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Effects of vitamin E supplementation on fattening performance, non-carcass components and retail cut percentages, and meat quality traits of Awassi lambs

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Abstract

This experiment was carried out to evaluate the effects of vitamin E supplementation on growth, non-carcass components and retail cut percentages, and meat quality traits of Awassi male lambs at approximately 8 months of age. The lambs were divided into two groups as control (CG, $n=12$) and experimental (VG, $n=12$) at the beginning of the fattening period. The CG and VG lambs were fed with a concentrate and grass hay close to ad-libitum by biweekly adjustment of the amount offered. In addition, the VG received a supplement of 45 mg vitamin E per lamb per day during a 75-day fattening period. Inital weight, final weight, daily weight gain and feed conversion efficiency were 31.8 ± 1.40 kg, 45.5 ± 1.37 kg, 183 ± 13 g and 7.6 for CG, 32.5 ± 1.45 kg, 46.7 ± 1.42 kg, 189 ± 15 g and 7.0 for VG, respectively. Vitamin E supplementation did not have a statistically significant effect on animal performance traits, non-carcass components and retail cut percentages, but produced an 8.1% improvement in feed conversion efficiency. After slaughter, carcasses were chilled at 4 °C for 24 h. Then, the carcasses were dissected into wholesale cuts, and *m. longissimus dorsi* (LD) muscles excised. The samples of muscle were subjected to moisture, protein, ether extract and ash analyses. Samples were cooked for shear test and cooking yield measurements. There were no significant differences between CG and VG lamb groups in chemical composition of meat samples from the LD muscles. Though the influence of vitamin E supplementation on color parameters (L^*, a^*, b^*) was not statistically significant, the mean a^* (redness) values decreased on days 2 and 4 and increased on days 7 and 12 of the storage period. However, the a^* values of muscles from the VG were higher than those grouping CG. L^* and a^* values in LD muscle from vitamin E-treated lamb groups were also preserved for a period of 12 days of maturation. In this study, drip loss was relatively preserved by vitamin E supplementation to the diet of animals.

The results showed that vitamin E supplementation to the diet of Awassi male lambs at an inclusion rate over the amount of nutritional recommendations relatively reduced lipid oxidation, drip loss and tended to maintain meat redness.
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Keywords: Awassi lambs; Growth; Carcass traits; Meat color; Lipid oxidation; Vitamin E; pH

1. Introduction

Meat from sheep is an important source of daily food consumption accounting for approximately 26% of the total red meat production in Turkey (Statistical Yearbook of Turkey, 2000). One of the basic principles of animal nutrition is to produce high quality meat. Hence, the diet in animal nutrition is very important, and different diet combinations have been applied to livestock. Vitamin E has frequently been used in animal nutrition to improve meat quality in recent years. It cannot be synthesized by the animal body, and is present in green plants and animal products (Aksoy, Macit, & Karaoglu, 2000). Vitamin E supplementation to the diet of livestock has had a positive effect on the fattening performance, carcass and meat quality characteristics. The dietary supplementation of vitamin E protects ruminal epithelium against action of ruminal content in ruminant animals fed with a high concentrate diet (Hill, Stuart, Utley, & Reagan, 1989). Oral supplementation of vitamin E has been effective in reducing lipid oxidation in meat of livestock. Because of its antioxidant

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activity, vitamin E in the muscle is important for its role in lipid oxidation by preventing formation of free radicals, known to improve color stability and reduces the drip loss of fresh and frozen meats during display, and extents shelf-life (Mitsumoto, Ozawa, Mitsuhashi, & Koide, 1998; Morrisey, Buckley, & Sheehy, 1994; Schaefer, Lui, Faustman, & Yin, 1995).

