($p<0.05$) improved FCR was noted in water-supplemented groups than feed-supplemented ones and at lower levels than the higher levels during finisher and overall study. Water intake in the groups where VE was supplemented in water was measured and it was noticed that water intake was approximately twice the feed intake (Table 3) hence justifying the relative concentrations of supplementary VE between feed and water. Water intake was only measured during the starter phase.

The nutrient digestibility studies conducted after 15 days in starter phase and 35 days in finisher phase are presented in Table 4. The digestibility of gross energy, crude protein and ether extract was found to be significantly ($p>0.05$) lower in non-supplemented diets than the supplemented ones at both phases and this must have affected the weight gains. When compared between feed and water, significantly ($p<0.05$) higher digestibility of gross energy was noted only during starter phase but crude protein digestibility was noted higher in both phases when VE was supplemented in feed rather than water. Similar increased CP digestibility was noted at higher levels as compared to lower levels in both the phases. Differences in digestibility of nutrients between feed and water supplementation were relatively small.

Effect on carcass traits

The dressing percentage was significantly ($p<0.05$) higher in the supplemented groups over the non-supplemented one (Table 5). The increased weight gain was reflected in increased dressing percentages in the supplemented groups. Higher dressing percentage and breast meat percent were also noticed when VE was fed in

Table 5. Effects of feeding methods (feed vs. water) of vitamin E on chicken meat quality in broilers

	Control	Feed		Water		SE[1]	Contrast[2]		
	0	10	20	5	10		1	2	3
Carcass traits (%)									
Dress percentage	72.83^{d}	73.51^{c}	75.58^{a}	73.48^{c}	74.11^{b}	0.25	0.0001	0.0001	0.0001
Breast meat	10.86^{d}	11.34^{c}	13.29^{a}	11.26^{c}	12.23^{b}	0.23	0.0001	0.0001	0.0001
Abdominal fat	2.51	2.37	2.61	2.34	2.49	0.03	NS*	NS	0.0083
Meat color									
L	58.81	59.14	58.92	59.14	61.06	0.35	NS	NS	NS
a	9.81	9.15	9.25	9.16	9.21	0.11	NS	NS	NS
b	7.27^{d}	9.25^{bc}	8.74^{c}	9.94^{ab}	10.18^{a}	0.29	0.0001	0.0015	NS

[a, b, c, d] Means of the same row with different superscripts significantly differ ($p<0.05$).
[1] Pooled standard errors. [2] 1: non-supplement vs. supplement, 2: feed vs. water, 3: low vs. high. * Not significant ($p>0.05$).

Table 6. The plasma and muscle VE content and TBARS level in breast muscle after VE supplementation in feed and water

	Control	Feed		Water		SE[1]	Contrast[2]		
	0	10	20	5	10		1	2	3
Plasma (μg/ml)	1.39^{d}	5.58^{c}	8.60^{a}	5.27^{c}	6.65^{b}	0.63	0.0001	0.0001	0.0001
Muscle (ppm)	0.48^{d}	2.46^{c}	4.97^{a}	2.98^{b}	2.78^{b}	0.38	0.0001	0.0001	0.0001
TBARS (mg/kg)									
0 d	0.33^{a}	0.30^{a}	0.23^{b}	0.29^{ab}	0.27^{ab}	0.01	0.0347	NS*	0.0467
5 d	1.52^{a}	1.03^{b}	0.77^{d}	1.06^{b}	0.88^{c}	0.07	0.0001	0.0455	0.0001
10 d	2.72^{a}	1.79^{b}	1.57^{c}	1.75^{b}	1.65^{bc}	0.11	0.0001	NS	0.0150

[a, b, c, d] Means of the same row with different superscripts significantly differ ($p<0.05$).
[1] Pooled standard errors. [2] 1: non-supplement vs. supplement, 2: feed vs. water, 3: low vs. high. * Not significant ($p>0.05$).

feed rather than water and at higher levels than the lower levels of supplementation. No difference was observed because of VE supplementation on the abdominal fat percent.

The meat colors 'L' and 'a' when compared between supplemented and un-supplemented, feed versus water, and higher versus lower levels did not show any significant differences. But the 'b' value for brownness was significantly lower in the un-supplemented group than in its counterparts. This means that the levels in water and feed are not sufficient to maintain the quality of the meat and that oxidation has resulted in brown discoloration, which was undesirable. Faustman et al. (1989) recorded color stability of beef and attributed it to a vitamin E mediated reduction in lipid and myoglobin oxidation following dietary VE supplementation.

