Effect of an herbal essential oil mixture on growth, laying traits, and egg hatching characteristics of broiler breeders

M. Bozkurt,* A. Alçiçek,† M. Çabuk,‡[1] K. Küçükyilmaz,* and A. U. Çatli*

*Poultry Research Institute, 09600 Erbeyli, Aydın, Turkey; †Department of Animal Science, Agricultural Faculty of Ege University, 35040 Bornova, Izmir-Turkey; and ‡Department of Poultry Science, Akhisar Vocational School of Celal Bayar University, 45210 Akhisar, Manisa, Turkey

ABSTRACT The effects of supplementing a basal diet with 2 levels of an essential oil mixture and an antibiotic on the growth, laying traits, and egg hatching characteristics of broiler breeders were examined in this study. Nine hundred sixty female and 128 male breeders at an age of 1 d old were randomly allocated to 16 replicates (i.e., 4 replicates of 4 dietary treatments) in a floor pen trial. Two levels of an essential oil mixture (EOM; i.e., 24 and 48 mg of EOM/kg of diet) and an antibiotic (i.e., l0 mg of avilamycin/kg of diet) were added to the basal starter, grower, and laying diets from 0 to 45 wk of age. Daily feed allocations were adjusted to produce a target BW and egg production rate of the breeders throughout the experimental period. The BW of the males and females were determined at 12, 21, and 45 wk of age. Livability during the growing and laying period was not affected by the dietary treatments. The fertility and hatchability of total eggs set were positively affected by the supplementation of the EOM in the diet ($P < 0.01$). The hen-day egg production, hatching egg weight, settable egg ratio, hatching of fertile eggs, extra large egg rate, and proportion of chick weight to egg weight were not affected significantly. The higher level of EOM (48 mg/kg) added to the diet led to the hatching of the heaviest chickens; the lower level of EOM (24 mg/kg) and antibiotic treatments led to the hatching of the intermediate weight chickens, followed by the control treatment ($P < 0.01$). Hens given the lower level of EOM in their diets produced a higher number of settable eggs and chicks as compared with those of other treatments, whereas hens fed the control diet yielded the lowest total settable eggs and chicks throughout the experimental laying period ($P < 0.05$). The results of this study showed that supplementing diets with EOM improved fertility, the hatchability of total eggs set, total settable eggs, total chicks, and the chick weight of broiler breeders.

Key words: essential oil, broiler breeder, laying trait, egg hatching characteristic

2009 Poultry Science 88:2368–2374
doi:10.3382/ps.2009-00048

INTRODUCTION

Feed additives as performance enhancers for broiler breeders have primarily been applied to increase utilization of the limited feed allowance and, in turn, improve egg production performance, fertility, and hatchability. Because of the increased multiple resistance of bacteria and decreasing acceptance of the consumers for antibiotic feed additive (Barton, 2000; Bach Knudsen, 2001; Schwarz et al., 2001), the use of antibiotics as feed additives has been gradually restricted (Kocher, 2005; Cervantes, 2006; Plail, 2006) and prohibited in the European Union since 2006. Therefore, considerable efforts have been made to search for alternatives to antimicrobial feed additives over the past decade. One alternative to antimicrobial feed additives is essential oils derived from herbs and spices. Today, this practice is receiving much attention particularly in broiler chickens (Alçiçek et al., 2003, 2004; García et al., 2007) and laying hens (Çabuk et al., 2006). Herbal essential oils assist in colonization of the beneficial microbial population within the gastrointestinal tract to more balanced levels (Zaika, 1988; Jang et al., 2007). Besides their antimicrobial properties (Ultee et al., 2002), they also exhibit antioxidant (Basmacioğlu et al., 2004), antifungal (Bang et al., 2000; Shin and Lim, 2004), digestion-stimulating, and enzymatic (Jamroz et al., 2003, 2005; Hernandez et al., 2004) activities. The benefits of essential oils from herbs and species in poultry diets have been recently demonstrated, not only in terms of improving performance traits but also in inhibiting pathogenic bacteria and reducing residue hazard of meat and egg