In the market, meat is generally exposed for a variable period of time in a display area before selling to the consumer. Under such conditions, changes may occur both in color and flavour traits. Visual appearance of fresh meat is quite important because discoloration of the surface can be interpreted by the consumer as a condition of unwholesomeness. Both pigment and lipid oxidations are accepted as the major quality defects in fresh meat occur during the storage or marketing in terms of consumer and producer. Changes in flavour are related to oxidative rancidity mainly when the unsaturated fatty acids content of the meat is high (Dufrasne et al., 2000). All the studies related to this subject suggested that supranutritional supplementation of vitamin E to diets of livestock can improve the color and lipid stability by accumulating in muscles.

The objective of this study is to investigate whether vitamin E supplementation is effective in Awassi lambs for improving fattening performance, carcass characteristics and meat quality traits.

2. Materials and methods

The experiment was conducted at the Application and Research Farm of the College of Agriculture, Ataturk University, Erzurum. Twenty-four (24) fat-tailed Awassi male lambs born in the 2000 lambing season were used in this study. The lambs were allowed to become adapted to concentrate to reduce the incidence of rumen acidosis for 2 weeks. After the adaptation period, the lambs at 8 months of age were weighed and randomly divided into two groups as control (CG, $n=12$) and experimental (VG, $n=12$) at the beginning of the fattening period. The CG and VG lambs were fed with a concentrate close to ad-libitum by biweekly adjustment of the amount offered. The VG also received a supplement of 45 mg vitamin E per lamb per day during a 75-day fattening period. The average concentrate consumption per lamb in a day was calculated to be 1054 and 1011 g for CG and VG, respectively. The concentrate feed was composed of barley (42%), corn (24%), soybean meal (10%), wheat bran (4%), molasses (8%) and sunflower meal (8%), premix (0.05%), salt (0.95%), dicalcium phosphate (3%). The concentrate mixture had 91% dry matter, 13.3% crude protein, 10.5% crude fibre, 3.2% ether extract, 55.9% nitrogen free extract and 2.5 MJ ME/kg. Grass hay was fed daily at the rate of 340 and 316 g per lamb per day during the fattening period for both groups.

On each of 3 days after a 75-day study period, the lambs were weighed repeatedly after 12 h starvation. The average of the three weights was recorded as the final weight, and four lambs from CG and VG close to the average final weigtht were slaughtered in a commercial abattoir for subsequent carcass dissection. The lambs were approximately 10.5 months old when slaughtered.

After slaughter, head, skin, feet and offals were removed and weighed. The carcasses were chilled at 4 °C for 24 h before jointing, and measurements were taken on the intact cold carcass (Kempster, Cuthbertson, & Harrington, 1982). The fat tail was removed from each carcass prior to cutting into wholesale cuts. Cold carcasses were carefully halved and left side was obtained according to standard methods and procedures for lamb carcass evaluation suggested by Macit, Karaoğlu, Yaprak, and Kopuzlu (1997). From the left side, the 12th and 13th rib was cut laterally to the vertebral column and parallel to the rib and the subcutenous fat thickness over *m. longissimus dorsi* muscle was measured with a caliper. At the same point the *m. longissimus dorsi* area was drawn on acetate paper and measured with a planimeter.

Feed consumption and body weight of lambs were determined biweekly during the fattening period. At time of slaughtering, head, skin, feet and offals were removed from the carcass and hot carcass weights were recorded. Meat quality was determined on 2 cm thick steak cuts from *m. longissimus dorsi* (LD) muscle. The LD muscles were maintained at 4 °C under fluorecent light for up to 12 days. Colorometer device (CR-200, Minolta Co, Osaka, Japan) was used to objectively measure CIELAB (Commission Internationale I' E Clairage) brightness (L^*) and color (a^* and b^*) on the LD muscle (Aurand, Woods, & Well, 1987; Rödel, 1992). A steak was divided into five slices which were placed individually in polystyrene trays covered by oxygen permeable polyethylene film and stored at 4 °C for periods of 2, 4, 7 and 12 days after slaughter, and then assessed for color and oxidative rancidity by the thiobarbutiric acid reacting substances (TBARS) procedure. The TBARS concentrations were measured using the method described by Gökalp, Kaya, Tülek, and Zorba (1993), and expressed as mg malonaldehyde per kg of fresh meat. Another steak was used for drip loss by the method of Dufrasne et al. (2000). The pH was measured on freshly cut surfaces of LD muscle by direct probe of pH meter (SCHOTT L 6880, Lab Star pH).

