African Journal of Biotechnology Vol. 10(34), pp. 6663-6669, 11 July, 2011
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB10.2592
ISSN 1684-5315 © 2011 Academic Journals

Full Length Research Paper

Fattening performance, blood parameters and slaughter traits of Karya lambs consuming blend of essential oil compounds

Mürsel Özdoğan[1]*, Sibel Soycan Önenç[2] and Alper Önenç[2]

[1]Agriculture Faculty, Adnan Menderes University, South Campus, Aydin, Turkey.
[2]Agriculture Faculty, Namık Kemal University, Tekirdag, Turkey.

Accepted 27 May, 2011

The effects of feeds containing a blend of essential oil compounds on fattening performance, some blood parameters, the slaughter traits, and internal organ weights of Karya lambs were researched. The lambs were divided into 2 treatment groups: the first group (control, C) consumed mixed feed without blend of essential oil compounds, while the other group (BEOC) consumed mixed feed with blend of essential oil compounds. The mixed feed of BEOC group contained 1 g blend of essential oil compounds per kg. Karya lambs weighed an average of approximately 19.05±1.65 kg and aged 5.5 months. Each lamb was housed in the individual pen and consumed alfalfa hay at 0.2 kg/lamb/day and mixed feed *ad libitum*. During a period of 56 days, the body weights (BW), body weight gains (BWG), total dry matter intake and feed conversion ratios (FCR) of males and females of BEOC group showed better results, but they were not important statistically (P>0.05). Blood parameters of male and female lambs between group C and group BEOC were similar values, but the values of blood parameters in favour of group BEOC were noticed recovery, numerically. It was determined that only the conformation score and lung weight of female lambs were significant (P<0.05). All the other slaughter traits and internal organs weights were not significantly observed the effect depending on the feeding diet containing a blend of essential oil compounds.

Key words: Blend of essential oil compounds, blood, carcass, lamb, performance.

INTRODUCTION

There are various ways to increase the performance of livestock fattening. One of these ways is sustainable livestock known as a healthy livestock breeding model. In the animal production model, friendly products for human and animal health are used at feeding programs. Healthy digestive organ and the optimum feeding are basic regulations of profitableness at animal husbandry. Natural and cheap feed additives could be important for improving meat production. Phytogenic feed additives are experiencing a revival in the world (CAFA, 1997; Church and Pond, 1988; Barragry and Powers, 1994; Greathead, 2003; Wallace, 2004; Westendarph, 2005; Zhang et al., 2005; Castillejos et al., 2007). From all the properties and the possible synergistic effects, numerous researches about essential oils and combinations of essential oils have investigated the mode of action, metabolic pathway, portions in feeds, the effects on animal health, digestive enzymes and microbial flora of digestive organs, and also pathogenic microorganisms (Patel and Srinivasan, 1996; Tsigarida et al., 2000; Losa, 2001; Skandamis and Nychas, 2001; Zhang et al., 2005; Jamroz et al., 2006; Svoboda and Hampson, 2007).

It was observed that essential oils affected the physiological and microbiological characteristics of digestive organs (Donzele et al., 1978; Horton et al., 1991a, b; Freitas et al., 2001; Lewis et al., 2003; McIntosh et al., 2003; Westendarp, 2005). Particularly, the antioxidative properties of plant extracts, which can

*Corresponding author. E-mail: mozdogan@adu.edu.tr.

Abbreviations: BEOC, Blend of essential oil compound; **BW,** body weight; **BWG,** body weight gain; **FCR,** feed conversion ratio; **DM,** dry matter; **DMI,** dry matter intake.

Table 1. The ingredients of mixed feeds.

Ingredient (%)	C group	BEOC group
Corn, ground	25.0	25.0
Barley, ground	18.0	18.0
Wheat, ground	11.7	11.6
Sunflower meal	10.0	10.0
Cottonseed meal	7.0	7.0
Soybean meal	7.0	7.0
Wheat bran	12.0	12.0
Molasses	7.0	7.0
Limestone	1.2	1.2
Salt	1.0	1.0
Vitamin- mineral premix[1]	0.1	0.1
Essential mix[2]	-	0.1

[1]For each kilogramme of the diets contained Vitamin A 12.000 IU, Vitamin D_3 2.400 IU, Vitamin E 30 mg, Mn 50 mg, Zn 50 mg, Fe 50 mg, Cu 10 mg, I 0.5 mg, Co 0.5 mg, Se 0.5 mg. [2]For each kilogramme of the commercial blend of essential oil compounds contained 50 mg essential oils composed of thyme leaf (*Origanum onites* L.), daphne leaf (*Laurus nobilis* L.), sage tea leaf (*Salvia triloba* L.), fennel seed (*Foeniculum vulgare* L.), orange cortes (*Citrus* sp.) and myrtle leaf (*Myrtus communis* L.).

