The Effect of Dietary Black Cumin Seeds (*Nigella Sativa L.*) on the Performance of Broilers

T. Guler*, B. Dalkılıç, O. N. Ertas and M. Çiftçi
Department of Animal Nutrition, Veterinary Faculty, University of Fırat, 23119 Elazığ, Turkey

ABSTRACT : Three hundred and sixty sexed 3-day-old broiler chicks were divided randomly into six treatment groups (control, antibiotic and black cumin at four levels) of 60 birds each. Black cumin seeds at 0.5%, 1%, 2% or 3% and avilamycin at 10 mg/kgt were added to the basal diet and their effects determined on feed intake, daily live weight gain, feed conversion ratio and carcass characteristics. There were no significant differences in daily feed intake at 21 and 42 days ($p>0.05$). Average daily gain was significantly different between the treatments. The birds fed the diet containing 1% black cumin seeds and antibiotic were the highest average daily gain, followed by those the other treatment diets and negative control ($p<0.05$). From 1 to 42 days of age, feed conversion ratios were improved significantly by supplementation with 1% black cumin seeds and with antibiotic ($p<0.05$) by approximately 5% compared to the control group. Similarly, the highest cold carcass, thigh, breast, wing, neck and liver weights were observed in the 1% black cumin and antibiotic groups ($p<0.05$). Accordingly, 1% supplementation of black cumin seeds to diets could be considered as an alternative natural growth promoter for poultry instead of antibiotics. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 3 : 425-430)***

Key Words : Black Cumin Seeds, Antibiotic, Broiler, Performance

INTRODUCTION

Antibiotics were the principal growth promoting substances for poultry. However, the use of antibiotics as feed additives is risky due to cross-resistance amongstt pathogens and residues in tissues (Schwarz et al., 2001). Therefore, the use of most antibiotic growth promoters has been banned in many countries in the world. Consequently, the use of antibiotics in poultry diets was reduced and scientists have searched for alternative natural growth promoters and aromatic plants and essential oils extracted from these plants are becoming more important due to their antimicrobial effects (Elgayyar et al., 2001; Singh et al., 2002; Valero and Salmeron, 2003; Wenk, 2003) and their stimulating effect on animal digestive systems (Jamroz and Kamel, 2002; Ramakrishna et al., 2003; Jang et al., 2004).

As an aromatic plant, black cumin (*Nigella sativa*) is widely grown in different parts of the world and the seeds of black cumin have been used to promote health for countries especially in the Middle East and Southeast Asia. Black cumin seeds have been widely used in traditional medicine as diuretic and antihypertensive (Zaoui et al., 2000), digestive and appetite stimulant (Gilani et al., 2004), antidiarrheal (Gilani et al., 2001), analgesic (Khanna et al., 1993; Khan et al., 1999), anthelmintic (Agarwal et al., 1979a; Chowdhury et al., 1998) and antibacterial agents (Ferdous et al., 1992; El-Kamali et al., 1998). Additionally, recent studies have shown black cumin to be antidiabetic (Meral et al., 2001), anticancer (Abuharfeil et al., 2001; Farah and Begum, 2003), anti-inflammatory (Al-Ghamdi, 2001), spasmolytic and bronchodilatory (Gilani et al., 2001), hepatoprotective (Janbaz et al., 2003), renal protective (Badary et al., 2000) and possessing antioxidant properties (Mansour et al., 2002).

The seeds of *Nigella sativa* contain a volatile oil (0.5-1.6%), a fixed oil (35.6-41.6%), proteins (22.7%) and amino acids (Al-Gaby, 1998). The seeds have also been found to contain fats, crude fiber, minerals; e.g. Fe, Na, Cu, Zn, P, Ca and vitamins like ascorbic acid, thiamine, niacin, pyridoxine and folic acid (Takruri et al., 1998). *Nigella sativa* seeds yield esters of fatty acids, free sterols and steryl esters (Menounos et al., 1986). The seeds also contain lipase, phytosterols and ·-sitosterol (Duke, 1992). The active constituents of the seeds include the volatile oil consisting of carvone, an unsaturated ketone, terpene or d-limonene also called carvene, ·-pinene and p-cymene (Kapoor, 1990). Pharmacologically active constituents of volatile oil are thymoquinone, dithymoquinone, thymohydroquinone and thymol (Ghosheh et al., 1999).

