

Effect of dietary oregano oil supplementation on lamb meat characteristics

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Abstract

The effect of dietary oregano essential oil supplementation on lamb meat characteristics was investigated. Eight male and eight female Chios lambs were divided into two equal groups. The first group was fed with the control diet consisting of concentrated feed and alfalfa hay, whereas the second group consumed the same diet, the only difference being that the concentrated feed was uniformly sprayed with oregano essential oil (1 ml/kg). Duration of the experimental period was two months.

No differences were observed after oregano essential oil supplementation in final body weight (kg), body weight gain (g) and carcass yield (%). Tenderness of *longissimus thoracis* muscle, expressed as sarcomere length and shear force value, was not influenced by the treatment, whereas pH and colour parameters (yellowness–redness) appeared to increase ($P < 0.05$). Moreover, results showed that dietary incorporation of oregano essential oil exerted strong antioxidant effects retarding lipid oxidation (MDA formation) in meat during refrigerated and long-term frozen storage ($P < 0.001$).

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1. Introduction

Plant extracts have demonstrated an antimicrobial effect *in vitro*, but their influence on growth performance of farm animal species has not yet been sufficiently documented (Burt, 2004). During the last decade, considerable interest has arisen in the use of natural antioxidants that would serve as alternatives to synthetic supplements with the intention to improve meat quality, without leaving residues in the product or the environment (Yanishlieva-Maslarova, 2001).

Oregano (*Origanum vulgare* L.) is an aromatic plant with a wide distribution throughout the Mediterranean area (Kokkini, Karousou, Hanlidou, & Lanaras, 2004).

The essential oil of oregano mainly consists of carvacrol, thymol, and their precursors, γ -terpinene and p -cymene. It possesses intense antimicrobial (Dorman & Deans, 2000), antifungal (Daouk, Dagher, & Sattout, 1995) and antioxidant (Cervato et al., 2000) properties and contains molecules that have intrinsic bioactivities on animal physiology and metabolism. Oregano action is mainly attributed to carvacrol and thymol, substances that make the bacterial cell membrane permeable (Lambert, Skandamis, Coote, & Nychas, 2001) and react with lipid and hydroxyl radicals converting them into stable products (Yanishlieva-Maslarova, 2001).

Oregano has already been used with the intention to improve the quality and quantity of animal products. It appears to improve growth performance in pigs (Namkung et al., 2004), but the results in poultry are controversial. Although, oregano dietary supplementation improves growth performance of broiler chickens in some cases

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(Giannenas, Florou-Paneri, Botsoglou, Christaki, & Spais, 2005), there are studies which demonstrate no effect of oregano on growth characteristics (Botsoglou, Christaki et al., 2004).

Furthermore, oregano improves meat storage stability after slaughter in poultry (Botsoglou, Govaris, Botsoglou, Grigoropoulou, & Papageorgiou, 2003) and rabbits (Botsoglou, Florou-Paneri, Christaki, Giannenas, & Spais, 2004), protects against the negative effects of stress on chicken meat quality characteristics (Young, Stagsted, Jensen, Karlsson, & Henckel, 2003) and reduces wastes and odour emissions in intensive farming (Varel, 2002).

Information related to oregano growth promoting effects when added to sheep diets is scarce (Bampidis et al., 2005). The objectives of this study were to illustrate oregano essential oil action on lamb meat characteristics and evaluate oregano oils ability to stimulate lamb performance when used as a feed supplement.

2. Materials and methods

2.1. Chemicals

Glutaraldehyde, butylated hydroxytoluene, 2-thiobarbituric acid and 1,1,3,3-tetraethoxypropane, the precursor of malondialdehyde were obtained from Sigma Chemical Co. (St. Louis, MO). Hexane and trichloroacetic acid were from Merck (Darmstadt, Germany). All chemicals used were of analytical grade. Oregano essential oil was produced by Ecopharm Hellas, SA (Kilkis, Greece).

