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Performance, Carcass Yield, and Qualitative Characteristics of Breast and Leg Muscles of Broilers Fed Diets Supplemented with Vitamin E at Different Ages

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ABSTRACT

The effects of vitamin E supplementation (300 mg/kg diet) in the diet of broiler chickens for different periods during rearing on the performance and qualitative traits of breast and leg muscles were evaluated. Seven hundred and twenty day-old chicks were distributed into six treatments: basal diet (25 mg vitamin E/kg diet), and diet supplemented with vitamin E from 1 to 15, 1 to 30, 1 to 45, 14 to 45 and 30 to 45 days of age. Vitamin E content, lipid percentage, TBARS (0 and 3 days of storage), color (*L, *a, *b), and pH were evaluated. There were no differences ($p>0.05$) among treatments in performance, carcass yield, and cut yields. Qualitative parameters (pH and color) presented no differences, although vitamin E positively affected TBARS values at 3 days of storage, mainly in leg muscles. Vitamin E levels in both muscles were higher in the birds supplemented throughout the experiment.

INTRODUCTION

Considering consumers' requirements as to product quality, and considering that Brazil is one of the largest poultry producers and exporters, it is crucial to maintain the quality of chicken products. The loss of quality is more evident in fatty acid-rich meat, such as pork, beef, and poultry meat products. Many studies on the use of natural and artificial antioxidants have been conducted (Papas, 1993) with the aim of reducing losses, especially during storage due to lipid oxidation, which is considered one of the major causes of deterioration of meat and meat products (Pearson *et al.*, 1983).

As a result of lipid oxidation, many undesirable degradation products are released, resulting in the typically unpleasant odour and taste of rancid meat.

Vitamin E has many functions and has been used in animal feeding. Undoubtedly, its role as antioxidant is the most important, and protects the muscle from peroxidation. Thus, it is known that diets supplemented with vitamin E are used in order to diminish lipid oxidation in muscle.

Among the various forms of vitamin E, á-tocopherol is up to 15 times more powerful as antioxidant (Burton *et al.*, 1983). In addition, the accumulation of vitamin E in tissues is related to dietary supplementation levels during pre-slaughter period in broilers (Asghar *et al.*, 1990; Lauridsen *et a*l., 1997). It was shown that cell membrane stabilization caused dietary vitamin E prevents the onset of lipid oxidation in poultry meat (Yamauchi *et al.*, 1991) and pork (Monahan *et al.*, 1993).

Lauridsen *et al.* (1997) evaluated breast and leg meat from broilers fed diets with 10% lard or olive oil, and two levels of vitamin E (20 or 200 mg/kg diet). Oxidative stability of the membrane fraction tended to increase with increasing levels of á-tocopherol in muscle samples, indicating that dietary vitamin E promoted higher stability in regard to oxidation. Higher vitamin E levels were also described as a reliable

measure to improve broiler health status, and, consequently, broiler performance. The increase in processed meat consumption as compared to fresh meat has economic advantages when vitamin addition strategies (*ante-mortem* or *post-mortem*) are used, reducing deterioration during storage, or improving meat qualitative traits (Lahucky *et al.*, 2005). The present study evaluated the effects of vitamin E supplementation (300 mg /kg diet) in the diets of broiler chickens during different periods ofrearing on performance and carcass and cuts quality .

MATERIAL AND METHODS

Location

The experiment was conducted at the Poultry Sector from the Department of Animal Science of Faculdade de Ciências Agrárias e Veterinárias, FCAV/Unesp, Jaboticabal, São Paulo, Brazil. Laboratorial analyses were conducted at Laboratory of Animal Food Technology from the Department of Technology of the same institution.

Animals and Husbandry

Seven hundred and twenty male Cobb chicks from one to 42 days of age were reared according to standard husbandry practices used in commercial broiler farms. Feed and water were provided *ad libitum* throughout the experimental period. Rearing period was divided into three phases, i.e., starter (1 to 21 days), grower (22 to 35 days), and finisher (36 to 45 days). Diets (Table 1) were formulated according to Rostagno (2000). Birds were slaughtered in a commercial slaughterhouse according to standard procedures (stunning, bleeding, scalding for 3 minutes at 54°C, defeathering, and evisceration). Carcass yield and cut yield were calculated using carcass and cuts weights before and after chilling .