Table 2. The Chemical analysis of mixed feeds and alfalfa hay (g/kg, as fed).

Nutrient content	C group	BEOC group	AH
Dry matter	895.4	897.5	920.1
Ash	46.7	53.0	95.7
Crude protein	139.8	143.8	130.9
Ether extracts	25.7	26.5	8.6
Crude fibre	88.9	82.9	341.3
Metabolizable energy, kcal /kg	2562	2577	1400

C, Control; BEOC, blend of essential oil compounds; AH, alfalfa hay.

also stimulate appetite and positively affect the secretion of endogenous digestive enzymes and influence blood constituents, are important for organisms (Jamroz et al., 2006). Enough informative papers were not found about the effects of essential oils on the blood values and carcass characteristics of ruminants. The objective of this study was to determine the effects of a specific blend of essential oil compounds in feeds on the fattening performance, blood parameters, slaughter traits and viscera mass of lambs.

MATERIALS AND METHODS

The experiment was carried out on 10 male and 10 female Karya lambs, which weighed an average of approximately 19.05±1.65 kg and aged 5.5 months. At the beginning of the study, lambs were randomly assigned to feeding treatments based on body weight. The lambs were divided into 2 treatment groups: the first group was the control (C), which consumed mixed feed without blend of essential oil compounds; the other group (BEOC) consumed mixed feed with blend of essential oil compounds. Each lamb was housed in an individual pen and randomly assigned to one of two groups (five male and five female lambs per group). All 20 pens were identical, with the same direction and orientation, the same covered area (2 m^2/pen). Lambs were fed 200 g alfalfa hay (sun-cured, mid bloom) and mixed feed *ad libitum* daily. The ingredients of mixed feeds are shown in Table 1; chemical compositions of mixed feeds and alfalfa hay are shown in Table 2.

The temperature and relative humidity of sheep house were respectively between average 5.6 and 24.9°C of day, between average 39 and 96% of day in the experiment duration. Lambs were weighed individually at the beginning of the experiment, and at 14 day intervals. Lambs were weighed after 12 h from feeding. Feed consumption was measured daily. Body weight gain (BWG), dry matter (DM) intake (DMI) and feed conversion ratio (FCR) was calculated at each pen on 14 day intervals. The experiment was carried out during a period of 56 days. After all, lambs were fasted for 18 h (water was allowed), lambs were weighed and slaughtered at 56 days of trial to meet the taste of the local market and to avoid excessive fattening (27 to 31 kg live weight), which occurs from that age onwards.

After slaughtering, carcasses were eviscerated. Internal organs (liver, lung, heart, spleen, kidney and testis, small intestine, caecum, and large intestine) were weighed / measured separately. Hot carcasses were weighed and classified according to their

Table 3. The effect of nutritional treatment on fattening performance of lambs[1].

Trait	Male		P value	Female		P value
	C group	BEOC group		C group	BEOC group	
BW (kg)						
Initial	19.36±0.953	19.23±0.847	0.92	18.96±0.726	18.41±0.502	0.62
Final	29.15±0.381	30.27±1.053	0.35	27.28±.521	27.71±1.008	0.68
BWG, g	174.82±19.008	197.05±7.133	0.31	148.48±8.290	166.02±11.735	0.26
DM Intake (kg/d)						
Mixed feed	0.90±0.019	0.93±0.051	0.637	0.79±0.023	0.83±0.028	0.31
Alfalfa hay	0.17±0.000	0.17±0.000	0.00	0.17±0.000	0.17±0.000	0.00
Total	1.074±0,191	1.100±0.051	0.65	0.96±0.025	1.003±0.028	0.35
FCR,(kg DM intake/kg BWG)	6.50±0.836	5.58±0.130	0.31	6.57±0.341	6.10±0.305	0.40

[1]: Values are least square means ± standard error of the mean. C, Control; BEOC, blend of essential oil compounds; FCR, feed conversion ratio.

fatness and conformation score on a scale with 15 points by comparison with photographic standards (Colomer et al., 1988). After chilling at 4°C for 24 h, carcasses were again weighed to determine the cold-carcass weight and then sectioned into two symmetric halves.