Received January 28, 2009.
Accepted June 13, 2009.
[1]Corresponding author: metin.cabuk@deu.edu.tr

products (Bassett, 2000; Gill, 2001; Hertrampf, 2001). These nutrient-sparing and health-promoting effects are most likely attributable to the effects of essential oils within the gastrointestinal track on improving the balance of gut microflora and improving nutrient digestion and absorption (Mitsch et al., 2004; Jamroz et al., 2005). However, experimental studies indicated that essential oils, either individually or in specific blends, were able to produce benefits comparable to traditional growth promoters including antibiotic, organic acid, prebiotic, and probiotic in maintaining general health status and performance of broilers (Alçiçek et al., 2003; Bozkurt et al., 2005; Zhang et al., 2005) and laying hens (Çabuk et al., 2006). In comparison with the vast number of research papers published on the essential oil mixture (**EOM**) and plant extract supplementation to broiler diets in the past decade (Alçiçek et al., 2004; Basmacioğlu et al., 2004; Hernandez et al., 2004; Jamroz et al., 2005), there is relatively little published data on laying hens (Botsoglou et al., 2005; Ma et al., 2005; Çabuk et al., 2006) and broiler breeders (Ather, 2000), which demonstrated antioxidant, immunostimulator, and performance enhancer aspects. The results of initial studies have demonstrated that the antimicrobial, antioxidant, digestion-stimulating, and performance enhancer effects of herbal essential oils in broilers and layers necessitates research on relevant mechanisms in broiler breeders.

Therefore, the primary objective of this study was to examine the effects of an EOM supplementation to broiler breeder diets on BW, livability, egg production performance, settable egg rate, egg weight, chick weight, fertility, hatchability, and number of total eggs and chicks per hen in both grower and egg production period.

MATERIALS AND METHODS

Pullet and Breeder Management

One-day-old male and female Ross 308 broiler breeder chicks (i.e., 128 male and 960 female) were obtained from a grandparent operation. Birds were weighed individually and then randomly distributed to an experimental unit. From hatching to 22 wk of age, all birds were housed in a 32-pen growing house; however, the males and females were penned separately during the growing period. Sixteen floor pens, each occupying a space of 13.8 m^2, were used to rear all of the females (i.e., 60 females per floor pen), and 16 floor pens, each 2.4 m^2 in size, were used to rear all of the males (i.e., 8 males per floor pen). Each pen that was used for females was equipped with 2 circular hanging drinkers and 6 circular hanging feeders; 1 drinker and 1 feeder were provided for each male pen. The diameter and depth of the feeder pans were 21 and 8 cm, respectively, with 132 cm of available feeder space per pan. Bell drinkers with a 17-cm diameter and a 4-cm lip depth supplied continuously available fresh water. Pine shavings were used as the litter material. All of the female and male birds were weighed individually at 12 and 21 wk of age. According to the average BW value for each pen, the heaviest and lightest birds were excluded from the female and male pens at the end of 21 wk of age. Accordingly, 50 female and 5 male birds remained in their pens, respectively. The birds were moved to a 16-pen, open-sided naturally ventilated breeder house at 22 wk of age; the same groups were kept with their pen mates throughout the treatments. Males were distributed to female pens according to the traditional ratio (i.e., 1 male per 10 females). Briefly, 50 hens and 5 males were assigned to each of the 16 breeder pens (i.e., continuing with the 4 replicates of the 4 treatments). In this phase, each breeder pen was equipped with a single circular hanging drinker, 6 circular hanging feeders, and one 12-hole nest box. Pine shavings were spread throughout the floor pens, each of which had the following dimensions: 3.4 × 4.8 m. To avoid probable feeding mistakes by the farmhands and head injuries to the males during the feed allocation to the pens in the early morning (i.e., at 0600 h), feeding each sex separately was not attempted. Therefore, female and male breeders used the same feeders and were fed the same diet. The birds were exposed to the natural day length and daylight from 1 wk of age through 20 wk of age. Upon movement to the breeder house at 21 wk of age, the day length was artificially increased to 16 h at the start of laying using a combination of natural and incandescent light.

Pullet and Breeder Diets

The birds were fed a chick starter diet for the first 6 wk of life and a grower diet from 7 to 20 wk of age, followed by a breeder diet until 46 wk of age (Table 1). Four experimental starter, grower, and breeder diets were formulated to meet or exceed NRC (1994) specifications.