2.2. Animals and diets

Eight male and 8 female Chios lambs with an average initial body weight of 59.50 ± 5.45 and 31.90 ± 4.65 kg, respectively, were used. Lambs were 7 months old at the beginning of the experiment and they were divided into two equal groups, according to their sex and body weight. Water was available ad libitum and feed, composed of concentrated pelleted feed (Nitsiakos Th., SA, Ioannina, Greece) and alfalfa hay (Table 1), was given once daily at 7:00 a.m to both groups before experiment implementation. During the experimental period, which started in October and finished after 2 months, the first group was fed the above control diet and the second group consumed the same diet, with the only difference that concentrated feed was uniformly sprayed with oregano essential oil (1 ml/kg).

Oregano essential oil used in the present study was stored in a stainless sealed container, appropriate for volatile compounds (1 l). It had a clear dark yellow colour and a herbal, spicy, pungent odour, characteristic of oregano. Samples of oregano oil were analyzed using a gas chromatography–mass spectrometry system (GC-14A, MS-QP2000). Gas chromatography was performed on a Shimadzu 14A GC equipped with flame ionization detector (FID) and connected with a PC workstation appropriate for gas

Table 1
Composition and analysis of diets

Components (g/kg)	Control ^a	Oregano ^b
Maize	740.6	740.6
Sunflower meal	69.9	69.9
Soybean meal	27.2	27.2
Rice bran	50.0	50.0
Calcium phosphate	25.2	25.2
limestone	18.0	18.0
Molasse	60.0	60.0
Salt	5.0	5.0
Vitamins & trace elements ^c	4.0	4.0
Oregano essential oil (ml/kg)	–	1.0
Analysis ^d	Control diet	Alfalfa hay
Dry Matter – DM (%)	89	88
Net Energy – NE (MJ/ kg)	7	4
Crude protein – CP (%)	10	17
NDF (%)	13	45
ADF (%)	6	30
Ash (%)	7	10
Calcium (%)	1	–
Phosphorus (%)	1	–

^{a,b} Control group was fed with a diet consisted of the above concentrated feed and alfalfa hay, whereas the oregano group consumed the same diet, with the only difference that concentrated feed was uniformly sprayed with oregano essential oil (1 ml/kg).

^c Vitamins & Trace elements contained per kg basal ration: 100 mg Mn, 108 mg Zn, 90 mg Fe, 4.5 mg I, 0.2 mg Se, 0.675 mg Co, 12600 KIU of vitamin A, 2520 KIU of vitamin D3 and 27 mg of vitamin E.

^d According to AOAC (1990) and Van Soest, Robertson, and Lewis (1991).

chromatography. GC operating conditions were: column (Supercowax 10), column temperature programmed at 70 °C isothermal for 10 min, then increased to 180 °C at a rate of 2 °C min^{−1}, carrier gas helium, flow rate 1 ml min^{−1}, injector temperature 240 °C. Mass Spectrometry performed by a Shimadzu QP2000 Spectrometer with working conditions: ionization voltage 70 eV, ion source temperature 240 °C. Oregano essential oil main components were (%): carvacrol (83.10), thymol (2.10), γ -terpinene (3.97), *p*-cymene (3.79) and β -caryophyllene (0.93).

Lambs of each group were kept together in identical pens, placed with the same direction and orientation, the same covered area (2 m²/lamb) and equipped with similar troughs for feeding. Animals were individually fed, twice per day; ram and ewe lambs were fed 750 g and 600 g of mixture of concentrated feed and 600 g and 500 g of alfalfa hay per day, respectively. Lambs were weighed in the beginning and at the end of the experiment.