Experimental design and treatments

A completely randomized experimental design was used, consisting of 6 treatments, 4 repetitions, with 30 birds in each experimental unit. Treatments included a non-supplemented basal diet (25 mg vitamin E/kg) and a diet supplemented with vitamin E (300 mg vitamin E/ kg diet) fed from 1 to 15 days of age, 1 to 30 days of age, 1 to 45 days, 15 to 45 days, or 30 to 45 days of age. At 45 days of age, production indexes and yields (carcass and cuts) were calculated. Data were submitted to analysis of variance and means were compared using the test of Tukey at 5% of significance.

Table 1 - Calculated composition of basal diets.

Ingredients (%)	*Starter (1-21 days)*	*Grower (22-35 days)*	*Finisher (36-45 days)*
Corn	54.50	59.30	61.30
Soybean meal	36.80	31.20	28.00
Oil	3.70	4.50	5.70
Premix	5.00	5.00	5.00
Total	100.0	100.0	100.0
Calculated composition			
ME (kcal/kg)	3,000	3,100	3,200
Crude protein (%)	21.40	19.30	18.20
Lysine (%)1.14	1.05	0.94	
Methionine (%)	0.49	0.45	0.41
Methionine + cysteine (%)	0.81	0.74	0.67
Calcium (%)	0.96	0.87	0.80
Available phosphorus (%)	0.45	0.41	0.37
Sodium (%)	0.22	0.19	0.19

Premix – Composition per kg of product: Vit. A 176,000 IU, Vit. D3 40,000 IU, Vit. E 500 mg, Vit. K3 100 mg, Vit. B1 36 mg, Vit.B2 200mg, Vit.B6 50mg, Vit. B12 560 mcg, Niacin 700mg, Biotin 3mg, Pantothenic acid 500mg, Folic acid 30mg, Choline 20g, Iron 1,1000mg, Copper 300 mg, Manganese 1,800mg, Zinc 1.200mg, Iodine 24mg, Selenium 3mg, Methionine 20g, Calcium 176g, Phosphorus 68g, Sodium 23g, Chloride 36g, Growth promoter 2g (Avilamycin), Anticoccidial 10g, Antifungal 200mg, Antioxidant 1g (BHT), Excipient (q.s.p) 1,000g.

Laboratorial analyses

Two birds from each replicate (8 birds per treatment) were randomly submitted to laboratory analyses, which included TBARS (thiobarbituric acid-related substances), colour, pH, lipid percentage, fatty acid profile, and vitamin E content in breast and leg muscles (thighs and drumsticks). TBARS analysis (oxidation) was performed in raw meat as described by Pikul *et al.* (1989), both at slaughter and after 3 days storage at 4°C. Color was determined using a Minolta Chrome Meter CR-300 according to CIELAB system, which provides values relative to L* (luminosity), a* (redness), and b* (yellowness). pH was measured in triplicate, using a digital insertion pHmeter (TESTO). Vitamin E levels were determined in triplicate: samples were frozen in liquid nitrogen after slaughter, and submitted to HPLC with mobile phase column (n-hexane/isopropanolol 95/ 5) at 1.5ml/min (Brubacher; Muller-Mulot; Southgate, 1985). Fatty acids were determined in triplicate after methylation and extraction (Bly & Dyer, 1959), and gas chromatography (Shimadzu). An Omegawax 250 Fused Silica Capillary Column (30mx0.25mmx0.25µm) with standard (Sigma, cat. 189-19) was used. Lipid contents in muscle samples were determined in triplicate according to AOAC (1995).

RESULTS

There were no differences ($p>0.05$) between treatments as to feed intake, weight gain, feed

conversion ratio, and livability of broilers slaughtered at 45 days of age (Table 2).

Slaughter weight, hot and cold carcass yields, and percentage of breast and legs (Table 3) were not different ($p>0.05$) among the experimental periods of vitamin E supplementation.