An EOM (Heryumix, Herba Ltd. Co., Izmir, Turkey), including carvacrol, thymol, 1:8-cineole, *p*-cymene, and limonene as active components, was composed of 6 totally different essential oils [i.e., oregano oil (*Origanum* sp.), laurel leaf oil (*Laurus nobilis*), sage leaf oil (*Salvia triloba*), myrtle leaf oil (*Myrtus communis*), fennel seed oil (*Foeniculum vulgare*), and citrus peel oil (*Citrus* sp.)]. Essential oil premixes (i.e., EOM1 and EOM2) used 976 and 952 g of zeolite, respectively, as a carrier for 24 and 48 g, respectively, of essential oil. An antibiotic (**ANT**) preparation containing 10,000 mg of avilamycin/kg of premix was also investigated as a supplement. The ANT, EOM1, and EOM2 premixes were added as supplements to the basal diet (i.e., 1 kg of supplement/1,000 kg of feed was added in place of the sawdust conventionally found in the feed mix). A commercial ANT for subtherapeutic use (i.e., avilamycin), which was a permitted ANT before the latest ban in the European Union, was used in this study to

Table 1. Ingredients and nutrient composition of the experimental basal diets (as fed)

Item	Chick diet	Grower diet	Layer diet
Ingredients, %			
Corn	43.36	54.37	61.53
Wheat	20.00	15.00	—
Soybean meal (48% CP)	24.30	14.94	18.94
Sunflower meal (31% CP)	8.00	12.00	8.58
Fish oil	—	—	1.30
NaCl	0.25	0.25	0.25
Ground limestone	1.44	1.83	7.06
Dicalcium phosphate	2.00	1.00	1.79
Vitamin premix[1]	0.25	0.25	0.25
Mineral premix[2]	0.10	0.10	0.10
DL-Methionine	0.10	0.06	0.10
Lysine HCl	0.10	0.10	—
Sawdust	0.10	0.10	0.10
Total	100	100	100
Nutrition composition, % analyzed			
DM	88.94	89.26	88.98
CP	19.63	15.84	16.23
Ether extract	3.28	3.53	4.16
Crude fiber	4.15	5.22	3.65
Crude ash	4.94	5.74	10.55
Starch	38.72	40.75	40.18
Sucrose	2.97	3.32	3.23
Calcium	1.09	1.13	3.38
Total phosphorus	0.70	0.63	0.69
Lysine[3]	0.85	0.86	0.85
Methionine + cystine[3]	0.68	0.60	0.68
ME, Mcal/kg	2.82	2.79	2.83

[1]Vitamin premix (per kg of diet): vitamin A, 16,000 IU; vitamin D_3, 3,000 IU; vitamin E, 26.67 mg; vitamin K_3, 2.5 mg; vitamin B_1, 2.5 mg; vitamin B_2, 10 mg; nicotinic acid, 50 mg; calcium D-pantothenate, 15 mg; vitamin B_6, 6.25 mg; vitamin B_{12}, 0.035 mg; folic acid, 15 mg; D-biotin, 0.045 mg; choline chloride, 150 mg.

[2]Mineral premix (mg/kg of diet): Mn, 80; Fe, 80; Zn, 60; Cu, 8; Co, 0.2; I, 0.5; Se, 0.15.

[3]Calculated.

compare the effects of a feed-grade ANT to that of an EOM. The 4 dietary treatments used in this study were as follows: 1) basal diet (control), 2) ANT (i.e., 10 g of avilamycin/kg of diet), 3) EOM1 (i.e., 24 mg of EOM/kg of diet), and 4) EOM2 (i.e., 48 mg of EOM/kg of diet). All diets were isocaloric and isonitrogenous. The standard techniques for proximate analysis were used to determine the nutrient concentrations in the diets (Naumann and Bassler, 1993). The experimental diets were also analyzed for starch, sucrose, total calcium, and phosphorus (Table 1) using the method of the Association of German Agricultural Analysis and Research Institute (Naumann and Bassler, 1993). Daily feed allowances were adjusted weekly to maintain a targeted weekly BW gain as recommended by the breeder (Ross Breeders Ltd., Newbridge, Midlothian, UK). Each feed treatment was adjusted to provide a similar nutrient intake. After the hens began laying eggs, the feed rations were adjusted according to the hen-day egg production. Weekly increases were made consistently in the feed allotments such that the feed allotments were adjusted from 120 g/bird per day at the commencement of laying (i.e., 26 wk of age) to 164 g/bird per day at the time of peak egg production (i.e., 34 wk of age). During the post-peak-production period (i.e., from 34 to 45 wk of age), the male and female breeders were fed 164 g/bird per day.