Collection and analysis of blood samples

Blood samples were collected from the individual animals after morning feedings in the beginning and final day of the experimental period. The blood samples were taken from *V. jugularis* into 10 ml-vacutainer tubes without anticoagulant and centrifuged at 4000 x *g* for the separation of serum. Using ready-to-use spectrophotometrical kits (Biomedical Systems, Barcelona, Spain) and the apparatus (UV-1601 Shimadzu, Japan), the serum samples were analyzed for determining the levels of aspartate aminotransferase (AST), alanine aminotransferase (ALT), total proteins (TP), albumin, glucose, cholesterol, urea.

Statistical analyses

All data were statistically analysed by the General Linear Models (GLM) procedure with SPSS software (SPPS, 1999). Differences among means were tested using Duncan's multiple-range tests. All statements of significance were based on a probability of $P<0.05$.

RESULTS

The effect of adding a blend of essential oil compounds to mixed feed was determined on fattening performance, blood parameters, slaughter traits and internal organ weights of male and female lambs. The body weights of male and female lambs in the end of the experiments were similar between C group and BEOC group (Table 3). The male lambs of BEOC group were higher weight than those of c group, but the difference was not statistically significant. It was seen that the same results were observed in the female groups. The body weight gains of male and female lambs at C group were lower than those at BEOC group but the difference was not statistically different.

Consumption of the mixed feed and alfalfa was not statistically significant between group C and BEOC group either for males or for females in Table 3. The male lambs of C group ate the same amount of mixed feed and total DM, as those of BEOC group, and the female lambs of C group ate same diets as those of BEOC Group. Feed conversion ratios of male and female lambs at BEOC group were found better than those in C group but there were no statistical differences. When the serum parameters of lambs in Table 4 were scrutinized, at the beginning day of the experiment, serum urea values of males in C group were statistically higher than those in BEOC group ($P<0.05$). Glucose values of females of C group were statistically higher than those of BEOC group ($P<0.05$).

With the exception to urea values of males and glucose values of females in the beginning day, all other serum parameters of males and females between C group and BEOC group in the beginning and final days of experiment were not found significant. In the final day of the experiment, glucose, total protein, urea and alanine aminotransferase (ALT) could be commented in favour of BEOC Group than C group, but these values were not found important statistically.

The effect of adding a blend of essential oil compounds to mixed feed on slaughter traits and internal organ weights is shown in Table 5. When comparing BEOC group on slaughter traits and internal organ weights or lengths with C Group, it was determined that only conformation scores and lung weights of female lambs were significant statistically ($P<0.05$).

All the other slaughter traits and internal organ weights and intestine lengths between C group and BEOC group were not significant statistically.

DISCUSSION

There have been a great number of literatures on

Table 4. The effect of nutritional treatment on serum parameters of lambs[1].

Trait	Male		P-value	Female		P-value
	C group	BEOC group		C group	BEOC group	
Beginning day of experiment						
Glucose, mg/dl	51.94±1.5842	69.68±4.8174	0.08	62.92±3.8408	49.43±3.0333	0.050
Total protein, g/dl	5.04±0.3076	4.68±0.3292	0.447	4.82±0.2764	5.07±0.3180	0.592
Albumin, g/dl	2.50±0.1304	2.80±0.1225	0.132	2.62±0.0490	2.37±0.2186	0.192
Cholesterol, mg/dl	99.46±12.7016	78.58±17.3020	0.359	95.62±11.4093	128.57±31.8090	0.280
Urea, mg/dl	40.80±1.9849	28.20±3.9674	0.022	32.60±3.8678	25.33±5.3333	0.304
AST, U/l	64.98±5.4748	68.78±9.7709	0.743	88.34±6.3143	70.40±15.6845	0.254
ALT, U/l	42.20±4.8518	39.20±5.6780	0.698	42.20±5.0040	41.67±1.2019	0.939
Final day of experiment						
Glucose, mg/dl	63.08±5.8784	63.80±3.5096	0.919	58.60±3.9083	64.53±7.2996	0.456
Total protein, g/dl	5.70±0.1612	6.34±0.2891	0.089	5.54±0.3326	5.63±0.4485	0.871
Albumin, g/dl	2.74±0.1166	2.72±0.0735	0.888	2.58±0.1594	2.57±0.2333	0.963
Cholesterol, mg/dl	61.86±5.0863	48.94±2.9449	0.059	57.38±3.4681	63.43±11.9382	0.446
Urea, mg/dl	38.40±5.0754	35.40±4.5011	0.670	44.20±2.9563	42.67±2.1858	0.731
AST, U/l	82.40±8.1004	68.72±3.7586	0.164	97.74±5.9821	88.80±4.3684	0.338
ALT, U/l	30.80±2.2672	31.40±2.4207	0.861	32.40±2.5807	25.66±3.4801	0.08