The preparation of oregano supplemented diet was carried out every 5 days, throughout the experimental period. In detail, a quantity of concentrated feed (30 kg) placed in a plastic container, was sprayed gradually with oregano essential oil (1 ml/kg). Feed was continuously mixed during spraying, with the intention to obtain a uniform distribution of the essential oil. After the application of the essential oil, container was sealed firmly so as to minimize the evaporation of volatile compounds. The size of

container was 0.125 m^3 (length \times width \times height: $0.5 \text{ m} \times 0.5 \text{ m} \times 0.5 \text{ m}$). The prepared quantity of feed was chosen by taking into account the nutritional needs of the oregano group of lambs for 5 days. At the end of the fifth day, after the utilization of oregano supplemented feed, the container was cleaned of feed remains and the procedure of feed preparation was repeated.

At the end of the experiment, sheep were fasted for 18 h (water was allowed), weighed and slaughtered. After dressing and refrigerated storage for 24 h at 4°C , carcasses were weighed and sectioned longitudinally into two symmetric halves. Each carcass consisted of the following joints: legs, chumps, loins, anterior loins, ribs, anterior ribs, shoulders, breast and neck.

The *longissimus dorsi* muscle thoracic region (6th–13th rib) was then excised and used for the analyses. pH, colour parameters, tenderness and sarcomere length were directly measured. Measurement of lipid oxidation was implemented on days 0, 3, 6 and 9 and 0, 1, 2, 3 and 4 months after storage at 4°C and -20°C , respectively. All animals used in the experiment were cared for according to applicable recommendations of US National Research Council (NRC, 1996).

2.3. Meat quality measurements

2.3.1. pH 24 and colour

Prior to testing, as it has already been pointed out, muscle samples (2 per lamb) were kept at 4°C for 24 h. pH of *longissimus thoracis* was measured using a Sentron 1001 pH System (Roden, Netherlands) model, with the electrode inserted into the muscles. The part of *longissimus thoracis* muscle between 12th and 13th ribs was sliced across the fibers, left exposed to the air at room temperature for 30 min and meat colour measured on the cut surface using a Miniscan XE (HunterLab, Reston, USA) chromameter set on the L^* , a^* , b^* system (CIE 1976, Commission International de l'Éclairage).

2.3.2. Shear force value

Samples ($80 \pm 2 \text{ g}$) of *longissimus thoracis* muscle from each lamb were placed in plastic bags and cooked in a water bath at 80°C for 1 h, left under running water for 30 min and then placed in a refrigerator at about 4°C for 24 h. Five sub samples with a cross section of 1 cm^2 were cut parallel to the muscle fibers and shear force value of the *longissimus thoracis* muscle was measured using a Warner Bratzler (WB) shear blade fitted to a Zwick Testing Machine Model Z2.5/TN1 S (Zwick GmbH & Co, Germany). Peak force values in Newtons were recorded.

2.3.3. Sarcomere length

The determination of sarcomere length was conducted according to Herring, Cassens, and Briskey (1965). *Longissimus thoracis* muscle samples (5 per lamb) were cut into pieces, so that their myofibrils were exposed. Thereafter,

samples were soaked in 25% glutaraldehyde solution, diluted with distilled water (1:10), for about an hour. Single fibers were teased out and their observation took place with a phase-contrast microscope equipped with an ocular micrometer. Sarcomere length was determined as an average of 30 myofibrils.