Experimental Responses Measured

All of the male and female birds were weighed individually upon hatching and at 12, 21, and 45 wk of age. Livability was recorded as a percentage of live birds daily, and the feed allowance was adjusted accordingly. Egg production performance was expressed as a percentage of hen-day egg production and recorded daily for each replicate pen when the hens were between 26 and 45 wk of age. One hundred twelve randomly sampled settable eggs for each treatment (i.e, 14 eggs/replicate per day) were collected on 2 consecutive days each week and weighed individually. Eggs that were not dirty, cracked, broken, excessively small or large, or double-yolked were accepted as settable eggs. Hence, a total of 8,960 eggs were weighed to determine the average egg weight. The laying and hatching traits of the experimental birds were summarized on a weekly basis between 26 and 45 wk of age for the entire 20-wk laying period. The settable egg rate and the extra large egg rate, which includes double-yolked eggs, were expressed as percentages of the total number of eggs laid per day and recorded daily. Eggs from each pen were collected 4 times a day (i.e., at 0900, 1100, 1300, and 1500 h). A sample of 54 settable eggs per replicate pen (i.e., 216 settable eggs per treatment) was collected weekly and used to determine the fertility and hatchability of the eggs. Settable eggs that were collected for 3 consecutive days (i.e., 18 eggs/d) per week per replicate were set for each week of the 20-wk period between 26 and 45 wk of age. A total of 17,280 settable eggs (4,320 eggs per treatment) were incubated. The eggs were stored for 3 d at the end of the collection before setting. The eggs were stored at 16°C and 70% humidity in an isolated room. The eggs were incubated in a Petersime Model S 20 multi-stage incubator (Petersime NV, Zulte, Belgium), and the setting trays were arranged individually for each replicate group. The eggs were randomly distributed by pen replicate throughout the same incubator to avoid a tray stratification effect. The eggs were incubated at 37.6°C dry bulb and 28.6°C wet bulb temperatures. The eggs were candled on the tenth day of incubation to identify infertile eggs. All infertile eggs were opened and examined macroscopically for evidence of embryonic mortality. Embryonic mortalities were not included in the determination of infertility. Therefore, the number of fertile eggs was clearly established, and fertility was calculated as a percentage of fertile eggs set. On d 19, the fertile eggs were immediately transferred to the hatchery compartment of the same incubator for hatching. The hatching incubators were set at 37.5°C dry bulb and 29.2°C wet bulb temperatures. The eggs were compartmentalized within separate hatching trays, and the numbers of hatched chicks were recorded for each treatment replication on d 21.5 of incubation.

Hatchability was expressed in the following 2 forms: as a percentage of total fertile eggs set and total eggs set. Twelve newly hatched chicks from each hatching tray of each replicate group (i.e., 48 chicks per treatment) were randomly selected and individually weighed to determine chick weight on a weekly basis. Additionally, the weight of the chicks was expressed as a percentage of the settable egg weight to identify the conversion capability of 1 unit of egg weight to body mass of chick during the incubation period. This calculation is based on the total bulk weight of all eggs set and all chicks hatched per replicate pen on a weekly basis throughout the experimental period.

The number of total settable eggs per hen was calculated using the hen house egg production records (i.e., the cumulative settable egg number) on a replicate pen basis. Total chickens was determined by multiplying the total settable eggs value for each pen by the hatchability of total eggs set data on a replicate pen basis.

Statistical Methods

The data for BW, egg production, and egg weight were analyzed using the GLM procedure with SPSS 15.0 (SPSS, 2006). Significant differences between treatment means were separated using Duncan's multiple range test with a 5% probability. The data for fertility, hatchability of fertile eggs, hatchability of total eggs set, settable egg rate, chick weight:egg weight, livability, and extra large egg were not normally distributed; thus, a Kruskal-Wallis test was applied.