[1]:Values are least square means ± standard error of the mean. C, control; BEOC, blend of essential oil compounds; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

commercial essential oil compounds and their blends for usage in ruminant nutrition (McIntosh et al., 2003; Duval et al., 2007; Hart et al., 2008). Besides, essential oil compounds have been used to cure nutrition diseases in the digestive system (Benchaar et al., 2008; Hart et al., 2008; Patra and Saxena, 2009), it was explained that they could positively affect fattening performance, carcass characteristics and blood parameters of animals in medicine, animal feeding and veterinary books at human and animal history (Bampidis et al., 2005a; Yoshino et al., 2005; Moñino et al., 2008). Nowadays, different essential oils or their blends have been investigated on fattening performance and carcass quality in animal feeding (Djouvinov et al., 1997; Westendarp, 2005; Zhang et al., 2005; Meyer et al., 2009; Nieto et al., 2010).

BW (initial and final), BWG, dry matter intake (mixed feed and total) and FCR of male and female lambs were not different between group C and group BEOC. When scrutinizing the previous studies related to steers and pigs consuming a blend of essential oil compounds, there were no significant effects of commercial essential oil compounds on the growth performance (Losa, 2001; Muhl and Liebert, 2007; Meyer et al., 2009). No other research is available to compare feedlot lamb performance when fed these essential oils. No differences were observed among dried oregano leaves inclusion treatments in the final BW, BW gain, dry matter intake and FCR (Bampidis et al., 2005b). Moreover, the diets containing essential oil compounds improved slightly the fattening performance of lambs, it was said that the addition of essential oils can shift the microbial fermentation in the rumen, modifying the production of volatile fatty acids by increasing the acetate to propionate ratio, inhibiting deamination, and the direct inhibition of methane production (Busquet et al., 2006; Castillejos et al., 2007).

Glucose values of females and urea values of males between C and BEOC groups were found important statistically in the beginning period of the experiment, but enough literatures were not

Table 5. The effect of nutritional treatment on slaughter traits and weights of internal organs[1].

Trait	Male		P- value	Female		P- value
	C group	BEOC group		C group	BEOC group	
Slaughter traits						
Slaughter wt, kg	27.82±0.37	28.52±1.04	0.542	26.02±0.46	26.30±0.90	0.767
Hot carcass wt, kg	13.60±0.34	14.24±0.46	0.292	13.20±0.36	13.13±0.55	0.917
Cold carcass wt, kg	13.47±0.30	14.13±0.48	0.278	13.11±0.34	13.03±0.54	0.900
Cold carcass yield, %	48.39±0.61	49.6±0.44	0.158	50.37±0.71	49.54±0.52	0.441
Conformation (1-15)	6.00±0.55	5.80±0.97	0.862	5.40±0.25	4.00±0.58	0.039
Fatness (1-15)	7.80±0.92	7.40±1.29	0.807	8.60±0.81	9.33±1.20	0.618
Internal organs						
Liver, g	668±17.81	628±27.94	0.266	547±20.25	565±30.06	0.616
Lung, g	600±23.24	542±23.68	0.123	566±13.96	494±16.29	0.017
Heart, g	128±5.25	126±6.34	0.778	110±0.00	130±0.03	0.397
Spleen, g	59.2±4.88	64.0±2.71	0.454	52.0±3.19	67.3±12.35	0.185
Kidney, g	41±3.41	49±2.94	0.106	40±1.94	37±0.67	0.206
Testis, g	94±19.04	90±16.75	0.867	-	-	-
Small intestine length, m	24.15±0.73	25.12±0.97	0.447	21.31±0.33	23.72±1.47	0.084
Large intestine length, m	5.33±0.15	5.50±0.13	0.418	5.12±0.43	4.48±1.24	0.574
Caecum length, cm	28.90±2.19	28.00±1.82	0.760	26.40±1.50	31.50±1.50	0.111

