The effect of a mixture of herbal essential oils, an organic acid or a probiotic on broiler performance

A. Alçiçek[1#], M. Bozkurt[2] and M. Çabuk[3]
[1]Department of Animal Science, Agricultural Faculty of Ege University, Bornova 35100, Izmir-Turkey
[2]Poultry Research Institute, Erbeyli 09600, Aydın-Turkey
[3]Department of Poultry Science, Akhisar Vocational School of Celal Bayar University, 45210, Manisa-Turkey

Abstract

The aim of the present study was to investigate the effect of dietary supplementation with an essential oil mixture, a commercially available organic acid and a probiotic on growth performance and carcass yield of broilers. One thousand two hundred and fifty sexed one day-old broiler chicks were randomly divided into five treatment groups of 250 birds each (negative control, organic acid, probiotic and essential oil mixture (EOM) at two levels). Each treatment group was further sub-divided into five replicates of 50 birds (25 male and 25 female) per replicate. The oil in the EOM was extracted from different herbs growing in Turkey. An organic acid at 2.5 g/kg diet, a probiotic at 1 g/kg diet and the EOM at 36 mg and 48 mg/kg diet were added to the basal diet of the birds. There were significant effects of dietary treatments on body weight gain, feed intake, carcass yield and intestinal weight of the broiler at 42 days of age. At day 42, birds fed the diet containing 36 mg EOM/kg showed the highest body weight gain. This was followed by chicks on the diet containing 48 mg EOM/kg, the probiotic, the organic acid and the negative control, in descending order. The addition of the essential oil mixture to the diet improved the feed conversion ratio significantly as compared to the negative control and the organic acid treatment. The feed intakes at days 21 and 42 were significantly different between the treatments. The addition of 48 mg EOM/kg increased carcass yield significantly above the other treatments, while the addition of EOM and the organic acid reduced the intestinal weight significantly. It was concluded that the supplementation of the herbal essential oil mixture to broiler diet had beneficial effects on body weight gain, feed conversion ratio and carcass yield.

Keywords: Essential oil mixture, herbs, organic acid, probiotic, performance, broilers
[#]Corresponding author. E-mail: alcicek@ziraat.ege.edu.tr

Introduction

Recently the use of antibiotic growth promoters (AGP) in the poultry industry has been seriously criticised by governmental policy makers and consumers because of the development of microbial resistance to these products and the potential harmful effects on human health. In the European Union (EU) this led to a ban on the use of antibiotics as antimicrobial growth promoters in animal nutrition. At present and up till 2006 only four antibiotic growth promoters are permitted for use in poultry nutrition. On the other hand, there is increasing public and government pressure in several countries of the EU and some non-EU to search for natural alternatives to antibiotics (Williams & Losa, 2001; McCartney, 2002). Since the prohibition on AGPs in the EU, aromatic plant extracts and essential oils as well as their purified constituents have gained interest in alternative feed strategies for the future. It is currently well known that enzymes, probiotics and organic acids are "generally regarded as safe" (GRAS) feed additives. The chemical constituents of most plant essential oils are also recognized as safe in general and commonly used in the food industry (Varel, 2002). The main functions of the essential oils cover pathogen control including antimicrobial activity (Cowan, 1999; Dorman & Deans, 2000; Azaz *et al.*, 2002), antioxidant activity (Botsoglou *et al.*, 2002; Botsoglou *et al.*, 2004), digestion aid including stimulation of endogenous enzyme activity and nitrogen absorption (Gill, 2001) and inhibition of odour and ammonia control (Varel, 2002). Their antimicrobial mode of action consists of interactions with cell membranes that change the permeability for cations such as H^+ and K^+ (Ultee *et al.*, 1999). Moreover, Bassett (2000) and Alçiçek *et al.* (2003) reported that the supplementation of the essential oil to the broiler diet or drinking water increased body weight and feed conversion ratio. Furthermore, it has been found that probiotics and organic acids have growth promoting properties and can be used as alternatives to antibiotics (Vanbelle *et al.*, 1990; Patten & Waldroup, 1988).