2.3.4. Measurement of lipid oxidation – MDA assay

Lipid oxidation was assessed on the basis of the malondialdehyde (MDA) formed during storage. MDA is the most frequently used indicator of lipid peroxidation, even in plasma as biomarker for oxidative stress (Nielsen, Mikkelsen, Nielsen, Andersen, & Grandjean, 1997). In the present study, MDA in *longissimus thoracis* muscle was determined by a selective third-order derivative spectrophotometric method previously developed by Botsoglou et al. (1994). In brief, 2 g of each sample (2 samples per lamb) were homogenized (Edmund Buehler 7400 Tuebingen/H04, Germany) in the presence of 8 ml aqueous trichloroacetic acid (TCA) (50 g/l) and 5 ml butylated hydroxytoluene (BHT) in hexane (8 g/l), and the mixture was centrifuged for 3 min at 3000g. The top hexane layer was discarded and a 2.5 ml aliquot from the bottom layer was mixed with 1.5 ml aqueous 2-thiobarbituric acid (TBA) (8 g/l) to be further incubated at 70°C for 30 min. Following incubation, the mixture was cooled under tap water and submitted to third-order derivative (3D) spectrophotometry (model Unicam Helios Alpha & Beta, Spectronic Unicam EMEA, United Kingdom) in the range of 500–550 nm. The concentration of MDA (ng/g wet tissue) in analyzed samples was calculated on the basis of the height of the third-order derivative peak at 522 nm by referring to slope and intercept data of the computed least-squares fit of a standard calibration curve prepared using 1,1,3,3-tetraethoxypropane (TEP), the malondialdehyde precursor. Derivative as opposed to conventional spectrophotometry was adopted because it offers improved sensitivity, specificity and reliability of the measurements, since it eliminates potential interferences from other reactive compounds.

2.4. Statistical analysis

Body weight (BW), carcass yield, body weight gain (BWG), and meat quality characteristics, such as pH, colour parameters (L^* , a^* , b^*), Warner Bratzler shear force measurements and sarcomere length for the *longissimus thoracis* muscle were analyzed using a general linear model (GLM) procedure which contained the fixed effects of sex, nutritional treatment and the interaction between sex and nutritional treatment.

Malondialdehyde (MDA) was also analyzed using a general linear model (GLM) appropriate for repeated measurements per subject, which included the effects of sex, nutritional treatment and the interaction between sex and nutritional treatment as fixed effects. All model analyses were performed by Sas/Stat (2005).

3. Results and discussion

3.1. Feed intake

Feed intake was not influenced by dietary oregano essential oil supplementation, apart from the first 2–3 days, when the group of lambs fed with the oregano essential oil supplemented diet appeared to eat smaller quantities of feed compared to the control group of lambs. As has already been pointed out, ram and ewe lambs consumed 750 g and 600 g of mixture of concentrated feed and 600 g and 500 g of alfalfa hay per day, respectively.

The chosen level of oregano essential oil supplementation (1 ml/kg) did not depress feed preference and palatability, and at the same time animals did not suffer aversive post-ingestive effects (Villalba & Provenza, 1997). Moreover, it seems that ruminal flora of lambs needs 2–3 days to get accustomed to the novel oregano essential oil supplemented diet (Simitzis, Feggeros, Bizelis, & Deligeorgis, 2005).

In poultry, results are controversial. Hernandez, Madrid, Garcia, Orengo, and Megias (2004) stated that there were no differences in feed intake after oregano extract treatment; oregano seems to improve nutrient digestibility. On the other hand, Cross, Acamovic, Deans, and McDevitt (2002) found that oregano herb negatively influenced feed intake but not body weight gain, in broilers.

3.2. Growing performance and carcass characteristics

No differences were observed in final body weight (BW) (kg), carcass yield (%) and BW gain (g) after dietary oregano essential oil supplementation in lambs (Table 2). Similar results have been reported by Bampidis et al. (2005), who stated that diet supplementation with oregano leaves, did not influence sheep growing performance, muscle tissue growth and carcass characteristics. Although, components of oregano extracts could control and limit the growth and colonization of numerous pathogenic and nonpathogenic species of bacteria in the gut (Bampidis et al., 2005), they appeared not to have a growth promoting effect in lambs,

in the present study. Also no growth promotion after oregano supplementation was observed in broiler chickens (Botsoglou, Christaki et al., 2004) and rabbits (Botsoglou, Florou-Paneri et al., 2004). Moreover, Young et al. (2003) demonstrated that chicken receiving an oregano supplement had a significantly lower weight after slaughter but did not eat significantly less feed.