RESULTS

The average BW and livability of male and female broiler breeders from 21 to 45 wk are presented in Table 2. No significant BW differences were observed among the treatments in either the growing period (i.e., at 12 and 21 wk of age) or the egg production period (i.e., at 45 wk of age). The livability of male and female broiler breeders was not affected by the dietary treatments throughout the growing period and the laying period (i.e., 0 to 21 wk of age and 22 to 45 wk of age, respectively). Essential oil mixture supplementation in broiler breeder diets resulted in no detrimental effects on general health status, such as growth performance associated with high inclusion rates. The dietary effects of EOM and ANT additives on the egg production performance of broiler breeders are shown in Table 3. No significant differences were observed in the hen-day egg

Table 2. Body weight and livability of female and male breeders from 0 to 45 wk of age[1,2]

Item	Sex	Control	EOM1	EOM2	ANT	SEM	Probability of treatment effect
BW, g							
1 d old	Female	39.34	39.04	38.98	38.87	0.34	0.62
	Male	39.83	39.56	39.53	39.91	0.32	0.74
12 wk	Female	1,308	1,317	1,348	1,319	15.50	0.28
	Male	1,908	1,884	1,922	1,912	12.48	0.41
21 wk	Female	2,352	2,349	2,309	2,309	23.06	0.37
	Male	3,186	3,179	3,194	3,214	22.51	0.50
45 wk	Female	3,839	3,796	3,855	3,782	30.62	0.27
	Male	5,168	5,229	5,193	5,214	40.63	0.49
Liveability, %							
0 to 21 wk	Female	95.41	99.25	97.50	95.50	1.95	0.47
	Male	93.75	96.87	96.87	96.87	1.92	0.76
22 to 45 wk	Female	93.50	98.00	95.50	94.00	2.08	0.38
	Male	90.00	95.00	95.00	90.00	2.25	0.34

[1]Data are means of 4 replicate pens with SEM for each treatment.

[2]EOM1 = 24 mg of essential oil mixture/kg of diet; EOM2 = 48 mg of essential oil mixture/kg of diet; ANT = 10 mg of avilamycin/kg of diet.

production, egg weight, extra large egg, and settable egg rate for any of the treatments throughout the entire experimental period.

The dietary effects of EOM and ANT additives on the hatching characteristics of broiler breeders are shown in Table 3. Fertility was affected by dietary treatment ($P < 0.01$). Specifically, EOM supplementation at both inclusion levels in the breeder diet significantly increased fertility compared with the control treatment ($P < 0.01$). The highest fertility was obtained in broiler breeders on the EOM1 diet, whereas fertility was lowest for the control treatment group. Hens that were fed ANT diets had significantly lower fertility than that of the EOM1 treatment. The hatchability of total eggs set was significantly affected by the addition of EOM and ANT to the diet (Table 3) and also followed a similar pattern as that of fertility. Thus, the highest and lowest hatchability of total eggs set values were observed in the EOM1 and control treatment groups, respectively. However, the fertility and hatchability of total eggs set values for the EOM1 and EOM2 groups were not significantly different.

In contrast, hatchability of fertile eggs was not affected by dietary treatment. However, neither ANT nor EOM supplementation to the diet resulted in undesirable effects on the hatchability of fertile eggs in this study, including weak piping effort, lower hatching ability, poor embryo viability, and delayed hatching period. All of the experimental feed additives increased the chick weight when compared with the control treatment ($P < 0.01$). Although no significant differences were observed in the egg weights for the experimental treatments, the results of this study also showed that broiler chickens being hatched from breeder hens fed with the EOM and ANT diets were heavier than those chickens obtained from hens receiving the control diet. Comparing all of the treatment groups, the weight of the chickens that hatched from hens fed EOM2 was highest, whereas those fed EOM1 and ANT were similar. The chick weight:egg weight ratio was not affected by either the EOM or ANT supplementation to the diet. The total settable eggs (per hen) and total chickens (per hen), which were calculated on a pen basis, were affected by dietary treatment ($P < 0.05$). The highest values for total settable eggs and total chickens per hen were observed in the EOM1 group, whereas the lowest total settable eggs and the lowest total chickens were observed in the control treatment group. Hens given the EOM2, ANT, and control diets yielded less total settable eggs and total chicks than hens fed the EOM1 diet ($P < 0.05$).