Yeo & Kim (1997) and Zilkifli *et al.* (2000) reported that dietary supplementation of probiotics improved body weight gain and feed intake significantly. The addition of organic acids to the broiler diet reduced the production of toxic components by bacteria and the colonization of pathogens in the gastro intestinal tract (Langhout, 2000; Denli *et al.*, 2003). Although there is sufficient literature on the growth promoting effects of probiotics and organic acids, the number of published studies on the effects of essential oils on broiler performance and carcass characteristics is still very limited.

The aim of the present study was to investigate the effect of dietary supplementation with essential oil mixture, commercially available organic acid and probiotic compounds on the growth performance and carcass yield of broilers.

Materials and Methods

Table 1 Ingredients and chemical composition of the experimental starter and finisher diets (as fed)

	Treatment									
	1 to 21 days					22 to 42 days				
Ingredients (kg/1000 kg)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Maize	546.5	544.4	543.5	544.6	544.9	621.9	621.3	621.5	621.3	621.3
Soyabean meal (0.48 CP)	284.7	287.2	288.4	287.2	287.2	253.7	250.1	249.2	251.6	250.6
Sunflower meal	56.9	53.7	52.4	55.1	54.7	0	0	0	0	0
Meat and bone meal	0.0	0.0	0.0	0.0	0.0	30.0	30.0	29.1	30.0	30.5
Fish meal	42.7	43.1	44.0	43.1	43.1	37.9	40.0	41.9	40.1	40.6
Vegetable oil	36.8	36.8	38.6	36.8	36.8	40.0	40.1	41.4	40.0	40.0
Salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Ground limestone	15.7	15.7	15.5	15.6	15.7	5.7	5.6	5.7	5.6	5.6
Dicalcium phosphate	8.7	8.6	8.6	8.6	8.6	2.8	2.4	2.2	2.4	2.4
Vitamin premix*	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Mineral premix**	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DL-methionine	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
L-lysine	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Organic acid premix	-	2.5	-	-	-	-	2.5	-	-	-
Probiotic premix			1.0					1.0		
EOM (36 g/kg) premix	-	-	-	1.0	-	-	-	-	1.0	-
EOM (48 g/kg) premix	-	-	-	-	1.0	-	-	-	-	1.0
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Composition, g/kg (analysed)										
Dry matter	909	915	908	917	916	903	904	904	900	906
Crude protein (CP)	216	215	217	218	215	196	194	193	195	193
Crude fat	47.3	47.5	45.4	45.1	46.8	59.1	64.5	59.6	60.8	61.3
Crude fibre	43.5	40.5	42.3	39.2	40.8	34.5	31.0	33.0	35.5	31.7
Crude ash	70.3	69.5	67.8	65.1	65.4	63.0	65.4	60.9	65.0	61.8
Starch	369	365	364	369	365	409	402	407	410	412
Sugar	53.0	58.1	58.4	57.5	55.3	41.6	44.0	43.2	41.8	42.4
Total calcium	12.2	11.2	10.9	11.6	10.2	11.2	12.0	10.6	10.9	10.3
Total phosphorus	6.3	6.6	6.8	6.7	6.7	6.1	6.5	6.5	6.6	6.6
Lysine (calculated)	12.4	12.4	12.4	12.4	12.4	11.3	11.3	11.3	11.3	11.3
Met. + Cys. (calculated)	8.3	8.3	8.3	8.3	8.3	7.4	7.4	7.4	7.4	7.4
ME (MJ/kg)	12.7	12.7	12.6	12.7	12.6	13.3	13.4	13.3	13.4	13.4