Black cumin has been a great focus of research for centuries and has several traditional uses and consequently has been extensively studied for its active constituents (Menounos et al., 1986; Atta-ur-Rahman et al., 1992; Al-Gaby, 1998; Ghosheh et al., 1999). To our knowledge, the effect of dietary black cumin seeds on performance in broilers has not been investigated. The current study was conducted to determine usefulness of black cumin seeds in animal nutrition as a natural growth promoting substance to replace antibiotics. For this purpose, the effects of different inclusion levels of black cumin seeds were also assessed.

* Corresponding Author: Talat Guler. Tel: +90-424-237-00-00, Fax: +90-424-238 81-73, E-mail: tguler@firat.edu.tr
Received July 17, 2005; Accepted November 8, 2005

Table 1. Ingredient and chemical composition of the experimental starter and finisher diets

Ingredients (kg/1,000 kg)	Treatment											
	1 to 21 days						22 to 42 days					
	Diet1	Diet2	Diet3	Diet4	Diet5	Diet6	Diet1	Diet2	Diet3	Diet4	Diet5	Diet6
Maize	570.3	566.3	563.3	560.3	559.3	569.3	608.1	606.1	603.1	596.1	593.7	607.1
Soybean meal (45 CP)	290.0	290.0	260.0	289.0	289.0	290.0	306.5	306.5	305.5	305.5	301.4	306.5
Vegetable oil	50.0	49.0	47.0	44.0	40.0	50.0	50.0	48.0	46.0	43.0	39.5	50.0
Fish meal	6.00	6.00	6.00	5.70	5.20	6.00	-	-	-	-	-	-
Salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
DL-methionine	2.2	2.2	2.2	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0	2.0
L-lysine hydrochloride	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.4	0.4	0.4	0.4	0.4
Vitamin premix*	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Mineral premix**	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Dicalcium phosphate	10.0	10.0	10.0	10.0	10.0	10.0	16.0	16.0	16.0	16.0	16.0	16.0
Ground limestone	9.0	9.0	9.0	9.0	9.0	9.0	9.5	9.5	9.5	9.5	9.5	9.5
Black cumin seeds	-	5.0	10.0	20.0	30.0	-	-	5.0	10.0	20.0	30.0	-
Antibiotic(Avilamycin)	-	-	-	-	-	1.0	-	-	-	-	-	1.0
Calculated analysis (%)												
Dry matter	89.20	89.20	89.20	89.20	89.20	89.20	89.10	89.10	89.10	89.10	89.10	89.10
Crude protein (CP)	21.50	21.50	21.60	21.60	21.50	21.50	18.80	18.90	19.00	19.10	19.10	18.80
Crude fiber	3.30	3.30	3.30	3.30	3.34	3.30	3.50	3.50	3.50	3.50	3.50	3.50
Ether Extract	7.16	7.34	7.25	7.31	7.27	7.16	6.70	6.70	6.69	6.75	6.78	6.70
Ca	0.93	0.93	0.93	0.92	0.92	0.93	0.79	0.79	0.79	0.79	0.79	0.79
P	0.70	0.70	0.70	0.69	0.69	0.70	0.66	0.66	0.66	0.65	0.65	0.66
Methionine+cystine	0.93	0.92	0.92	0.92	0.91	0.93	0.81	0.81	0.81	0.80	0.80	0.81
Lysine	1.28	1.28	1.28	1.27	1.26	1.28	1.01	1.01	1.01	1.01	1.00	1.01
Linoleic acid	3.90	3.90	3.90	3.70	3.70	3.90	4.00	3.90	3.90	3.80	3.70	4.00
ME (MJ/kg)	13.39	13.40	13.39	13.41	13.41	13.39	13.35	13.34	13.34	13.35	13.36	13.35

ME: Metabolisable energy.