DISCUSSION

In the present study, the 2 levels of EOM supplementation and ANT supplementation in the diets of broiler breeders did not affect the BW and livability of the broiler breeders in either the growing or egg production periods (i.e., 12 and 21 wk of age and 45 wk of age, respectively). Recent scientific articles regarding dietary supplementation with etheric oils and the extracts of some plants indicated encouraging initial results [i.e., exhibited growth promotion, nutrient digestibility enhancement, and feed efficacy mechanisms in broiler chickens without affecting bird mortality; Alçiçek et al., 2003, 2004; Hernandez et al., 2004; Jamroz et al., 2005; Çabuk et al., 2006; García et al., 2007]. However, published data were not found in the scientific literature regarding the effect of dietary supplementation with essential oil on the growth rate of broiler breeders that were fed restricted diets throughout the growing and laying periods. No significant differences were observed in the hen-day egg production, settable egg weight, extra large egg rate, and settable egg rate among treatments.

In contrast, regarding the egg production performance, breeder hens given the EOM1 diet laid more settable eggs compared with the other treatments. Our findings related to egg production traits did not confirm earlier work that indicated beneficial effects from essential oils in the diets of laying hens.

Table 3. Egg production performance and hatching traits of broiler breeder hens[1,2]

Variable	Control	EOM1	EOM2	ANT	SEM	Probability of treatment effect
Egg production (%), hen-day	66.13	67.69	66.76	66.86	0.58	0.30
Egg weight, g (n = 8,960)	59.40	59.26	59.69	59.63	0.19	0.36
Extra large egg, %	2.32	1.52	1.57	1.76	0.36	0.46
Settable egg rate, %	89.56	90.40	89.77	90.50	0.94	0.87
Fertility, %	93.20^{c}	94.68^{a}	94.56^{ab}	93.81^{bc}	0.27	0.01
Hatchability of fertile eggs, %	93.51	94.20	93.85	93.64	0.36	0.38
Hatchability of total eggs set, %	87.18^{c}	89.21^{a}	88.76^{ab}	87.87^{bc}	0.43	0.01
Chick weight, g (n = 3,840)	38.43^{c}	38.97^{b}	39.47^{a}	38.93^{b}	0.14	0.01
Chick weight:egg weight, %	64.71	65.77	66.14	65.30	2.62	0.39
Total settable eggs (per hen)	80.38^{b}	85.00^{a}	82.45^{b}	82.32^{b}	1.67	0.04
Total chicks (per hen)	70.07^{c}	75.83^{a}	73.18^{ab}	72.33^{bc}	1.54	0.04

[a–c]Means within rows with different superscripts differ at $P < 0.05$.

[1]Data are means of 4 replicate pens with SEM for each treatment.

[2]EOM1 = 24 mg of essential oil mixture/kg of diet; EOM2 = 48 mg of essential oil mixture/kg of diet; ANT = 10 mg of avilamycin/kg of diet.