EOM-Essential oil mixture; ME- Metabolisable energy
Diet 1: Negative control: without organic acid, probiotic and EOM
Diet 2: with commercial organic acid including formic, lactic and citric acid, at 2.5 g/kg diet
Diet 3: with commercial probiotic including *Lactobacillus*, *Bifidobacterium* and *Enterococcus* at 1.0 g/kg diet
Diets 4 and 5: with 36 and 48 mg of EOM/kg diet, respectively
*Vitamin premix (/kg diet): Vitamin A - 12000 IU; vitamin D_3 - 1500 IU; vitamin E - 30 mg; vitamin K_3 - 5 mg; vitamin B_1 - 3 mg; vitamin B_2 - 6 mg; vitamin B_6 - 5 mg; vitamin B_{12} - 0.03 mg; nicotine amid - 40 mg; calcium-D-pantothenate - 10 mg; folic acid - 0.75 mg; D-biotin - 0.075 mg; choline chloride - 375 mg; antioxidant - 10 mg
**Mineral combination (mg/kg diet): Mn - 80; Fe - 80; Zn - 60; Cu - 8; I - 0.5; Co - 0.2; Se - 0.15

One thousand two hundred and fifty sexed day-old broiler chicks (Cobb 500) were divided into five treatment groups of 250 birds each and randomly assigned to the five treatment diets, consisting of a negative control and diets supplemented with an organic acid, a probiotic and an essential oil mixture (EOM) at two different levels of inclusion. Each treatment group was further sub-divided into five replicates of 50 birds (25 male and 25 female) per replicate. In the negative control treatment the birds were fed a standard commercial starter diet from days 1 to 21 and a grower diet from days 22 to 42. The organic acid, probiotic and the EOM were added to the basal diet. In the organic acid treatment a kg of feed contained 2.5 g of the commercial organic acid, based on mainly formic, lactic and citric acid. In the probiotic treatment a kg of feed contained 1.0 g of the commercial probiotic, based on *Lactobacillus*, *Bifidobacterium* and *Enterococcus*. For the EOM treatments, 36 and 48 mg of a commercial EOM (Herbromix™) were added per kg of feed. The EOM contained six different essential oils derived from selected herbs growing in Turkey, viz. oregano oil (*Origanum* sp.), laurel leaf oil (*Laurus nobilis* L.), sage leaf oil (*Salvia triloba* L.), myrtle leaf oil (*Myrtus communis*), fennel seeds oil (*Foeniculum vulgare*), citrus peel oil (*Citrus* sp.). Hydrodistillation was used to extract the herbal essential oils.

The ingredients and chemical composition of the diets are presented in Table 1. The diets were isoenergetic and isonitrogenous. The experimental diet was in mash form and water was provided *ad libitum.* The experiment lasted for 42 days. The birds were kept in 25 pens (3 x 1.7 m) in an open-sided naturally ventilated broiler house containing wood shavings as litter material. Bird density was 10 chicks per square meter. A photoperiod of 24 h/d was maintained. The body weights of the birds were measured individually and feed intakes per pen were recorded. Feed conversion ratio (FCR) was adjusted for weight of chicks at first day and FCR was calculated at the end of the 21- and the 42-day experimental periods. Mortality was recorded daily and was used to adjust the total number of birds to determine the total feed intake per bird. At days 42, 12 male and 12 female birds of similar body weight were selected from each treatment group, weighed and killed by CO_2 asphyxiation to determine the carcass yield, abdominal fat and intestinal weight.

The standard techniques of the proximate analysis were used to determine the nutrient concentrations in the experimental diets (Naumann & Bassler, 1993). The experimental diets were analysed also for starch, sugar, total calcium and phosphorus according to the VDLUFA method (Naumann & Bassler, 1993). Metabolisable energy content of the diets was calculated based on chemical composition (Anonymous, 1991). The data were analyzed using the General Linear Models procedure of SAS (1985). Significant differences between treatment means were separated using the Duncan's multiple range test with a 5% probability.

Results and Discussion

The effects of the supplementation of an essential oil mixture, organic acid and a probiotic on the feed intake and feed conversion ratio are presented in Table 2.