Diet 1: Negative control: without antibiotic and black cumin seed.

Diet 2, 3, 4 and 5: with 0.5, 1, 2 and 3% diet, respectively.

Diet 6: with antibiotic, 10 mg avilamycin/kg diet.

* Per 2.5 kg including; 2,000,000 IU vit A, 2,000,000 IU vit D_3, 35,000 mg vit E, 4,000 mg vit K_3, 3,000 mg vit B_1, 7,000 mg vit B_2, 5,000 mg vit B_6, 15 mg B_{12}, 20,000 mg Niacin,1,000 mg Folic acid, 45 mg Biotin,10,000 mg Cal-D-Pantothenate (Pantothenic acid), 125,000 mg Colin chloride and 50,000 mg vit C.

** Per kg including; 60,000 mg Fe, 60,000 mg Zn, 5,000 mg Cu, 1,000 mg I, 200 mg Co, 150 mg Se, 80,000 mg Mn.

MATERIAL AND METHODS

Three hundred and sixty 3-day-old broiler chicks (Ross-308) were used in this study. The chicks were divided into six groups, each of 60 birds, and randomly assigned to the six treatment diets. Each treatment group was further sub-divided into six replicates of 10 birds each. The experiment was carried out over 42 days. The presence and levels of black cumin seeds and antibiotic in diets were the main tested factors. The birds in the control group were fed the standard diets (18.8-21.6% CP and 13.34-13.41 MJ ME/kg). Four different levels of black cumin seeds (Kırkambar Co., Elazığ, Turkey) or an antibiotic (Avilamycin, Kartal Kimya, Turkey) were added to the standard diets. For the black cumin seed treatments, 0.5% (0.5 black cumin group), 1% (1 black cumin group), 2% (2 black cumin group) and 3% (3 black cumin group) black cumin seeds were added to the standard diets. In the antibiotic treatment, the feed contained 0.1% (10 mg/kg) antibiotic. Black cumin seeds and antibiotic were mixed carefully with the standard diet. The six diets were isocaloric and isonitrogenous. The diets and water were provided *ad libitum*. The ingredient and chemical composition of the diets are presented in Table 1.

A photoperiod was maintained for 23 h/d until the 4th week and for 14 h/d in weeks 4-6. The body weights of the birds were measured individually and feed intakes per pen were recorded. Feed conversion ratio was calculated at the end of the 21st and 42nd day experimental periods. Mortality was recorded daily and used to adjust the total number of birds to determine the total feed intake per bird. At 42 days, 20 birds were selected from each treatment group, weighed and slaughtered to determine carcass yields.

Chemical composition of feed ingredients (dry matter, crude protein, ash and ether extract) as dried samples were analyzed using AOAC (1990) procedures; crude fiber was determined by the methods of Crampton and Maynard (1983).

Data collected were subjected to analyses of variance, and where significant differences were observed, means were further subjected to Duncan's multiple range test by using SPSS for Windows: 10.1, SPSS inc., (1993).

Table 2. The effect of dietary black cumin seed and antibiotic on the average daily feed intake and the feed conversion ratio of broilers up to the age of 42 days

Treatments	Feed intake (g/d)			Feed conversion ratio (g feed/g gain)		
	1-21 days	22-42 days	1-42 days	1-21 days	22-42 days	1-42 days
Control	62.47	144.86	103.66	1.52[a]	2.00[a]	1.82[a]
Antibiotic	59.40	150.27	104.84	1.47[b]	1.85[b]	1.72[b]
0.5% Black cumin	59.37	146.23	103.80	1.48[b]	2.02[a]	1.84[a]
1% Black cumin	59.68	149.99	104.83	1.47[b]	1.86[b]	1.73[b]
2% Black cumin	60.10	146.13	103.12	1.49[ab]	2.04[a]	1.84[a]
3% Black cumin	60.96	146.86	103.91	1.53[a]	2.05[a]	1.86[a]
SEM	1.88	2.24	2.05	0.33	0.75	0.12
P	NS	NS	NS	*	*	*

NS: Non significant, * $p<0.05$, [a, b] Mean values with different superscripts within a row differ significantly.