VE content in plasma and muscle and TBARS values

The plasma and muscle VE content were positively correlated with the levels supplemented (Table 6). As the VE levels in water and feed increased, there was a concomitant increase in plasma and muscle VE levels. The plasma VE levels were 1.39, 5.58, 8.60, 5.27 and 6.65 μg/ml and that of muscle VE were 0.48, 2.46, 4.97, 2.98 and 2.78 ppm in 0 ppm, 10 ppm, 20 ppm in feed and 5 and 10 ppm in water fed groups, respectively. Higher plasma and muscle VE were noted in 20 ppm VE supplemented in feed group as compared with others. Significantly ($p<0.05$) higher VE levels in plasma and muscle were noticed in feed supplemented groups than in water supplemented groups and at higher levels than the lower levels. This showed the higher bioavailability of VE in feed than that in water. The thiobarbituric acid reactive substances (TBARS) level is a good index to judge the lipid oxidation in meat. The breast meat was ground and stored for 10 days at 1°C and the TBARS levels were measured at 5 and 10 d interval. Significantly ($p<0.05$) higher TBARS levels were noted in the control group than the supplemented groups at both intervals, which signified that lipid oxidation had been progressed and lower levels were noted in 20 ppm fed group than the others. These results suggest that VE improved lipid stability of meat during storage and was in agreement with that reported by Guo et al. (2001). Chae et al. (2002) also reported that α-tocopherol content in the diet is very important to improve meat stability when they fed fresh, and rancid rice bran to broilers for 6 weeks. There exists an inverse correlation between the muscle TBARS value and the VE content in the muscle. The retention of VE in the muscle must have prevented the meat from oxidative damage during storage. There was no difference when feed and water were compared and the values were comparable at 10 d of storage. The present findings were in accordance with the findings of Guidera et al. (1997), Lauridsen et al. (1997) and Mitsumoto et al. (1998), where VE supplementation of the diets for meat producing animals effectively elevated muscle vitamin E levels and lowered the susceptibility of muscle and ultimately products to lipid oxidation and the onset of flavor defects but it remained obscure why the 'b' value for brownness was higher in the VE supplemented group than the un-

Table 7. Effects of feeding methods (feed vs. water) of vitamin E on bone characteristics and its composition in broilers

	Control	Feed		Water		SE[1]	Contrast[2]		
	0	10	20	5	10		1	2	3
Bone characteristics									
Bone resistance (kg)	20.29^{e}	24.63^{b}	25.33^{a}	23.52^{d}	24.14^{c}	0.47	0.0001	0.0001	0.0001
Chemical composition (%)									
Dry matter	80.17^{b}	83.76^{a}	78.16^{c}	83.51^{a}	83.87^{a}	0.62	0.0001	0.0001	0.0001
Crude ash	52.09^{c}	52.44^{b}	52.53^{ab}	52.17^{c}	52.62^{a}	0.06	0.0001	NS*	0.0001
Calcium	14.21^{d}	15.64^{bc}	16.24^{a}	15.48^{c}	15.71^{b}	0.18	0.0001	0.0002	0.0001
Phosphorus	6.43^{d}	6.72^{bc}	7.28^{a}	6.66^{c}	6.81^{b}	0.08	0.0001	0.0001	0.0001

[a, b, c, d, e] Means of the same row with different superscripts significantly differ ($p<0.05$).

[1] Pooled standard errors. [2] 1: non-supplement vs. supplement. 2: feed vs. water. 3: low vs. high. * Not significant ($p>0.05$).

supplemented one in our study. This effect was undesirable as a meat quality parameter.

Effect on bone resistance and composition

The tibia breaking strength was significantly ($p<0.05$) increased by supplementing with VE either in feed or water (Table 7). Bone resistance was improved because of VE supplementation and it was higher in feed than in water fed groups and at higher levels than at the lower levels of supplementation. Fewer studies were conducted with respect to effects of supplementation with VE on bone strength and composition. The chemical composition of tibia was analyzed and presented in Table 7. The dry matter, crude ash, calcium and phosphorus were significantly ($p<0.05$) higher in the supplemented groups than the non-added group. The dry matter was significantly higher at the lower levels than the higher levels. Higher calcium and phosphorus content in bone was noted in the 20 ppm VE fed group as compared with other groups. The higher content of the minerals in the bone must have increased its resistance to breakage in the supplemented groups. More research needs to be conducted to clarify why the mineral content was increased because of VE supplementation.

ACKNOWLEDGEMENT

The authors appreciate the financial support for this study from LG Life Sciences Ltd. Seoul, Korea.

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