Table 2 The effect of the inclusion of an essential oil mixture (EOM), an organic acid and a probiotic on feed intake (g) and the feed conversion ratio (g feed/g gain) of the broilers up to the age of 42 days

Treatments	Feed intake g		Feed conversion ratio g feed/g gain	
	21 days*	42 days*	21 days	42 days*
Control	1018.0^{b}	3942.6^{b}	1.87	2.07^{a}
2.5 g Organic acid/kg	1043.8^{ab}	3993.6^{ab}	1.84	2.06^{a}
1.0 g Probiotic/kg	1064.4^{ab}	4045.8^{a}	1.89	2.01^{ab}
36 mg EOM/kg	1087.8^{a}	4078.0^{a}	1.88	1.97^{b}
48 mg EOM/kg	1089.6^{a}	4037.8^{a}	1.83	1.96^{b}
s.e.m. pooled	17.78	28.53	0.05	0.02
P	0.0472	0.0285	0.8531	0.0412

*Means within columns with different superscripts differ at $P < 0.05$

At day 21 the feed intake differed significantly between treatments. The feed intake of the birds fed on the diet containing 48 mg EOM/kg was the highest and those consuming the control diet the lowest. There were also significantly differences between the treatments in the feed intake at 42 days of age, *viz*. the feed intake of the broilers was significantly increased by the supplementation of 36 mg EOM/kg, the probiotic and 48 mg EOM/kg when compared to the negative control, but there were no significant differences in the feed intake between the organic acid and probiotic or essential oil mixture treatments. No significant differences were found for feed conversion ratios between treatments at 21 days of age. On the other hand, after 42 days, the supplementation of 36 mg or 48 mg EOM/kg improved ($P < 0.05$) the feed conversion ratio compared to those of the organic acid and negative control treatments. However, there were no significant differences between probiotic and both of essential oil mixtures (36 mg and 48 mg EOM/kg). The effects on the 21st and 42nd days of experiment of the dietary essential oil mixture, organic acid and probiotic on body weight gain, carcass yield, intestinal weight, abdominal fat and mortality of broilers are given in Table 3.

Table 3 The effect of the inclusion of an essential oil mixture (EOM), an organic acid and a probiotic on body weight gain (g), carcass yield (%), intestinal weight (g), abdominal fat (g) and mortality (%) of broilers

Treatments	Body weight g	Body weight gain g		Carcass yield, %	Intestinal weight, %	Abdominal fat, %	Mortality %
	1 day	21 days*	42 days*	42 days*	42 days*	42 days	42 days
Control	40.9	543.6^{d}	1909.0^{c}	73.9^{b}	3.30^{a}	1.78	0.8
2.5 g Organic acid/kg	40.8	566.2^{bc}	1937.5^{c}	73.9^{b}	3.09^{b}	2.05	0.8
1.0 g Probiotic/kg	40.7	562.1^{c}	2015.3^{b}	74.3^{b}	3.14^{ab}	1.97	1.2
36 mg EOM/kg	40.3	578.3^{b}	2063.7^{a}	74.3^{b}	3.01^{b}	1.94	1.2
48 mg EOM/kg	40.6	595.2^{a}	2060.7^{a}	75.2^{a}	2.99^{b}	1.97	1.2
s.e.m. pooled	0.47	4.91	15.26	0.28	0.07	0.10	1.2
P	0.890	0.0001	0.0001	0.0102	0.0147	0.4506	0.4017

*Means within columns with different superscripts differ at $P < 0.05$

As shown in Table 3, there were significant effects of dietary treatments on body weight gain of broilers at 21 and 42 days of age. Birds fed the diet supplemented with 48 mg EOM/kg had a significantly higher body weight gain at day 21 compared to those birds fed on diets containing 36 mg EOM/kg, organic acid, probiotic and the negative control. On the other hand, significant differences on the body weight gain were not found between organic acid and 36 mg EOM/kg treatments, whereas the broilers receiving the probiotic showed significantly lower body weight gains compared to those on the 36 mg EOM/kg treatment. Furthermore, organic acid and probiotic treatments had similar body weight gains at 21 days of age. From 1 to 42 days of age, body weight gain was also significantly different between the treatments; birds fed the diet containing 36 mg EOM/kg being highest. This treatment was followed by chicks fed the diet containing 48 mg EOM/kg, probiotic, organic acid and the negative control. The carcass yield and intestinal weight of broilers differed ($P < 0.05$) between treatments at day 42. The birds fed the diet containing 48 mg EOM/kg had a higher ($P < 0.05$) carcass yield compared with the 36 mg EOM/kg, probiotic, organic acid and negative control treatments. Intestinal weight of broilers was reduced ($P < 0.05$) by the addition of the essential oil mixture both at inclusion rates of 36 mg EOM/kg and 48 mg EOM/kg and by the organic acid compared with negative control. However, there were no significant differences on the intestinal weight between broilers fed the diet supplemented probiotic and negative control. Deposition of abdominal fat and mortality of the broilers were not affected by the dietary treatments.