Table 3. The effect of dietary black cumin seed and antibiotic on daily live weight gain, carcass yield and mortality of broilers up to the age of 42 days

Treatments	Average daily gain (g/d)			Carcass yield (%)	Mortality (%)
	1-21 days	22-42 days	1-42 days	42 days	42 days
Control	41.14	72.54[b]	56.84[b]	71.92[b]	-
Antibiotic	40.48	81.44[a]	60.96[a]	72.53[a]	-
0.5% Black cumin	40.17	72.37[b]	56.27[b]	71.39[b]	2.00
1% Black cumin	40.59	80.61[a]	60.60[a]	72.67[a]	-
2% Black cumin	40.26	71.65[b]	55.96[b]	71.44[b]	2.00
3% Black cumin	39.97	71.66[b]	55.82[b]	71.51[b]	-
SEM	2.18	1.72	2.14	0.64	-
P	NS	*	*	*	-

NS: Non significant, * $p<0.05$, [a, b] Mean values with different superscripts within a row differ significantly.

RESULTS AND DISCUSSION

The effect of dietary black cumin seeds and antibiotic on the daily feed intake and feed conversion ratio are presented in Table 2. Daily feed intake did not differ between treatments ($p>0.05$). Similar feed intake may be due to the birds being kept in a clean environment and fed well-balanced diets. Similarly, Denli et al. (2004) reported that supplementation with black cumin seed extract did not significantly affect feed intake of quail. From days 1 to 42, feed conversion ratios were significantly improved by supplementation with 1% black cumin, and antibiotic ($p<0.05$). The supplementation of 1% black cumin seeds and antibiotic in the diet improved feed conversion ratio by approximately 5% compared to the control group and by approximately 6.5% compared to the other black cumin groups. There were no differences between 0.5%, 2%, 3% black cumin groups and control groups ($p>0.05$).

The effects of black cumin seeds and antibiotic addition on average daily gain, carcass yield and mortality are presented in Table 3. There was a significant effect ($p<0.05$) of 1% black cumin seeds and also of antibiotic additive on average daily gain and carcass yield. At 42 days of age, average daily gains differed ($p<0.05$) between treatments. The highest average daily gains were observed in antibiotic and 1% black cumin groups. The birds consuming the diets containing antibiotic and 1% black cumin improved average daily gain by 7.2% and 6.6% respectively compared to the control group. There were no differences between average daily gains of birds receiving the diets containing 0.5%, 2%, 3% black cumin and the control group ($p>0.05$). The average daily gain of birds fed the diets containing 0.5%, 2% and 3% black cumin seeds were lower than those of the birds on the diet containing 1% black cumin seed ($p<0.05$). Carcass yields differed ($p<0.05$) between the treatments at day 42. The birds consuming the diets containing antibiotic and 1% black cumin had a higher carcass yield than the other treatment groups ($p>0.05$). Significant differences were also found between 1% black cumin group and 0.5%, 2% and 3% black cumin groups. Mortality was not significantly different between treatments. The effects of black cumin seeds and antibiotic on carcass characteristics are presented in Table 4. The highest cold carcass weight were determined in antibiotic and 1% black cumin groups ($p<0.05$). The supplementation of the diets with 1% black cumin seed and antibiotic improved cold carcass weight approximately 8% compared to the control group. Similarly, the highest liver, abdominal fat, thigh, breast, wing and neck weights were in antibiotic and 1 % black cumin groups ($p<0.05$). There were no differences in heart weights between groups ($p>0.05$).