In a recent study by Çabuk et al. (2006), the hen-day egg production of brown layers between 54 to 74 wk of age that were given diets supplemented individually with an EOM, ANT, and mannan oligosaccharide were 79.64, 77.05, and 78.92%, respectively; hence, the egg production rate for EOM and mannan oligosaccharide treatments was significantly higher than that of the ANT group ($P < 0.01$). In another study (Botsoglou et al., 2005), the dietary effects of aromatic plant extracts on the laying performance of hens from 32 to 40 wk of age were investigated. The results of this study showed no significant differences in egg production and egg weight among the treatment groups. Unfortunately, very limited scientific data were found in the literature relating to the effects of dietary essential oils on the performance of broiler breeders. In a study by Ather (2000), 48-wk-old broiler breeders were given diets supplemented with a polyherbal additive that consisted of 6 herbs. The author reported that hen-day egg production, settable egg rate, and fertility significantly improved for hens receiving the herbal additive supplementation in their diet during the 8-wk trial period. Due to the lack of information with respect to broiler breeders, the results of this study were compared with research that examined effects of dietary supplementation with some botanical additives on the laying performance of layers. A comparison of the dietary effects of the 2 levels of EOM (i.e., 24 and 48 mg/kg) indicated that the increasing supplementation dose of EOM did not result in any significant benefits on the performance traits of broiler breeders except chick weight. No significant effects from the dietary EOM and ANT supplementation was observed on the extra large egg rate throughout the experimental period. However, the extra large egg rate tended to decrease for the ANT and EOM supplementation in the diet. Additionally, the beneficial effects of the herbal additives on the egg production rate of laying hens during heat stress was observed in a recent study by Ma et al. (2005). The dietary essential oils resulted in the most important effects on the following breeder performance traits in the present study: fertility, hatchability of total eggs set, and chick weight. In this study, chick weight was significantly increased with the supplementation of EOM and ANT to the diet when compared with the control treatment. Consistent with the results of better total settable egg production and hatchability of total eggs set, hens that were given EOM1 diets produced more chicks as compared with all other treatments. Because total settable eggs and chick production are of high value in broiler breeder production, EOM1 supplementation to the diet seemingly presents a profitable production method. These benefits of dietary essential oil supplementation could be attributed to various modes of action from the essential oils that have been shown in earlier broiler and layer case studies, such as antimicrobial, enzymatic, antioxidative, and immunostimulator effects (Ultee et al., 2002; Jamroz et al., 2003, 2005; Basmacioğlu et al., 2004; Botsoglou et al., 2005).

In conclusion, the results of this study showed encouraging improvement in fertility, hatch of total eggs set, and chick weight in broiler breeders when their diets were supplemented with an EOM. Further research is needed to clarify the immunomodulator effects of essential oils to obtain healthier progenies of broiler breeders in addition to the observed improved reproductive performance.

REFERENCES

Alçiçek, A., M. Bozkurt, and M. Çabuk. 2003. The effects of an essential oil combination derived from selected herbs growing wild in Turkey on broiler performance. S. Afr. J. Anim. Sci. 33:89–94.

Alçiçek, A., M. Bozkurt, and M. Çabuk. 2004. The effects of a mixture of herbal essential oil, an organic acid or a probiotic on broiler performance. S. Afr. J. Anim. Sci. 34:217–222.

Ather, M. A. M. 2000. Polyherbal additive proves effective against vertical transmission of IBD. World Poult. 16:50–52.

Bach Knudsen, K. E. 2001. Development of antibiotic resistance and options to replace antimicrobials in animal diets. Proc. Nutr. Soc. 60:291–299.

Bang, K. H., D. W. Lee, H. M. Park, and Y. H. Rhee. 2000. Inhibition of fungal cell wall synthesizing enzymes by *trans*-cinnamaldehyde. Biosci. Biotechnol. Biochem. 64:1061–1063.

Barton, M. 2000. Antibiotic use in animal feed and its impact on human health. Nutr. Res. Rev. 13:279–299.

Basmacioğlu, H., Ö. Tokuşoğlu, and M. Ergül. 2004. The effect of oregano and rosemary essential oils or α-tocopheryl acetate on performance and lipid oxidation of meat enriched with n-3 PUFA's in broilers. S. Afr. J. Anim. Sci. 34:197–210.

Bassett, R. 2000. Oregano's positive impact on poultry production. World Poult. 16:31–34.

Botsoglou, N. A., P. Florou-Paneri, E. Botsoglou, V. Datos, I. Giannenas, A. Koidis, and P. Mitrakos. 2005. The effect of feeding rosemary, oregano, saffron and α-tocopheryl acetate on hen performance and oxidative stability of eggs. S. Afr. J. Anim. Sci. 35:143–151.

Bozkurt, M., K. Küçükyilmaz, A. U. Çatli, and M. Çinar. 2005. Growth performance and carcass yield of broiler chickens given antibiotic, mannan oligosaccharide and dextran oligosaccharide supplemented diets. Pages 68–69 in Nutritional Biotechnology in the Feed and Food Industries. Proceedings of the 21st Annual Symposium, Lexington, KY. (Suppl. 1). Alltech Inc., Nicholasville, KY.