The addition of a mixture of herbal essential oils to the diet increased ($P < 0.05$) body weight gain of the broilers at 42 days of age. The improvement in body weight gain in this study agreed with results reported by Hertrampf (2001), McCartney (2002), Tucker (2002), Alçiçek *et al.* (2003) and Demir *et al.* (2003). However, contrary to these findings, Botsoglou *et al.* (2002) and Botsoglou *et al.* (2004) found that the addition of an essential oil isolated from oregano to broiler diet had no beneficial effect on performance. A beneficial effect on body weight gain was also found when broiler chicks were fed a diet supplemented

with probiotic compared with organic acid and negative control, as reported by Cavazzoni *et al.* (1998), Jin *et al.* (1998) and Zilkifli *et al.* (2000).

The addition of the essential oil mixture to the broiler diet improved ($P < 0.05$) feed conversion ratio compared with the control and the organic acid supplemented diet at 42 days of age. The better feed conversion ratio in our study supported the results of Mandal *et al.* (2000) and Jamroz & Kamel (2002) who observed that the broilers receiving plant extracts had significantly better body weight gain than their controls. Furthermore, Langhout (2000) and Williams & Losa (2001) reported that the inclusion of a blend of essential oil to broiler diet improved not only feed efficiency, but also the digestion process. These results suggest that the improved digestibility of the nutrients leads to a more balanced gut flora with the potential to reduce the proportion of pathogenic bacteria. The benefits of the use of essential oils in broiler nutrition may be due to the greater efficiency in the utilization of feed, resulting in enhanced growth.

The supplementation of the diet with 48 mg EOM/kg increased ($P < 0.05$) the carcass yields of the broilers compared with other treatments, while significantly reduced the intestinal weight of the broiler. Our findings are in agreement with those of Jamroz & Kamel (2002) who found higher slaughter percentages of breast muscle in broilers. Contrary to our results on carcass yield, Mandal *et al.* (2000) observed that the carcass yield was not affected by the dietary essential oil treatments.

Conclusions

The results obtained from this study indicated that the supplementation of a mixture of herbal essential oils to the diet significantly improved the body weight gain, feed conversion ratio and carcass yield of broilers when compared with organic acid and probiotic treatments. The herbal essential oil mixture may be considered as a growth promoter similar to organic acids and probiotics with the potential to achieve an environmental friendly broiler production system. However, more and detailed research are required on the effect of essential oil supplementation to diet on performance of broilers.

Acknowledgements

Technical and financial assistance of Poultry Research Institute of Erbeyli, Aydın and Herba Ltd. Co., Izmir-Turkey is gratefully acknowledged.

References

Alçiçek, A., Bozkurt, M. & Çabuk, M., 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.

Anonymous, 1991. Animal feeds-determination of metabolizable energy (chemical method). Turkish Standards Institute (TSE), Publ. No. 9610, 1-3.

Azaz, D., Demirci, F., Satıl, F., Kürkçüoğlu, M. & Başer, K.H.C., 2002. Antimicrobial activity of some *Satureja* oils. Z. Naturforsch. 57c, 817-821.

Bassett, R., 2000. Oreganos positive impact on poultry production. World Poultry-Elsevier 16 (9), 31-34.

Botsoglou, N.A., Christaki, E., Florou-Paneri, P., Giannenas, I., Papageorgiou, G. & Spais, A.B., 2004. The effect of a mixture of herbal essential oils or á-tocopheryl acetate on performance parameters and oxidation of body lipid in broilers. S. Afr. J. Anim. Sci. 34, 52-61.

Botsoglou, N.A., Florou-Paner, P., Christaki, E., Fletouris, D.J. & Spais, A.B., 2002. Effect of dietary oregano essential oil on performance of chickens and on iron-induced lipid oxidation of breast, thigh and abdominal fat tissues. Br. Poult. Sci. 43, 223-230.