The meat samples from LD muscles were analysed by AOAC (1970) procedures for moisture, ether extract, crude protein and ash. The lamb meat samples were cooked, in a plastic bag, in a water bath at 90 °C, until the internal temperature reached 70 °C as outlined by

Esenbuga, Yanar, and Dayıoglu (2001). Cooking yield was determined by recording uncooked and cooked weights of LD samples. Cooked samples were placed on a paper towel for 5 min to remove cooking drip. Yield was calculated by dividing cooked weight to uncooked weight and converted to a percentage. Mechanical assesment of tenderness was performed 12 days after slaughter using the Warner-Bratzler Shear device (Ockerman, 1985).

Data were analysed according to *t* test for determination of differences between groups, and variance analyses for determination of differences among maturation (storage) days using the MINITAB Package Program (1998). Statistical differences between means were tested using Duncan's multiple range tests (Duncan, 1955). The effect of inital weight as covariant on growth and carcass characteristics was omitted because its effect on these characteristics was not significant. In addition, the inital weight did not differ between control and vitamin treatment groups.

3. Results

Inital weight, final weight, daily weight gain and feed conversion efficiency were 31.8±1.40 kg, 45.5±1.37 kg, 183±13 g and 7.6 for CG ($n=12$), 32.5±1.45 kg, 46.7±1.42 kg, 189±15 g and 7.0 for VG ($n=12$), respectively. The inital weight, final weight and daily weight gain did not differ between control and vitamin treatment groups. The average daily feed intake per animal per day was 1394 g (concentrate = 1054, grass hay = 340) and 1327 g (concentrate = 1011, grass hay = 316) for CG and VG, respectively. The results of the present study consistently indicated that vitamin E supplementation to diet of lambs had no effect on fattening performance traits.

The average proportions of non-carcass component and wholesale cuts with tail fat are presented in Table 1. Vitamin E supplementation did not have a significant effect on non-carcass components and retail cut percentages. Comparing measurements of fatness, such as average fat thickness over LD muscle, amount of kidney, pelvic and tail fat, indicated no significant differences between treatment groups.

Carcass measurements taken on intact cold carcass are summarized in Table 2. Most of the carcass measurements, except for width of gigot, were not affected by vitamin E supplementation. The CG lambs showed better performance than VG lambs in terms of width of gigot.

Warner-Bratzler shear (WBS), cooking yield values and the results of chemical analysis for LD muscles from CG and VG are shown in Table 3. WBS and cooking yield values and proportion of moisture, protein, fat and ash were not affected by vitamin E supplementation. Meat samples from the vitamin treatment group had lower cooking yield values compared with CG lambs.

Table 1
Proportions of some non-carcass components and wholesale cuts (mean±S.E.) of control (CG) and vitamin E supplemented (VG) Awassi lamb groups