In summary, supplementation of the diets with 1% black cumin seed and antibiotic significantly improved average daily gain, feed conversion ratio and carcass yield. Antibiotics have been used as growth promoters in poultry for a long time and many studies have reported that

Table 4. The effect of dietary black cumin seed and antibiotic on carcass characteristic of broilers up to the age of 42 days (n: 20)

	Control	Antibiotic	Black cumin, %				SEM	P
			0.5	1	2	3		
Live weight (g)	2,417.00^{b}	2,590.00^{a}	2,428.00^{b}	2,575.00^{a}	2,380.00^{c}	2,374.00^{c}	4.27	*
Cold carcass (g)	1,738.38^{b}	1,878.58^{a}	1,743.27^{b}	1,871.15^{a}	1,700.35^{c}	1,697.63^{c}	1.08	*
Heart (g)	14.68	15.08	14.65	14.88	14.82	13.67	3.40	NS
Liver (g)	49.25^{b}	55.03^{a}	50.03^{b}	54.18^{a}	48.30^{b}	48.58^{b}	2.11	*
Abdominal fat (g)	36.32^{b}	39.10^{a}	36.73^{b}	35.93^{b}	34.83^{b}	34.02^{b}	0.85	*
Thigh (g)	715.83^{b}	776.48^{a}	718.75^{b}	775.63^{a}	701.75^{b}	700.07^{b}	1.12	*
Breast (g)	707.75^{b}	755.62^{a}	710.18^{b}	753.83^{a}	688.27^{b}	689.17^{b}	1.88	*
Wing (g)	182.52^{b}	194.92^{a}	184.60^{b}	192.87^{a}	179.72^{b}	179.10^{b}	2.01	*
Neck (g)	132.28b^{c}	151.55^{a}	133.72^{b}	148.87^{a}	130.62^{b}	129.30^{b}	1.44	*

NS: Non significant, * $p<0.05$, $^{a, b, c}$ Mean values with different superscripts within a row differ significantly.

antibiotics increased live weight gain, feed conversion ratio and carcass yield (Elwinger et al., 1998; Engberg et al., 2000; Owens et al., 2004). The positive effect of supplementation with 1% black cumin seed on performance may be due to its antimicrobial effects on the pathogenic bacteria, fungi and parasites in the digestive system (Gilani et al., 2004). Different investigations have reported that black cumin had antimicrobial activity against *Streptococcus mutans* (Namba et al., 1985); *Micrococcus pyogenes var. aureus* (Kapoor, 1990); *Shigella dysenteriae, Shigella sonnei, Vibrio cholerae* and *Escherichia coli* (Ferdous et al., 1992); *Staphylococcus aureus, Pseudomonas aeruginosa* (Sokmen et al., 1999); *Bacillus pumilus, Bacillus suptilus*, *Staphylococcus lutea* (El-Kamali et al., 1998) and *Shigella flrxneri* (Chowdhury et al., 1998). Black cumin also showed anthelmintic activity (Agarwal et al., 1979a). Additionally, the essential oil in black cumin showed antifungal activity against *Aspergillus* species and *Curvularia lunata* (Agarwal et al., 1979b) as well as against pathogenic yeast *Candida albicans* (Hanafy and Hatem, 1991). It is clear that controlling the gut micro flora could positively influence broiler performance. Furthermore,, the black cumin seed oil and its main active constituent thymoquinone (approximately 60%) and other components (carvone, anethole, carvacrol and 4-terpineol) have high antioxidant activity (Badary et al., 2000; Kruk et al., 2000). Also, black cumin oil (Mahmoud et al., 2002) and thymoquinone (Mansour et al., 2002) have hepatoprotective effects. Additionally, black cumin seeds have been traditionally used in a wide range of gastrointestinal disorders (El-Abhar et al., 2003). The seeds also contain lipase (Duke, 1992). Improved performance of the 1% black cumin group may be due to the combined effect of all these active ingredients acting in a positive manner. In agreement with these results, Hernandez et al. (2004) reported that the supplementation of essential oils improved apparent whole-tract and ileal digestibility of the nutrients. Similarly, Ramakrishna et al. (2003) reported that the effects of pancreatic lipase and amylase were increased with the supplementation of essential oil. Also, Jang et al. (2004) reported that the supplementation of essential oil increased trypsine and pancreatic amylase activity. Similar positive effects reported by Jamroz and Kamel (2002). They observed that the supplementation with essential oil increased digestion of protein, cellulose and fat. The positive effect of dietary black cumin seeds on gain and feed conversion ratio could relate to increased efficiency of feed utilization and/or altered carcass composition. Similarly, recent studies reported that essential oils blocked effect of pathogens in the digestive system (Alçiçek et al., 2003), and improved feed intake, feed conversion ratio and carcass yield (Tucker, 2002; Alçiçek et al., 2003; Giennenas et al., 2003). The reason for the lower performance of 2% and 3% black cumin groups compared with the 1% black cumin group may be due to negative effects of components such as alkaloids, saponin, volatile oils and other anti nutritional factors contained in black cumin. Similarly, El-Shabrawy and Nada (1996) reported that toxic symptoms were observed after intra peritoneal administration of 2.5% black cumin. The toxic effects of black cumin seeds were emphasized by Zaoui et al. (2002).