Considering the results presented in Table 4, higher vitamin E levels were observed in breast and leg muscles from supplemented birds as compared to controls. Moreover, such differences were not related to the supplementation period. There was no difference in lipid levels among the different vitamin E supplementation periods.

TBARS, color, and pH results for breast and leg muscles are shown in Tables 5 and 6, respectively. TBARS values at 0 day of storage were not significantly different. However, there was a positive effect ($p<0.01$) of treatments with vitamin E supplementation on leg muscles at 3 days storage.

No significant differences were observed in muscles color and pH (Tables 5 and 6), suggesting that there was no effect of vitamin E supplementation on these quality parameters.

Fatty acids profiles in breast and leg muscles are shown in Tables 7 and 8. The results show minor differences between treatments for saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA).

DISCUSSION

No significant differences in performance were observed between treatments. These findings are consistent with Guo *et al.* (2001), and similar to those reported by Nan *et al.* (1997), which indicates that although vitamin E may be important for reducing mortality and increasing bird immunity against pathogens, no positive effects were detected on

Table 2 – Feed intake (FI), weight gain (WG), feed conversion (FC) and viability from 1 to 45 days of age.

Treatments	*FI (kg)*	*WG (kg)*	*FC (kg/kg)*	*Viability (%)*
Non-supplemented	4.27	2.29	1.87	96.67
Supplementation from 1 to 15 days	4.45	2.31	1.93	94.17
Supplementation from 1 to 30 days	4.38	2.34	1.87	99.17
Supplementation from 1 to 45 days	4.27	2.21	1.93	98.33
Supplementation from 15 to 45 days	4.38	2.29	1.91	95.00
Supplementation from 30 to 45 days	4.30	2.26	1.90	96.67
F	2.74^{NS}	2.40^{NS}	0.51^{NS}	1.34^{NS}
LSD	0.20	0.13	0.15	7.40
CV (%)	2.01	2.50	3.29	3.40

NS – non-significant ($p>0.05$).

Table 3 – Slaughter weight (SW), hot carcass yield (HCY), cold carcass yield (CCY), breast yield (BY) and leg yield (LY) at 45 days of age.

Treatments	*SW (kg)*	*HCY (%)*	*CCY (%)*	*BY (%)*	*LY (%)*
Non-supplemented	2.32	69.23	76.52	30.73	35.94
Supplementation from 1 to 15 days	2.37	67.84	75.16	31.09	36.80
Supplementation from 1 to 30 days	2.38	70.03	76.52	32.00	34.45
Supplementation from 1 to 45 days	2.23	68.19	75.27	31.69	36.04
Supplementation from 15 to 45 days	2.34	69.57	77.55	30.73	35.64
Supplementation from 30 to 45 days	2.30	68.55	76.53	31.94	34.56
F	1.41^{NS}	0.73^{NS}	0.65^{NS}	0.76^{NS}	1.92^{NS}
LSD	0.16	4.46	5.01	4.02	2.96
CV (%)	3.56	2.88	2.92	5.73	2.96

NS – non-significant ($p>0.05$).

Table 4 – Vitamin E (mg α-tocopherol/100g) and lipids (%) in breast and leg muscles of broiler chickens fed diets supplemented with vitamin E.

Treatments	*Vitamin E (mg/100g)*		*Lipids (%)*	
	Breast	*Leg*	*Breast*	*Leg*
Non-supplemented	0.62 d	1.92 e	2.31	7.25
Supplementation from 1 to 15 days	4.20 b	5.00 d	2.47	8.29
Supplementation from 1 to 30 days	3.32 c	7.35 b	2.27	8.38
Supplementation from 1 to 45 days	6.15 a	8.02 a	2.59	7.42
Supplementation from 15 to 45 days	4.02 b	5.27 d	2.49	7.33
Supplementation from 30 to 45 days	4.25 b	6.15 c	2.01	6.82
F	291.29**	260.65**	0.36^{NS}	2.10^{NS}
LSD	0.47	0.60	1.56	1.89
CV (%)	5.61	4.75	19.46	11.10

** ($p<0.01$); NS – non-significant ($p>0.05$).

Table 5 - TBARS (0 and 3 days of storage), L*(luminosity), a*(redness), b*(yellowness), and pH of breast meat of broilers supplemented with vitamin E for different periods.