Slaughter and carcass traits	CG ($n=4$)	VG ($n=4$)	*P*
Proportion of non-carcass components (out of 100)			
Slaughter weight (kg)	45.0±0.46	45.6±0.82	Ns
Skin	9.2±0.30	9.0±0.07	Ns
Feet	2.5±0.14	2.4±0.09	Ns
Lungs + liver	3.6±0.14	3.6±0.10	Ns
Testes	0.6±0.08	0.6±0.06	Ns
Omental fat	0.5±0.05	0.7±0.13	Ns
Proportion of wholesale cuts including tail fat (out of 100)			
Hot carcass weight (kg)	19.9 ±0.23	20.4±0.19	Ns
Cold carcass weight (kg)	19.0±0.43	19.1±0.30	Ns
Hot dressing percentage	44.3±1.2	44.7±1.2	Ns
Cold dressing percentage	42.3±1.2	42.0±1.2	Ns
Shoulder	16.5±0.53	16.4±0.14	Ns
Neck	4.9±0.27	4.9±0.64	Ns
Rib	8.7±0.36	7.4 ±0.12	Ns
Loin	6.9±0.37	7.0±0.13	Ns
Sirloin	5.6±0.21	5.7±0.09	Ns
Foreshank and breast	16.9±0.68	16.3±0.49	Ns
Flank	4.4±0.15	4.6±0.27	Ns
Leg	19.4±0.36	19.6±0.67	Ns
Hindshank	4.7±0.16	4.9±0.10	Ns
Tail fat	10.2±1.00	11.4±0.98	Ns
Kidney fat	0.6±0.08	0.5±0.03	Ns
Kidney	0.6±0.02	0.6±0.03	Ns
Longissimus dorsi area (cm^2)	13.3±1.30	13.5±0.81	Ns
Fat thickness over LD (mm)	2.4±0.24	2.3±0.25	Ns

Ns, $P>0.05$.

There was no difference between groups in the color parameters after slaughter (Table 4). The changes in redness (a^*) over the 12-day period of storage after slaughter are given in Table 5. Although the differences between groups were not significant, the meat color of the VG lambs tended to be relatively redder.

There were differences between groups in terms of TBARS values on days 7 and 12 of storage (Table 4). The TBARS content was higher in the CG than in the VG group on days 2, 4, 7 and 12 of storage. Based on drip loss, there was significant difference between groups on day 2. On days 4 and 7 of storage there were no statistical differences, but there was a numerical increase in the drip loss of CG compared to VG (Table 5).

There were no significant differences between groups in pH values of LD muscles on days 2, 4, 7 and 12 of the storage period. The influence of vitamin E supplementation on pH values from slaughter time up to 12 days of storage was not statistically significant. The mean pH values decreased from slaughter time up to

Table 2
Carcass measurements (mean ± S.E.) of CG and VG lamb groups

Carcass measurements	CG ($n=4$)	VG ($n=4$)	P
Carcass length (cm)	71.2±2.80	72.1±0.72	Ns
Internal length of gigot (cm)	26.5±0.87	25.7±0.48	Ns
Width of gigot (cm)	19.0±0.03	17.5±0.29	*
Heart girth (cm)	79.2±0.25	76.7±0.85	Ns

Ns, $P>0.05$.
* $P<0.05$.

Table 3
Chemical composition, cooking yield and Warner-Bratzler shear (WBS) force traits (mean ± S.E.) of CG and VG lambs

	CG ($n=4$)	VG ($n=4$)	P
Dry matter (%)	24.4±0.19	24.5±0.57	Ns
Ash (%)	1.1±0.06	1.1±0.03	Ns
Crude protein (%)	20.3±0.61	20.8±0.44	Ns
Ether extract (%)	3.0±0.76	2.6±0.52	Ns
Cooking loss (%)	29.9±2.30	31.5±0.87	Ns
Cooking yield (%)	70.1±2.30	68.5±0.87	Ns
WBS force (kg)	2.8±0.14	3.2±0.17	Ns

Ns, $P>0.05$.

24 h, however, it was vice versa from 24 h until the 12th day of the storage period.

4. Discussion

The vitamin E-treated group received a supplement of 45 mg vitamin E per lamb per day for a 75-day fattening period. Institut National de Recherche Agricole (INRA) (Jarrige, 1988) recommended 5–10 mg vitamin E per kg dry feed for ruminants. The Agricultural Research Council (ARC, 1980) suggested a minimal requirement lying between 10 and 15 mg/kg dietary dry matter. However, higher levels of vitamin E are likely improve performance and meat quality traits of livestock.