Unfortunately, reports on the value of black cumin seeds in poultry are limited. This study showed that the supplementation of 1% black cumin seeds in broiler diets significantly improved body weight, feed conversion ratio and carcass yield of broilers after a growing period of 6 weeks. Howevert, the supplementation of black cumin in excess of 1% had no additional beneficial effect on these production traits. In conclusion, these results showed that black cumin seeds (1% levels) could be used a natural growth promoter substance to replace antibiotics for broiler diets.

REFERENCES

AOAC. 1990. Official Methods of Analysis. 15th end. Association of Official Analytical Chemists. Arlington, Virginia.

Abuharfeil, N. M., S. Maher and S. V. Kleist. 2001. Augmentation of natural killer cell activity *in vivo* against tumor cells by some wild plants from Jordan. Phytoth. Res. 15:109-113.

Agarwal, R., M. D. Kharya and R. Shrivastava. 1979a. Antimicrobial and anthelmintic activities of the essential oil of

Nigella sativa. Ind. J. Experi. Biol. 17:1264-1265.

Agarwal, R., M. D. Kharya and R. Shrivastava. 1979b. Pharmacological studies of essential oil and unsaponifiable matter of seeds of Nigella sativa. Ind. J. Pharmacol. Sci. 41:248, Abst. C1.

Alçiçek, A., M. Bozkurt and M. Çabuk. 2003. The effect of essential oil combination derived from selected herbs growing wild in Turkey on broiler performance. South Afrc. J. Anim. Sci. 33:89-94.

Al-Gaby, A. M. 1988. Amino acid composition and biological effects of supplementing broad bean and corn proteins with *Nigella sativa* (Black cumin) cake protein. Nahrung. 42:290-294.

Al-Ghamdi, M. S. 2001. The anti-inflammatory analgesic and antipyretic activity of Nigella sativa. J. Ethnopharmacol. 76:45-48.

Atta-ur-Rahman, S., S. Malik and K. Zaman. 1992. Nigellimine: A new isoquinoline alkaloid form the seeds of *Nigella sativa*. J. Nat. Prod. 55:676-678.

Badary, O. A., A. B. Abdel-Naim, M. H. Abdel-Wahab and F. M. Hamada. 2000. The influence of thymoquinone on doxorubicin-induced hyperlipidemic nephropathy in rats. Toxicol. 143: 19-226.

Chowdhury, A. K. A., A. Islam, A. Rashid and A. Ferdous. 1998. Therapeutic potential of the volatile oil of Nigella sativa seeds in monkey model with experimental shigellosis. Phytotherapy Res. 12:361-363.

Crampton, E. W. and L. A. Maynard. 1983. The Relation of cellulose and lignin content to nutritive value of animal feeds. J. Nutr. 15:383-395.

Denli, M., F. Okan and A. N. Uluocak. 2004. Effect of dietary black seed (*Nigella sativa L.*) extract supplementation on laying performance and egg quality of quail (*Coturnix coturnix japonica*). J. Appl. Anim. Res. 26:73-76.

Duke, J. A. 1992. Handbook of Phytochemical Constituents of GRAS Herbs and other Economic Plants. CRC press, Inc. Florida, USA.

El-Abhar, H. S., D. M. Abdallah and S. Saleh. 2003. Gastroprotective activity of Nigella sativa oil and its constituent, thymoquinone, against gastric mucosal injury induced by ischaemia/reperfusion in rats. J. Ethnopharmacol. 84:251-258.