Treatments	*TBARS (0 days)*	*TBARS (3 days)*	*L**	*a**	*b**	*pH*
			(0 days)			
Non-supplemented	0.28	0.60a	46.56	3.25	4.38	5.99
Supplementation from 1 to 15 days	0.30	0.50ab	46.22	3.66	3.86	5.93
Supplementation from 1 to 30 days	0.35	0.51ab	45.84	3.99	3.79	5.93
Supplementation from 1 to 45 days	0.33	0.41b	48.32	3.39	4.57	5.88
Supplementation from 15 to 45 days	0.15	0.55a	46.67	3.64	4.06	5.91
Supplementation from 30 to 45 days	0.19	0.49ab	46.32	3.14	4.39	5.87
F	2.55^{NS}	5.28**	0.85^{NS}	1.56^{NS}	0.71^{NS}	0.77^{NS}
LSD	0.21	0.12	4.17	1.13	1.70	0.22
CV (%)	27.46	10.76	3.96	14.33	18.08	1.66

** ($p<0.01$); NS – non significant ($p>0.05$).

Table 6 - TBARS (0 and 3 days of storage), L*(luminosity), a*(redness), b*(yellowness), and pH of leg meat of broilers supplemented with vitamin E for different periods.

Treatments	*TBARS (0 days)*	*TBARS (3 days)*	*L**	*a**	*b**	*pH*
			(0 days)			
Non-supplemented	0.38	0.75a	46.56	8.61	4.38	6.45
Supplementation from 1 to 15 days	0.35	0.55b	46.22	7.88	3.86	6.39
Supplementation from 1 to 30 days	0.39	0.53b	45.84	7.62	3.79	6.34
Supplementation from 1 to 45 days	0.37	0.49b	48.32	8.36	4.57	6.36
Supplementation from 15 to 45 days	0.19	0.61b	46.67	7.68	4.06	6.47
Supplementation from 30 to 45 days	0.17	0.55b	46.32	8.01	4.39	6.35
F	3.75*	10.34**	0.85^{NS}	1.10^{NS}	0.71^{NS}	1.47^{NS}
LSD	0.22	0.13	4.17	1.66	1.70	0.21
CV (%)	22.92	9.80	2.69	9.19	18.93	1.48

** ($p<0.01$); NS – non significant ($p>0.05$).

Table 7 – Fatty acid profile in breast muscle samples of broilers fed diets supplemented with vitamin E for different periods

Fatty acid	*Breast (g/100g)*					
	Treatments					
	NonSuppl.	*Suppl.1-15 days*	*Suppl.1-30 days*	*Suppl.1-45 days*	*Suppl.15-45 days*	*Suppl.30-45 days*
C 14:0	0.43	0.43	0.43	0.44	0.45	0.43
C 16:0	20.02	20.59	20.17	19.67	20.02	20.78
C 16:1	2.11	2.58	2.27	2.01	2.26	2.72
C 18:0	6.86	6.61	7.03	7.39	7.15	6.80
C 18:1n9C	28.11	29.62	28.72	28.57	28.80	29.75
C 18:2n6	34.87	33.10	33.91	34.56	34.87	33.31
C 18:3n6	0.72	0.82	0.54	1.12	0.15	0.22
C 18:3n3	2.11	1.93	1.94	1.91	1.93	1.88
C 20:0	0.19	0.12	0.11	0.14	0.12	0.12
C 20:1n9	0.25	0.25	0.24	0.24	0.22	0.23
C 20:2	0.42	0.37	0.42	0.39	0.40	0.42
C 20:3n6	0.39	0.34	0.40	0.41	0.38	0.36
C 20:3n3	2.84	2.70	3.12	2.72	2.73	2.52
C 20:4n6	0.32	0.20	0.21	0.16	0.28	0.21
C 20:5n3	0.11	0.11	0.12	-	-	-
C 22:6n3	0.25	0.33	0.37	0.27	0.24	0.25
TOTAL	100	100	100	100	100	100
SFA	27.5	27.75	27.74	27.64	27.74	28.13
MUFA	30.47	32.45	31.23	30.82	31.28	32.70
PUFA	42.03	39.90	41.03	41.54	40.98	39.17