[1]: Values are least square means ± standard error of the mean. C: Control; BEOC: blend of essential oil compounds.

found explaining differences, as these values were based on feeding essential oil compounds. It was observed that some essential oils may result in thinning of the intestinal wall by suppressing the growth of undesirable intestinal microflora, and thus, they were to improve nutrient absorption (Bampidis et al., 2005a; Jamroz et al., 2006). This may explain the higher glucose, total protein in lambs consuming the diet containing a blend of essential oil compounds. The previous studies related to the effects of diet containing essential oils or blend on blood parameters in lambs have not been found. On the other hand, Case et al. (1995) reported that dietary carvacrol and thymol at 150 mg/kg diet significantly decreased serum cholesterol concentrations in cockerels.

In contrast, Lee et al. (2003a, b) gave female broiler chickens dietary thymol at 100 and 200 mg per kg diet and carvacrol at 200 mg per kg diet, and they reported no differences in plasma cholesterol with control group.

When scrutinizing at the results of slaughter traits and weights of internal organs, it was agreed that adding the blend of essential oil compounds to mixed feed was not affecting slaughter traits and weights of internal organs. But, non-significant positive recovery was found, the slaughter traits of male lambs. The remarkable effect of BEOC on internal organs was not sighted in this study. There were not available researches to compare the slaughter traits and internal organs of feedlot lambs consuming essential oils or their blends. The values of slaughter traits and non carcass values of lambs were variable in the previous literatures, because it was claimed that these values may or may not be affected by diet (Fluharty et al., 1999; Kandylis et al., 1999; Olfaz et al., 2005), different slaughter weights (Balcı and Karakaş, 2007) or breed (Pérez et al., 2007). The differences of conformation score and lung weight in the groups of females in this study, were caused from the individual characteristic. Further studies are required to reveal the effect of adding a blend of essential oil compounds to mixed feed on the slaughter traits and internal organ weights of lambs.

Conclusion

This study has demonstrated that the BEOC containing thyme leaf, daphne leaf, sage tea leaf, fennel seed, orange cortes and myrtle leaf did not have statistically positive effect on fattening performance, blood parameters, the slaughter traits, and internal organ weights of male and female lambs. It is to be thought that the addition of BEOC to mixed feed at higher levels or unsuitable housing conditions will affect blood parameters and internal organ weights positively.

Acknowledgement

This study was financially supported by Adnan Menderes University, Scientific Research Projects Fund, Aydın, Turkey.

REFERENCES

Balcı, F, Karakaş E (2007). The effect of different slaughter weights on the fattening performance, slaughter and carcass characteristics of male Karayaka lambs. Turk. J. Vet. Anim. Sci., 31(1): 25-31.

Bampidis VA, Christodoulou V, Christaki E, Florou-Paneri P, Spais AB (2005a). Effect of dietary garlic bulb and garlic husk supplementation on performance and carcass characteristics of growing lambs. Anim. Feed Sci. Technol., 121(2005): 273-283.

Bampidis, VA, Christodoulou V, Florou-Paneri P, Christaki E, Spais AB, Chatzopoulou PS (2005b). Effect of dietary dried oregano leaves supplementation on performance and carcass characteristics of growing lambs. Anim. Feed Sci. Technol., 121: 285–295.

Barragry TB, Powers T (1994). Veterinary Drug Therapy. Lea and Febiger, Philadelphia, PA, USA.

Benchaar C. Calsamiglia S, Chaves AV, Fraser GR, Colombatto D, McAllister T A, Beauchemin K A (2008). A review of plant-derived essential oils in ruminant nutrition and production. Anim. Feed Sci. Technol., 145: 209–228.

Busquet M, Calsamiglia S, Ferret A, Kamel C (2006). Plant extracts affect in vitro rumen microbial fermentation. J. Dairy Sci., 89:761-771.