Çabuk, M., M. Bozkurt, A. Alçiçek, A. U. Çatli, and K. H. C. Başer. 2006. The effect of a mixture of herbal essential oils, a mannan oligosaccharide or an antibiotic on performance of laying hens under hot climatic conditions. S. Afr. J. Anim. Sci. 36:135–141.

Cervantes, H. 2006. Banning antibiotic growth promoters: Learning from the European experience. Poult. Int. 45:14–15.

Ma, D, A. Shan, Z. Chen, J. Du, K. Song, J. Li, and Q. Xu. 2005. Effect of *Ligustrum lucidum* and *Schisandra chinensis* on the egg production, antioxidant status and immunity of laying hens during heat stress. Arch. Anim. Nutr. 59:439–447.

García, V., P. Catalá-Gregori, F. Hernández, M. D. Megías, and J. Madrid. 2007. Effect of formic acid and plant extracts on growth, nutrient digestibility, intestine mucosa morphology, and meat yield of broilers. J. Appl. Poult. Res. 16:555–562.

Gill, C. 2001. Safe and sustainable feed ingredients. Feed Int. 22:40–45.

Hernandez, F., J. Madrid, V. Garcia, J. Orengo, and M. D. Megias. 2004. Influence of two plant extracts on broiler performance, digestibility, and digestive organ size. Poult. Sci. 83:169–174.

Hertrampf, J. W. 2001. Alternative antibacterial performance promoters. Poult. Int. 40:50–52.

Jamroz, D., J. Orda, C. Kamel, A. Wiliczkiewicz, T. Wertelecki, and J. Skorupinska. 2003. The influence of phytogenetic extracts on performance, nutrient digestibility, carcass characteristics, and gut microbial status in broiler chickens. J. Anim. Feed Sci. 12:583–596.

Jamroz, D., A. Wiliczkiewicz, T. Wertelecki, J. Orda, and J. Sukorupinska. 2005. Use of active substances of plant origin in chicken diets based on maize and locally grown cereals. Br. Poult. Sci. 46:485–493.

Jang, I. S., Y. H. Ko, S. Y. Kang, and C. Y. Lee. 2007. Effect of a commercial essential oil on growth performance, digestive enzyme activity and intestinal microflora population in broiler chickens. Anim. Feed Sci. Technol. 134:304–315.

Kocher, A. 2005. AGP alternatives–Part IV. Poultry production without AGPs–Challenges and solutions. World Poult. 21:32–33.

Mitsch, P., K. Zitter-Eglseer, B. Köhler, C. Gabler, R. Rosa, and I. Zimpernik. 2004. The effect of two different blends of essential oil components on the proliferation of *Clostridium perfringens* in the intestines of broiler chickens. Poult. Sci. 83:669–675.

Naumann, C., and R. Bassler. 1993. Chemical Analyses of Feedstuff. Method Book III. 3rd ed. VDLUFA Press, Darmstadt, Germany.

NRC. 1994. Nutrient Requirements of Poultry. 9th rev. ed. Natl. Acad. Press, Washington, DC.

Plail, R. 2006. The innovative power of probiotics. Poult. Int. 45:34–36.

Schwarz, S., C. Kehrenberg, and T. R. Walsh. 2001. Use of antimicrobial agents in veterinary medicine and food animal production. Int. J. Antimicrob. Agents 17:431–437.

Shin, S., and S. Lim. 2004. Antifungal effects of herbal essential oils alone and in combination with ketaconazole against *Trichophyton* spp. J Appl. Microbiol. 97:1289–1296.

SPSS. 2006. SPSS for Windows, Version 15.0. SPSS Inc., Chicago, IL.

Ultee, A., E. P. W. Kets, and E. J. Smid. 2002. Mechanisms of action of carvacrol on the food borne pathogen *Bacillus cereus.* Appl. Environ. Microbiol. 65:4606–4610.

Zaika, L. L. 1988. Spices and herbs: Their antimicrobial activity and its determinatin. J. Food Saf. 9:97–118.

Zhang, K. Y., F. Yan, C. A. Keen, and P. W. Waldroup. 2005. Evaluation of microencapsulated essential oils and organic acids in diets for broiler chickens. Int. J Poult. Sci. 4:612–619.