C14:0-myristic; C16:0-palmitic; C16:1-palmitoleic; C18:0-estearic; C18:1n9C-oleic; C18:2n6-linoleic; C18:3n6-y-linolenic; C18:3n3-alfa-linolenic; C20:0-arachidic; C20:1n9-cis11-eicosenoic; C20:2-cis 11,14-eicosadienoic; C20:3n6-cis 8,11,14-eicosatrienoic; C20:3n3-cis 11,14,17-eicosatrienoic; C20:4n6-arachidonic; C20:5n3-cis 5,8,11,14,17- eicosapentaenoic; C22:6n3-cis4,7,10,13,16,19-docosahexanoic.

performance parameters.

Slaughter weights, as well as carcass and cut yields, were not influenced by vitamin E supplementation. Such results are consistent with a similar study reported by Gardini (2000).

Vitamin E retention in breast and leg muscles was higher ($p<0.01$) in birds supplemented with vitamin E for 45 days. Sheehy *et al.* (1991), O'Neill *et al.* (1998), and Nan *et al.* (1997) reported optimal effects of vitamin E supplementation at 180-200mg/kg. It was reported

Table 8 – Fatty acid profile of leg samples of broilers fed diets supplemented with vitamin E for different periods

Fatty acid	*Legs (g/100g)*					
	Treatments					
	NonSuppl.	*Suppl.1-15 days*	*Suppl.1-30 days*	*Suppl.1-45 days*	*Suppl.15-45 days*	*Suppl.30-45 days*
C 14:0	0.42	0.41	0.43	0.54	0.40	0.39
C 16:0	19.25	19.85	19.46	19.01	18.94	19.28
C 16:1	2.75	3.24	2.85	2.55	2.83	3.27
C 18:0	6.20	5.94	6.25	6.45	6.04	5.81
C 18:1n9C	29.66	30.79	30.28	30.17	30.16	31.25
C 18:2n6	36.67	34.94	35.85	36.24	36.52	35.27
C 18:3n6	0.28	0.27	0.29	0.27	0.31	0.26
C 18:3n3	2.27	2.14	2.17	2.18	2.18	2.16
C 20:0	0.12	0.12	0.12	0.13	0.12	0.12
C 20:1n9	0.22	0.23	0.23	0.23	0.22	0.23
C 20:2	0.28	0.25	0.29	0.29	0.29	0.29
C 20:3n6	0.27	0.25	0.29	0.30	0.29	0.28
C 20:3n3	1.38	1.33	1.22	1.35	1.39	1.48
C 20:4n6	0.13	0.12	0.15	0.17	0.22	0.16
C 20:5n3	-	-	-	-	0.06	0.04
C 22:6n3	0.10	0.12	0.12	0.11	0.10	0.11
TOTAL	100	100	100	100	100	100
SFA	25.99	26.32	26.26	26.13	25.70	25.60
MUFA	32.63	34.26	33.36	32.95	33.21	34.35
PUFA	41.38	39.42	40.38	40.92	41.09	40.05

C14:0-myristic; C16:0-palmitic; C16:1-palmitoleic; C18:0-estearic; C18:1n9C-oleic; C18:2n6-linoleic; C18:3n6-y-linolenic; C18:3n3-alfa-linolenic; C20:0-arachidic; C20:1n9-cis11-eicosenoic; C20:2-cis 11,14-eicosadienoic; C20:3n6-cis 8,11,14-eicosatrienoic; C20:3n3-cis 11,14,17-eicosatrienoic; C20:4n6-arachidonic; C20:5n3-cis 5,8,11,14,17- eicosapentaenoic; C22:6n3-cis4,7,10,13,16,19-docosahexanoic.

that optimal levels of vitamin E retention were observed around 3 e 4 weeks, respectively, in breast (14.2 and 17.1ìg/g) and leg (17.3 and 20.1ìg/g) muscles when vitamin E was supplemented for 5 weeks before slaughter (Morrissey *et al.*, 1997).