CAFA (1997). Antimicrobial feed additives. Commission on Antimicrobial Feed Additives. Swedish Official Government Reports 1997:132. Ministry of Agriculture, Stockholm, Sweden.

Case GL, He L, Mo H, Elson CE (1995). Induction of geranyl pyrophosphate pyrophosphatase activity by cholesterol-suppressive isoprenoids. Lipids, 30: 357-359.

Castillejos L, Calsamiglia S, Ferret A, Losa R (2007). Effects of dose and adaptation time of a specific blend of essential oil compounds on rumen fermentation. Anim. Feed Sci. Technol., 132 :186–201.

Church DC, Pond WG (1988). Basic Animal Nutrition and Feeding, 3rd ed. Wiley, New York, NY, USA.

Colomer F, Delfa R, Sierra I (1988). A normalized method to study the quantitative and qualitative characteristics of sheep carcasses produced in different livestock systems in the Mediterranean region. Cuadernos INIA, number 17.

Djouvinov D, Pavlov D, Ilchev A, Enev E (1997). Peppermint (Mentha piperita Huds.) and basil (*Ocimum basilicum* L.) etheric oil by-products as roughages for sheep feeding. Anim. Feed Sci. Technol., 68(3): 287-294(8).

Donzele JL, Costa PMA, Silva MA, Mello HV (1978). Use of garlic (*Allium sativum* L.) as a swine growth stimulant feed supplement. Revista Society Brasileira de Zootecnia, 7: 196–207.

Duval SM, McEwan NR, Graham RC, Wallace RJ, Newbold CJ (2007). Effect of a blend of essential oil compounds on the colonization of starch-rich substrates by bacteria in the rumen. J. Appl. Microbiol., 103: 2132–2141.

Fluharty FL, McClure KE, Solomon MB, Clevenger DD, Lowe GD (1999). Energy source and ionophore supplementation effects on lamb growth, carcass characteristics, visceral organ mass, diet digestibility, and nitrogen metabolism. J. Anim. Sci., 77: 816-823.

Freitas R, Fonseca JB, Soares RTRN, Rostagno HS, Soares PR (2001). Utilization of garlic (*Allium Sativum* L.) as growth promoter of broilers. Revista Brasileira de Zootecnia, 30: 761–765.

Greathead H (2003). Plants and plant extracts for improving animal productivity. Proceed. Nutr. Soc., 62: 279-290.

Hart KJ, Yanez-Ruiz DR, Duval SM, McEwan NR, Newbold CJ (2008) Plant extracts to manipulate rumen fermentation. Anim. Feed Sci. Technol., 147: 8–35.

Horton GMJ, Blethen DB, Prasad BM (1991a). The effect of garlic (*Allium sativum*) on feed palatability of horses and feed consumption, selected performance, and blood parameters in sheep and swine. Can. J. Anim. Sci., 71: 607–610.

Horton GMJ, Fennell MJ, Prasad BM (1991b). Effects of dietary garlic (*Allium sativum*) on performance, carcass composition and blood chemistry changes in broiler chickens. Can. J. Anim. Sci., 71: 939–942.

Jamroz D, Wertelecki T, Houszka M, Kamel C (2006). Influence of diet type on the inclusion of plant origin active substances on morphological and histochemical characteristics of the stomach and jejunum walls in chicken. J. Anim. Physiol. Anim. Nutr., 90: 255–268

Kandylis K, Nikokyris PN, Deligiannis K (1999). Proformance of growing-fattenning lambs fed diets containing different proportions of cotton seed meal. J. Sci. Food Agric., 79:1613-1619.

Lee KW, Everts H, Kappert HJ, Yeom KH, Beynen AC (2003a). Dietary carvacrol lowers body weight gain but improves feed conversion in female broiler chickens. J. Appl. Poult. Res., 12: 394-399.

Lee KW, Everts H, Kappert HJ, Frehner M, Losa R, Beynen AC (2003b). Effects of dietary essential oil components on growth performance, digestive enzymes and lipid metabolism in female broiler chickens. British Poult. Sci., 44: 450-457.

Lewis MR, Rose SP, Mackenzie AM, Tucker LA (2003). Effects of dietary inclusion of plant extracts on the growth performance of male broiler chickens. British Poult. Sci., 44(Suppl. 1): S43–S44.