3.3. pH24

As presented in Table 3, muscle pH increased ($P < 0.05$) after dietary oregano essential oil incorporation in female sheep. Higher muscle pH for lambs fed with the oregano essential oil supplemented diet, might have reflected different glycogen reserves pre-slaughter. Nutritional treatments have been shown to influence muscle glycogen levels in cattle (Tudor, Couper, & Pethick, 1996) and sheep (Shorthose, 1978). Differences may be related with an altered utilization of dietary energy or a different reaction to the stress of slaughter, due to the activity of specific muscle enzymes (Hopkins, Hall, Channon, & Holsy, 2001). However, the observed increase was not so great as to influence bacteriological stability (Young, Reid, & Scales, 1993). In chickens, oregano supplements incorporation in feed did not affect pH values (Young et al., 2003).

Sex also influenced pH values (Table 4), since male lambs had a higher value than females ($P < 0.05$). These results are in agreement with previous studies (Johnson, Purchas, McEwan, & Blair, 2005), although there are studies which demonstrate that pH values are not affected by sex, suggesting that both sexes respond equally well to stress at slaughter at these early ages in sheep (Teixeira, Batista, Delfa, & Cadavez, 2005).

3.4. Colour

Values of a^* and b^* in *longissimus thoracis* muscle from lambs fed with the oregano supplemented diet were higher than the controls (Table 3), as it has also been observed in chickens fed with oregano supplements (Young et al., 2003). It is possible that dietary oregano essential oil

Table 2

Body weight (BW), body weight gain (BWG), carcass yield of lambs, as they are influenced by sex and oregano oil supplementation (LS means \pm s.e.m.)

	Male		Difference ^d	Female		Difference
	Control ^a	Oregano ^b		Control	Oregano	
Initial BW (kg)	59.3 \pm 5.40	59.8 \pm 5.50	NS	31.9 \pm 4.60	31.9 \pm 4.70	NS
BWG (g/day)	92.6 \pm 12.90	95.7 \pm 11.80	NS	78.7 \pm 12.10	85.3 \pm 12.90	NS
Fasted BW (kg)	64.8 \pm 4.60	65.8 \pm 4.70	NS	36.5 \pm 3.75	37.0 \pm 3.80	NS
Hot carcass weight (kg) ^c	30.6 \pm 2.40	31.1 \pm 2.45	NS	17.8 \pm 3.43	17.9 \pm 3.48	NS
Carcass yield (%)	47.6 \pm 1.34	47.2 \pm 1.27	NS	48.8 \pm 1.52	48.3 \pm 1.49	NS

^{a,b} Ram and ewe lambs were fed 750 g and 600 g of concentrated feed and 600 g and 500 g of alfalfa hay per day, respectively. Control group was fed with a diet consisted of concentrated feed and alfalfa hay, whereas the oregano group consumed the same diet, with the only difference that concentrated feed was uniformly sprayed with oregano essential oil (1 ml/kg). Number of lambs per treatment is 4 males and 4 females.

^c Carcass consisted of legs, chumps, loins, ribs, anterior ribs, shoulders, breast and neck.

^d NS – not significant.

Table 3

Meat quality characteristics (pH, colour, sarcomere length and shear force values) as they are influenced by oregano oil dietary supplementation (LS means \pm s.e.m.)

	Male		Female	
	Control ^a	Oregano ^b	Control	Oregano
pH	5.8 \pm 0.06 ^c	5.9 \pm 0.09 ^c	5.5 \pm 0.05 ^d	5.6 \pm 0.03 ^e
Colour				
<i>L</i> [*]	48.8 \pm 3.54	50.3 \pm 5.48	42.1 \pm 3.16	46.3 \pm 1.69
<i>a</i> [*]	11.3 \pm 0.67 ^c	12.6 \pm 0.65 ^d	13.1 \pm 0.69 ^d	14.4 \pm 0.62 ^e
<i>b</i> [*]	6.1 \pm 0.21 ^c	6.5 \pm 0.21 ^d	6.6 \pm 0.21 ^d	7.2 \pm 0.23 ^e
Sarcomere length (μ m)	1.7 \pm 0.05	1.8 \pm 0.05	1.8 \pm 0.04	1.7 \pm 0.04
Shear force (N)	53.9 \pm 3.5	49.7 \pm 5.45	43.9 \pm 3.14	40.2 \pm 1.68