Differences between CG and VG groups in inital weight, final weight, daily weight gain, non-carcass and carcass cuts percentages were not found to be significant. Although the daily weight gain and feed conversion efficiency were not affected by vitamin E supplementation to diet of animals, vitamin E supplementation resulted in an 8.1% improvement in feed conversion efficiency. This improvement may occur due to protection of ruminal epithelium against the ulcerative action of ruminal content in ruminant animals fed with vitamin E supplemented diets. The results from the present study were in agreement with the findings of Dufrasne et al. (2000). However, Hill et al. (1989) have suggested enhanced fattening performance by steers fed supplemental vitamin E.

Table 4
Meat quality characteristics (mean ± S.E.) of control and vitamin E-supplemented lamb groups

	N	2nd day	4th day	7th day	12th day
		$\bar{X}\pm S_{\bar{x}}$	$\bar{X}\pm S_{\bar{x}}$	$\bar{X}\pm S_{\bar{x}}$	$\bar{X}\pm S_{\bar{x}}$
Colour (L, a* and b*)*					
*L**					
P		Ns	Ns	Ns	Ns
CG	4	46.1±1.80	43.4±1.60	46.1±1.20	41.7±1.20
VG	4	44.1±1.50	46.4±1.30	47.1±0.86	44.3±1.60
*a**					
P		Ns	Ns	Ns	Ns
CG	4	18.6±1.20	15.4±1.80	15.6±1.20	17.0±0.80
VG	4	18.4±1.20	15.8±0.97	16.2±1.40	17.9±0.99
*b**					
P		Ns	Ns	Ns	Ns
CG	4	7.8±0.96	8.6±0.92	8.5±0.23	4.2±0.33
VG	4	7.9±0.63	7.8±0.96	8.0±0.60	4.3±0.53
TBARS (mg malonaldehyde/kg fresh meat)					
P		Ns	Ns	*	**
CG	4	0.4±0.08	0.4±0.06	0.6±0.06	1.0±0.09
VG	4	0.3±0.06	0.4±0.07	0.4±0.09	0.6±0.09
Drip loss (%)					
P		*	Ns	Ns	Ns
CG	4	0.8±0.08	1.6±0.24	2.9±0.44	3.8±0.67
VG	4	0.6±0.68	1.2±0.08	2.5±0.44	3.8±0.46
pH					
P		Ns	Ns	Ns	Ns
CG	4	5.7±0.03	5.7±0.03	5.8±0.05	5.8±0.03
VG	4	5.6±0.02	5.7±0.03	5.8±0.06	5.8±0.01

*L**, lightness; *a**, redness; *b**, yellowness. Ns, $P>0.05$.
* $P<0.05$.
** $P<0.01$.

The carcass measurements except for width of gigot were not affected by vitamin E supplementation (Table 2). The CG lambs showed better performance than VG lambs in terms of width of gigot measurement.The data for carcass measurements were found to be higher than results reported by Esenbuga et al. (2001) for Awassi ram lambs slaughtered at 30 kg.

No significant differences between CG and VG groups were observed for Warner-Bratzler shear values ranged from 2.8 to 3.2 kg. Vitamin E supplementation did not alter LD steak tenderness by shear force measurement. These results were supported by the findings of Vergara and Gallego (1999). In addition, cooking yield was not affected by vitamin E treatment and the value for VG was lower compared with the CG.

The chemical analysis of LD muscles revealed that moisture, protein, fat and ash content of CG and VG were not significantly different. In general, the values were found to be within the range reported by Carpenter, Rice, Cockett, and Snowder (1996) and Esenbuga et al. (2001).