Losa R (2001). The use of essential oils in animal nutrition. In: Feed Manufacturing in the Mediterranean Region. Improving Safety: From Feed to Food. Proceedings of the III Conference of Feed Manufacturers of the Mediterranean, Reus, Spain, March 2000, Cahiers Options Méditerranéennes 54: 39–44.

McIntosh FM, Williams P, Losa R, Wallace RJ, Beever DA, Newbold CJ (2003). Effects of Essential Oils on Ruminal Microorganisms and Their Protein Metabolism. Appl. Environ. Microbiol., 69(8): 5011–5014.

Meyer NF, Erickson GE, Klopfenstein TJ, Greenquist MA, Luebbe MK, Williams P, Engstrom MA (2009). Effect of essential oils, tylosin, and monensin on finishing steer performance, carcass characteristics, liver abscesses, ruminal fermentation, and digestibility. J. Anim. Sci., 87: 2346–2354.

Moñino I, Martìnez C, Sotomayor JA, Lafuente A, Jordán MJ (2008). Polyphenolic Transmission to Seguren˜o Lamb Meat from Ewes' Diet Supplemented with the Distillate from Rosemary (*Rosmarinus officinalis*) Leaves. J. Agric. Food Chem., 2008, 56: 3363–3367.

Muhl A, Liebert F (2007). Growth and parameters of microflora in intestinal and faecal samples of piglets due to application of a phytogenic feed additive. J. Anim. Physiol. Anim. Nutr., 91(2007): 411-418.

Nieto G, Díaz P, Bañón S, Garrido MD (2010). Dietary administration of ewe diets with a distillate from rosemary leaves (Rosmarinus officinalis L.): Influence on lamb meat quality. Meat Sci., 84: 23–29.

Olfaz M, Ocak N, Erener G, Cam MA, Garipoglu AV (2005). Growth, carcass and meat characteristics of Karakaya growing rams fed sugar beet pulp, partially substituting for grass hay as forage. Meat Sci., 70: 7-14.

Patel K, Srinivasan K (1996). Influence of dietary spices or their active principles on digestive enzymes of small intestinal mucosa in rats. Int. J. Food Sci. Nutr., 47: 55-63.

Patra AK, Saxena J (2009). Dietary phytochemicals as rumen modifiers: a review of the effects on microbial populations. Antonie van Leeuwenhoek, 96: 363–375.

Pérez P, Maino M, Morales MS, Köbrich C, Bardon C, Pokniak J (2007). Gender and slaughter weight effects on carcass quality traits of suckling lambs from four different genotypes. Small Ruminant Res., 70: 124-130.

Skandamis PN, Nychas GJE (2001). Effect of oregano essential oil on microbiological and physico-chemical attributes of minced meat stored in air and modifed atmospheres. J. Appl. Microbiol., 91: 1011-1022.

SPSS (1999). SPSSfor windows; advanced statistics release 10. Chigago, USA.

Svoboda KP, Hampson JB (2007). Bioactivity of essential oils of selected temperate aromatic plants: antibacterial, antioxidant, antiinflammatory and other related pharmacological activities. http://www.ienica.net/specchemseminar/svoboda.pdf

Tsigarida E, Skandamis P, Nychas GJE (2000). Behaviour of Listeria monocytogenes and autochthonous flora on meat stored under aerobic, vacuum and modified atmosphere packaging conditions with or without the presence of oregano essential oil at 5°C. J. Appl. Microbiol., 89: 901-909.

Wallace RJ (2004). Antimicrobial properties of plant secondary metabolites. Proceed. Nutr. Soc., 63: 621–629.

Westendarp H (2005). Essential oils for the nutrition of poultry, swine and ruminants. Dtsch Tierarztl Wochenschr, 112(10): 375-380.

Yoshino H, Imai N, Naabae K, Doi Y, Tamano S, Ogawa K, Shirai T (2005). Thirteen-week oral toxicity study of dokudami extract

(Houttuynia Cordata Thunb.) in F344/DuCrj rats. J. Toxicol. Pathol., 18: 175-182.
Zhang KY, Yan F, Keen CA, Waldroup PW (2005). Evaluation of Microencapsulated Essential Oils and Organic Acids in Diets for Broiler Chickens. Int .J. Poult. Sci., 4 (9): 612-619.