Higher lipid levels found in leg as compared to breast muscles may suggest a higher probability of occurring oxidative processes in leg muscles. The present study corroborate the findings reported by Gardini (2000), in which there were no significant differences between breast and leg muscles as to lipid contents in birds supplemented with different vitamin E levels. A lower oxidation in breast and leg muscles expressed as TBARS values suggests a positive effect of vitamin E during storage, especially for birds that received vitamin E supplementation for 45 days. In a study on the supplementation of poultry diets with vitamin E at 220mg/kg for 12 days before slaughter (Webb *et al.*, 1972), a significant reduction in lipid oxidation in breast and leg muscles was observed. O'Neill *et al.* (1998) reported a reduction in muscle oxidation of chickens supplemented with vitamin E at 150 mg/kg. Such decrease was independent of part, supplementation period, and storage conditions, suggesting that vitamin E supplementation could be an alternative to increase the shelf-life of chicken products. Guo *et al.* (2001) attributed this reduction in oxidation and consequent better meat stability to the increased levels of á-tocopherol in tissues. In a similar study, Bartov and Frigg (1992) described that supplementation of vitamin E at 150mg/kg from 0 to 3 weeks, or 100mg/kg from 5 to 7 weeks of age, resulted in better muscle stability against oxidation. Cortinas *et al.* (2005) evaluated supplementation of polyunsaturated fatty acids together with vitamin E (0, 100, 200 and 400 mg/kg), and observed no improvement in oxidation stability of leg muscles of chickens fed 200 or 400mg vitamin E/ kg of diet. Carreras *et al.* (2004) reported that vitamin E supplementation resulted in lower TBARS levels in breast and leg muscles of broilers. The possibility of reducing peroxidation indicates the antioxidative ability of the muscle (Nuernberg *et al.*, 2002; Lahucky *et al.*, 2004). Although different methods of vitamin E supplementation have been reported (vitamin E forms and periods of supplementation), economic aspects must be considered, as supplementation must be included in feed costs.

Quality parameters (lipid percentage, color, and pH) of chicken muscles were not affected by vitamin E supplementation. These results are consistent with Ristic (1990), who did not observe differences in physical-chemical characteristics of breast meat of chickens supplemented for 7 days before slaughter with 40, 80, or 150 mg/kg vitamin E. Ohene-Adjei *et al.* (2004) did not find any differences in pork color in animals that received 0, 100, 200, or 300mg/kg of vitamin E supplementation.

The susceptibility of muscular tissue to oxidation

depends on several factors. However, the most important is polyunsaturated fatty acids (PUFA) muscle content (Gray *et al.*, 1996), which is high in poultry.Some studies demonstrated that different oil sources in the diet may increase the efficiency of absorption of polyunsaturated fatty acids as compared to monounsaturated fatty acids (Marion & Woodroof, 1963; Bartov *et al.*, 1974; Sklan *et al.*, 1983). As a result, the percentage of unsaturated fatty acids in the carcass would increase, and the oxidative stability of the chicken carcass would be lower.

Turkeys were fed three different fat sources (soybean oil, linseed oil and lard) and two levels of vitamin E (30 and 400 mg/kg) in a previous study (Mercier *et al.*, 1998). There was lower oxidation of breast and leg muscles at 9 days of storage under refrigeration in the group supplemented with 400 mg/kg of vitamin E. Furthermore, there was no effect of the fat source used.

CONCLUSIONS

The supplementation of diets with vitamin E at 300 mg/kg for different periods did not improve performance, yields of carcass and cuts, fatty acid profile, total lipid percentage, color, or pH of breast and leg muscles.

Vitamin E supplementation positively affected vitamin E retention levels in breast and leg muscles. As to TBARS values, the effect was more evident in leg muscles than in breast muscle.

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