Cavazzoni, V., Adami, A. & Castrovilli, C., 1998. Performance of broiler chickens supplemented with *Bacillus coagulans* as probiotic. Br. Poult. Sci. 39, 526-529.

Cowan, M.M., 1999. Plant products as antimicrobial agents. Clin. Microbiol. Rev. 12, 564-582.

Demir, E., Sarica, S., Ozcan, M.A. & Suicmez, M., 2003. The use of natural feed additives as alternatives for an antibiotic growth promoter in broiler diets. Br. Poult. Sci. 44, 44-45.

Denli, M., Okan, F. & Çelik, K., 2003. Effect of dietary probiotic, organic acid and antibiotic supplementation to diets on broiler performance and carcass yield. Pakistan J. Nutr. 2 (2), 89-91.

Dorman, H.J.D. & Deans, S.G., 2000. Antimicrobial agent from plants: antimicrobial activity of plant volatile oils. J. Appl. Microbiol. 88, 308-316.

Gill, C., 2001. Safe and sustainable feed ingredients. Feed Int. 22 (3), 40-45.

Hertrampf, J.W., 2001. Alternative antibacterial performance promoters. Poult. Int. 40 (1), 50-52.

Jamroz, D. & Kamel, C., 2002. Plant extracts enhance broiler performance. In non ruminant nutrition: Antimicrobial agents and plant extracts on immunity, health and performance. J. Anim. Sci. 80 (E. Suppl. 1), pp. 41.

Jin, L.Z., Ho, Y.W., Abdullah, N. & Jalaludin, S., 1998. Growth performance, intestinal microbial populations, and serum cholesterol of broilers fed diets containing Lactobacillus cultures. Poult. Sci. 77, 1259-1265.

Langhout, P., 2000. New additives for broiler chickens. World Poultry-Elsevier 16 (3), 22-27.

Mandal L., Biswas, T. & Sarkar, S.K., 2000. Broiler perform well on herbs or enzymes in maize diet. World Poultry-Elsevier 16 (5), 19-21.

McCartney, E., 2002. The natural empire strikes back. Poult. Int. 41 (1), 36-42.

Naumann, C. & Bassler, R., 1993. *Die chemische Untersuchung von Futtermitteln. Methodenbuch, Band III. 3. Erg.,VDLUFA-Verlag, Darmstadt.*

Patten, J.D. & Waldroup, P.W., 1988. Use of organic acids in broiler diets. Poult. Sci. 67, 1178-1182.

SAS, 1985. Statistical Analysis Systems user's guide (5th ed.). SAS Institute Inc., Raleigh North Carolina, USA.

Tucker, L., 2002. Botanical broilers: Plant extracts to maintain poultry performance. Feed Int. 23, 26-29.

Ultee, A., Kets, E.P.W. & Smid, E.J., 1999. Mechanisms of action of carvacrol on the food borne pathogen *Bacillus cereus*. Appl. Environ. Microbiol. 65, 4606-4610.

Vanbelle, M., Teller, E. & Focan, M., 1990. Probiotics in animal nutrition: A review. Arch. Tierernahr. 40, 543-567.

Varel, V. H., 2002. Livestock manure odor abatement with plant-derived oils and nitrogen conservation with urease inhibitors: A review. J. Anim. Sci. 80 (2), E1-E7.

Williams, P. & Losa, R., 2001. The use of essential oils and their compounds in poultry nutrition. World Poultry-Elsevier 17 (4), 14-15.

Yeo, J. & Kim, K.I., 1997. Effect of feeding diets containing an antibiotic, probiotic or yucca extract on growth and intestinal urease activity in broiler chicks. Poult. Sci. 76, 381-385.

Zilkifli, I., Abdullah, N., Azrin, N.M. & Ho, Y.W., 2000. Growth performance and immune response of two commercial broiler strains fed diets containing *Lactobacillus* cultures and oxytetracycline under heat stress condition. Br. Poult. Sci. 41, 593-597.