^{a,b} Control group was fed with a diet consisted of concentrated feed and alfalfa hay, whereas the oregano group consumed the same diet, with the only difference that concentrated feed was uniformly sprayed with oregano essential oil (1 ml/kg). Number of lambs per treatment is 4 males and 4 females.

^{c,d,e} Rates within a row with different superscripts are significantly different ($P < 0.05$).

Table 4

Effect of refrigerated (at 4 °C) and long-term frozen (at –20 °C) storage (LS means \pm s.e.m.) on lipid oxidation of raw sheep *longissimus thoracis* muscle as a function of oregano oil dietary concentrated feed supplementation with 1 ml/kg feed

MDA (ng/g)	Male		Female	
	Control ^a	Oregano ^b	Control	Oregano
<i>Storage period (days, at 4 °C)</i>				
0	28.0 \pm 1.80 ^c	20.5 \pm 1.90 ^d	29.2 \pm 1.72 ^c	20.0 \pm 1.63 ^d
3	57.1 \pm 2.38 ^c	28.0 \pm 2.50 ^d	60.2 \pm 2.26 ^c	30.8 \pm 2.14 ^d
6	82.3 \pm 2.77 ^c	56.9 \pm 2.92 ^d	65.5 \pm 2.64 ^d	40.5 \pm 2.50 ^e
9	247.4 \pm 6.17 ^c	102.6 \pm 6.49 ^d	245.0 \pm 5.88 ^c	96.6 \pm 5.56 ^d
<i>Storage period (months, at –20 °C)</i>				
0	28.0 \pm 1.80 ^c	20.5 \pm 1.90 ^d	29.2 \pm 1.72 ^c	20.0 \pm 1.63 ^d
1	30.0 \pm 1.66 ^c	21.0 \pm 1.74 ^d	32.0 \pm 1.58 ^c	21.9 \pm 1.49 ^d
2	33.6 \pm 1.60 ^c	21.5 \pm 1.67 ^d	37.2 \pm 1.53 ^c	24.1 \pm 1.44 ^d
3	35.3 \pm 1.87 ^c	22.5 \pm 1.97 ^d	42.7 \pm 1.78 ^c	27.2 \pm 1.68 ^d
4	42.0 \pm 2.25 ^c	24.2 \pm 2.37 ^d	48.8 \pm 2.15 ^c	33.0 \pm 2.03 ^d

^{a,b} Control group was fed with a diet consisted of concentrated feed and alfalfa hay, whereas the oregano group consumed the same diet, with the only difference that concentrated feed was uniformly sprayed with oregano essential oil (1 ml/kg). Number of lambs per treatment is 4 males and 4 females.

^{c,d,e} Rates within a row with different superscripts are significantly different ($P < 0.001$).

supplementation modifies indirectly meat colour, probably by decreasing haemoglobin oxidation and activating mechanisms that modify pigment distribution in animal tissues.

Colour parameters were also different between ram and ewe lambs (Table 3). Males tended to have brighter meat than females ($P < 0.05$), since ewe's meat could be darker than rams' (Teixeira et al., 2005), due to their greater precociousness and fatness (Sanudo, Sanchez, & Alfonso, 1998). At the same time, ewe lambs appear to have higher *a*^{*} and *b*^{*} values in relation to ram lambs, as also reported by Johnson et al. (2005), revealing the increased levels of haem pigment in ewe lambs (Ledward & Shorthose, 1971). However, there are previous studies that indicated no differences in colour parameters (*L*^{*}, *a*^{*}, *b*^{*}) existed between sexes in sheep (Horcada, Beriain, Purroy, Lizaso, & Chasco, 1998).