Elgayyar, M., F. A. Draughon, D. A. Golden and J. R. Mount. 2001. Antimicrobial activity of essential oils from plants against selected pathogenic and saprophytic microorganisms. J Food Prot. 64:1019-24.

El-Kamali, H. H., A. H. Ahmad, A. S. Mohammad, A. A. M. Yahia, I. El-Tayeb and A. A. Ali. 1998. Antibacterial properties of essential oils from Nigella sativa seeds etc. Fitoterapia, 69:77-78.

El-Shabrawy, O. A. and S. A. Nada. 1996. Biological evaluation of multicomponent tea used as hypoglycemic in rats. Fitoterapia, 67:99-102.

Elwinger, K., E. Berndtson, B. Engstrom, O. Fossum and L. Waldenstedt. 1998 Effect of antibiotic growth promoters and anticoccidials on growth of Clostridium perfringens in the caeca and on performance of broiler chickens. Acta Vet. Scand. 39:433-41.

Engberg, R. M., M. S. Hedemann, T. D. Leser and B. B. Jensen. 2000. Effect of zinc bacitracin and salinomycin on intestinal microflora and performance of broilers. Poult. Sci. 79:1311-9.

Farah, I. O. and R. A. Begum. 2003. Effect of Nigella sativa and oxidative stress on the survival pattern of MCF-7 breast cancer cells. Biomed. Sci. Instrum. 39:359-364.

Ferdous, A. J., S. N. Islam, M. Ahsan, C. M. Hasan and Z. U. Ahmad. 1992. *In vitro* antibacterial activity of the volatile oil of Nigella sativa seeds against multiple drug-resistant isolates of Shigella species and isolates of Vibrio cholerae and *Escherichia coli*. Phytotherpy Res. 6:137-140.

Giannenas, I., P. Florou-Paneri, M. Papazahariadou, E. Christaki, N. A. Botsoglou and A. B. Spais. 2003. Effect of dietary supplementation with oregano essential oil on performance of broilers after experimental infection with Eimeria tenella. Arch Tierernahr. Apr. 57:99-106.

Gilani, A. H., N. Aziz, I. M. Khurram, K. S. Chaudhary and A. Iqbal. 2001. Bronchodilator, spasmolytic and calcium antagonist activities of Nigella sativa seeds (Kalonji): a traditional herbal product with multiple medicinal uses. J. Pak. Med. Assoc. 51:115-120.

Gilani, A. H., Q. Jabeen and M. A. U. Khan.2004. A Review of Medicinal Uses and Pharmacological Activities of Nigella sativa. Pakistan J. Biol. Sci. 7:441-451.

Ghosheh, O. A., A. A. Houdi and P. A. Crooks. 1999. High performance liquid chromatography analysis of the pharmacologically active quinines and related compounds in the oil of the black seed (*Nigella sativa*). J. Pharm. Biomed. Ana. 19:757-762.

Hanafy, M. S. and M. E. Hatem. 1991. Studies on the antimicrobial activity of Nigella sativa seed (*Black cumin*). J. Ethnopharmacol. 34:275-278.

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

Jamroz, D. and C. Kamel. 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.

Janbaz, K. H., S. A. Saeed, A. H. Gilani and M. K. Ashfaq. 2003. The *in vitro* effect of Aqueous extract of Nigella sativa seeds on Nitric Oxide Production. Phytotherapy Res. 17:921-924.

Jang, I. S., Y. H. Ko, H. Y. Yang, J. S. Ha, J. Y. Kim, J. Y. Kim, S. Y. Kang, D. H. Yoo1, D. S. Nam1, D. H. Kim and C. Y. Lee. 2004. Influence of Essential Oil Components on Growth Performance and the Functional Activity of the Pancreas and Small Intestine in Broiler Chickens. Asian-Aust. J. Anim. Sci. 17:394-400.

Kapoor, L. D. 1990. Handbook of Ayurvedic Medicinal Plants. CRC Press, Inc. Boca Raton, Florida, USA.