The effect of vitamin E supplementation on *a** (redness) values of LD muscles over 12 days of storage are presented in Tables 4 and 5. No significant difference in

Table 5
Least squares means and standard errors for meat quality traits of CG and VG lambs

		2nd day	4th day	7th day	12th day	*P*
		$\bar{X} \pm S_{\bar{x}}$	$\bar{X} \pm S_{\bar{x}}$	$\bar{X} \pm S_{\bar{x}}$	$\bar{X} \pm S_{\bar{x}}$	
*Colour (*L*, a* *and* b**)*						
CG	*L**	46.1±1.51	43.4±1.51	46.1±1.51	41.7±1.51	Ns
	*a**	18.6±1.29	15.4±1.29	15.6±1.29	17.0±1.29	Ns
	*b**	7.8±0.69a	8.6±0.69a	8.5±0.69a	4.2±0.69[b]	**
VG	*L**	44.1±1.30	46.4±1.30	47.1±1.30	44.3±1.30	Ns
	*a**	18.4±1.15	15.8±1.15	16.2±1.15	17.9±1.15	Ns
	*b**	7.9±0.58a	7.8±0.58a	8.0±0.58a	4.3±0.58[b]	**
TBARS (mg malonaldehyde/kg fresh meat)						
CG		0.4±0.07b	0.4±0.07b	0.6±0.07b	1.0±0.07a	**
VG		0.3±0.09	0.4±0.09	0.4±0.09	0.6±0.09	Ns
Drip loss (%)						
CG		0.8±0.34b	1.6±0.34b	2.9±0.34a	3.8±0.34a	**
VG		0.6±0.41c	1.2±0.41c	2.5±0.41b	3.8±0.41a	**
PH						
CG		5.7±0.02b	5.7±0.02b	5.8±0.02a	5.8±0.02a	*
VG		5.6±0.04b	5.7±0.04b	5.8±0.04a	5.8±0.04a	**

Ns, $P > 0.05$. *L**, lightness; *a**, redness; *b**, yellowness. Means with different letters are significantly different at $P < 0.01$ or $P < 0.05$.
* $P < 0.01$.
** $P < 0.05$.

*a** values was observed between supplemented and basal meat samples. The mean *a** values decreased on days 2 and 4 of storage, and again relatively increased on days 7 and 12 of the storage period. However, the *a** values of muscles from the VG were numerically higher than those of muscles from lambs fed the basal diet. *L** and *a** values in LD muscle from vitamin E-treated lamb groups were also preserved for a period of 12 days of maturation. In addition, *a** (redness) relatively tended to increase after the 7th day of storage. Similar results with respect to vitamin E supplementation on muscle color parameters were determined for beef cattles (Mitsumoto et al., 1998; Morrisey et al., 1994; Schaefer et al., 1995) and pork (Asghar et al., 1991).

The effect of vitamin E supplementation on the oxidative stability of LD muscles during 12 days of storage period is given in Tables 4 and 5. In the case of fresh muscle, concentrations of TBARS were low in both groups at days 2 and 4 (Table 4), the mean values increased after a 4-day period. The mean TBARS values between CG and VG groups differed significantly on days 7 and 12 of storage. TBARS values for LD muscles from lambs fed the basal diet were significantly higher than those of muscles from lambs fed the supplemented diet. Lipid oxidation was suppressed for a longer period of storage for lambs supplemented with vitamin E than for control lambs. These results were in agreement with findings of Mitsumoto et al. (1998), Asghar et al. (1991) and Dufrasne et al. (2000).

This experiment provides evidence of potential usefulness of providing lambs vitamin E supplementation to enhance fattening performance, carcass and meat quality traits. Although the effect of 45 mg vitamin E supplementation per lamb per day during the 75-day fattening period on the growth, carcass and some meat quality traits was not statistically significant. Lower case had a positive effect on suppresession of lipid oxidation and drip loss and a tendency for a redder meat due to vitamin E supplementation for up to 12 days of storage. More detailed, larger-scale experiments need to be conducted to confirm and clarity the possible role that vitamin E supplementation may have as a positive influence on growth, carcass and meat quality traits.

In conclusion, vitamin E supplementation to the diet of Awassi lambs at an inclusion rate over the amount of nutritional recommendations showed no differences in fattening performance, most carcass characteristics, chemical composition, cooking yield and Warner-Bratzler shear values between treatment groups.

Supplementation resulted in a difference in the width of gigot measurement. It also relatively suppressed lipid oxidation and drip loss for up to 12 days of storage and tended to maintain meat redness.

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