3.5. Shear force value and sarcomere length

Oregano essential oil supplementation did not influence meat shear force values (Table 3). There is no evidence of

nutritional practices having a direct effect on meat tenderness (Hopkins et al., 2001). At the same time, oregano essential oil treatment appeared not to have a significant effect on sarcomere length (Table 3). Sarcomeres' length is closely related with the diameter of muscle fibers and shear force values (Devine, Wahlgren, & Tornberg, 1999). Several other factors influence drastically sarcomere length: temperature (Devine et al., 2002), pH (McGeehin, Sheridan, & Butter, 2001) and days after slaughter (Wheeler & Koohmaraie, 1994).

No differences in shear force values and sarcomeres' length were found between the sexes (Table 3), reflecting no significant variation in the proportion of collagen at the early stages of life. Many researchers have reached to the same conclusions (Hopkins et al., 2001; Teixeira et al., 2005). In contrast, some reports have demonstrated that there are differences in tenderness between ewe and ram meat; ram meat is found to be tougher than ewe meat (Johnson et al., 2005) or the opposite (Dransfield, Nute, Hogg, & Walters, 1990). Variation in the above results could partially be attributed to the different type of muscle examined or the effect of genotype of sheep.

3.6. Lipid Oxidation

Refrigerated storage increased lipid oxidation in stored (4 °C) compared to fresh meat (Table 4). However, dietary oregano essential oil supplementation appeared to retard significantly ($P < 0.001$) lipid oxidation (MDA formation) in raw sheep *longissimus thoracis* after storage at 4 °C and –20 °C (Table 4). No studies have been conducted, concerning the effect of dietary oregano oil supplementation on lipid oxidation in ruminant meats. However, similar effects have been reported after storage at 4 °C and –20 °C, in broilers (Botsoglou, Christaki, Fletouris, Florou-Paneri, & Spais, 2002; Giannenas et al., 2005), turkeys (Govaris, Botsoglou, Papageorgiou, Botsoglou, & Ambrosiadis, 2004) and rabbits (Botsoglou, Florou-Paneri et al., 2004). Retardation of lipid oxidation was also found after dietary administration of rosemary and sage to broilers (Lopez-Bote, Gray, Gomaa, & Flegel, 1998).

Sarraga and Regueiro (1999) found that broilers fed with an antioxidant supplemented diet, had meat with a lower degree of oxidation than that from broilers fed with an unsupplemented basal diet. In general, dietary supplementation has been proved to be a simple and convenient strategy to uniformly introduce a natural antioxidant into phospholipid membranes where it may effectively inhibit the oxidative reactions at their localized sites (Lauridsen, Buckley, & Morrissey, 1997). Oregano oil contains phenolic antioxidants that react with lipid and hydroxyl radicals and convert them into stable products (Jadhav, Nimbalkar, Kulkarni, & Madhavi, 1996; Yanishlieva-Maslarova, 2001). This study provides indirect evidence that antioxidant, presumably phenolic, compounds occurring in oregano essential oil are absorbed and enter the systemic circulatory system after ingestion.

MDA concentrations were not different between males and females during storage at 4 °C and –20 °C (Table 4). MDA is produced as a result of unsaturated fatty acid oxidation. Velasco et al. (2000) state that the differences in overall carcass fatness due to sex are not reflected in differences in unsaturation of *longissimus dorsi* muscle fat. Moreover, the degree of fat unsaturation is similar in both sexes at the early stages of lambs' life (Horcada et al., 1998).

4. Conclusion

Natural feed supplements appear to be an alternative to synthetic additives in animals' diet. In the present experiment, dietary oregano essential oil administration is positively influenced by meat quality characteristics, mainly by retarding lipid oxidation. However, further study is needed to elucidate its exact action and establish its regular use in sheep husbandry.

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