Khan, M., T. H. Shaila Jabbar, M. S. K. Choudhuri and M. A. Ghafur. 1999. Analgesic and antiinflammatory activity of Nigella sativa Linn. Hamdard Medicus, 42:22-29.

Khanna, T., F. A. Zaidi and P. C. Dandiya. 1993. CNS and analgesic studies on Nigella sativa. Fitoterapia. 64:407-410.

Kruk, I., T. Michalska, K. Lichszteld, A. Klanda and H. Y. Aboul-Enein. 2000. The effect of thymol and its derivatives on reactions generating reactive oxygen species. Chemosphere. 41:1059-1064.

Mahmoud, M. R., H. S. El-Abhar and S. Saleh. 2002. The effect of

Nigella sativa oil against the liver damage induced by Schistosoma mansoni infection in mice. J. Ethnopharmacol. 79:1-11.

Mansour, M. A., M. N. Nagi, A. S. El-Khatib and A. M. Al-Bekairi. 2002. Effects of thymoquinone on antioxidant enzyme activities, lipid peroxidation and DT- diaphorase in different tissues of mice: a possible mechanism of action. Cell Biochem. Funct. 20:143-151.

Menounos, P., K. Staphylakis and D. Gegiou. 1986. The sterols of *Nigella sativa* seed oil. Phytochem. 25:761-763.

Meral, I., Z. Yener, T. Kahraman and N. Mert. 2001. Effect of Nigella sativa on glucose concentration, lipid peroxidation, anti-oxidant defense system and liver damage in experimentally-induced diabetic rabbits. J. Vet. Med. A. Physiol. Pathol. Clin. Med. 48:593-599.

Namba, T., M. Tsunezuka, K. Saito, N. Kakiuchi, M. Hattori, D. M. R. B. Dissanayake and U. Pilapitiya. 1985. Studies on dental caries prevention by traditional medicines, screening of Ayuruedic medicines for anti-plaque action. Shoyakugaku Zasshi, 39:146-153.

Owens, B., M. A. Collins and K. J. McCracken. 2004. The effects of different growth promoters and combinations of growth promoters, on the performance and gut histology of broiler chickens. Br. Poult. Sci. 45 Suppl 1:62-3.

Ramakrishna, R. R., K. Platel and K. Srinivasan. 2003. *In vitro* influence of species and spice-active principles on digestive enzymes of rat pancreas and small intestine. Nahrung. Dec. 47:408-412.

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

Singh, G., I. P. Kapoor, S. K. Pandey, U. K. Singh and R. K. Singh. 2002. Studies on essential oils: part 10; antibacterial activity of volatile oils of some spices. Phytother Res. 16:680-2.

Sokmen, A., B. M. Jones and M. Erturk. 1999. The effect of black seed oil from Nigella sativa against murine cytomegalovirus infection. Int. J. Immunopharmacol. 22:729-740.

SPSS for Windows. 1993. Released 6.0 June 17 1993 Copy right (c. Spss inc. 1989-1993).

Takruri, H. R. H. and M. A. F. Dameh. 1998. Study of the nutritional value of black cumin seeds (*Nigella sativa*). J. Sci. Food Agric. 76:404-410.

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

Valero, M. and M. C. Salmeron. 2003. Antibacterial activity of 11 essential oils against Bacillus cereus in tyndallized carrot broth. Int. J. Food Microbiol. 85:73-81.

Wenk, C. 2003. Herbs and Botanicals as Feed Additives in Monogastric Animals. Asian-Aust. J. Anim. Sci. 16:282-289.

Zaoui, A., Y. Cherrah, M. A. Lacaille-Dubois, A. Settaf, H. Amarouch and M. Hasar. 2000. Diuretic and and hypotensive effects of Nigella sativa in the spontaneously hypertensive rat. Therapie. 55:379-382.

Zaoui, A., Y. Cherrah, N. Mahassine, K. Alaoui, H. Amarouch and M. Hasar. 2002. Acute and chronic toxicity of Nigella sativa fixed oil. Phytomedicine. 9:69-74.