IMPACT OF SUPPLEMENTATAL L-CARNITINE, THYME AND CLOVE OILS ON GROWTH PERFORMANCE, NUTRIENT DIGESTIBILITY, SERUM METABOLITES, LYMPHOID ORGANS AND IMMUNE RESPONSE OF BROILER CHICKENS

M. H. Soliman

Dept. of Nutrition and Clinical Nutrition, Faculty of Vet. Medicine,

Zagazig University, Egypt

ABSTRACT

This work was carried out to study the effects of supplemental L-carnitine (LC), essential oils mix (EOM) (thyme and clove oils) or L-carnitine plus essential oil mix (LC+EOM) on growth performance, nutrient digestibility, some serum metabolites, lymphoid organs and immune response against Newcastle disease virus vaccine in broiler chickens. One hundred ninety two day-old chicks of commercial meat type (Ross) were randomly divided into four treatment groups. Each treatment group was further subdivided into three replicates of sixteen chicks each. Chicks were fed isocaloric and isonitrogenous starter diets (3000 Kal/kg ME and 23 % CP) for three weeks and grower-finisher diets (3200 Kcal/kg ME and 20 % CP) for the next three weeks. Throughout the growth phases, diets were supplemented with LC (150 mg/kg), EOM (200 mg/kg thyme oil + 200 mg /kg clove oil) or LC+EOM. Chicks were vaccinated against Newcastle disease virus using Hitchner and Lasota vaccines at 7 and 14 days of age, respectively. Body weight and feed intake were measured during each feeding phase and feed conversion ratios were calculated. A digestibility trial was carried out to determine digestibility of dry matter, crude protein and ether extract. At end of the study, six chickens from each group were randomly chosen, killed by decapitation and blood samples were collected for measurement of glucose, total protein, total cholesterol, high density lipoprotein (HDL) and haemagglutinating antibodies against Newcastle disease virus. Thymus, spleen, and bursa were individually weighed and expressed as a percent of live body weight. The results revealed that LC, EOM or LC+EOM supplementation have significant ($P < 0.05$) effect on body weight and daily gain, while feed intake was not significantly affected by any of the treatments. Supplementation of the diets with EOM or LC+EOM had significantly ($P < 0.05$) decreased feed conversion ratio. Dietary supplementation with EOM or LC+EOM had significantly increased digestibility of dry matter, crude protein and ether extract. Serum glucose and total cholesterol

were significantly (P < 0.05) decreased due to EOM or LC+EOM supplementation. Dietary supplementation with LC or LC+EOM had significantly increased high density lipoprotein. The dietary treatments have no significant effect on total protein in serum. Weight of thymus and spleen relative to body weight were was significantly higher in broiler chickens fed diets supplemented with LC+EOM. Birds fed diets supplemented LC+EOM have significant (P < 0.05) higher value of heamagglutinating inhibition antibody titer in their sera. It could be concluded that, supplementation of the diets with EOM or LC+EOM has beneficial effects as evidenced by improved growth performance parameters, nutrient digestibility and some serum metabolites. Health status and immune response of the birds were enhanced, especially due to LC+EOM supplementation.

INTRODUCTION

Allover the world, antibiotics have been used extensively as growth promoters in animal feeds for many years, especially in the fields of poultry production. The prophylactic use of antibiotics in animal feeds has made intensive farming possible and improved feed efficiency (**Hernandez et al., 2004**). In the presence of low levels of antibiotics, resistant cells survive and grow producing an antibiotic-resistant population. Therefore, objections to the use of growth-promoting antibiotics are increasing as consumers fear that their use in livestock feeds may produce harmful effects to humans (**Denli et al., 2004**). Consequently, the use of antibiotic as growth promoters for broilers had been banned by **European Union (1998)** and limited to only four antibiotics that are not associated with human treatments (avilamycin and flavophospholipol as growth promoter additives and salinomicin sodium and monensin sodium as coccidiostats). As a consequence, efforts had been made to search for growth promoting alternatives and reduce the use of antibiotic growth promoters. For many years, herbs and spices and their essential oils have been used as a pharmaceutical in alternative therapy and as a natural therapy (**Mitscher et al., 1987**). Commercial additives of plant origin, considered to be natural products that the consumer would accept, have been proposed to animal producers. The chemical components of most essential oils from plants are generally recognized as safe, and are used commonly in the food industry (**Varel, 2002**). There is evidence to suggest that herbs, spices and various plant extracts have appetizing and digestion-stimulating properties and antimicrobial effects (**Madrid et al., 2003**; **Alçiçek et al., 2004**; **Zhang et al., 2005**). Moreover, herbs and plant extracts stimulate the growth of beneficial bacteria and minimize pathogenic bacterial activity in the gastrointestinal tract of poultry (**Langhout, 2000**; **Wenk, 2000**). Thyme and clove are two herbs that have been proposed as alternative to antibiotics for organic poultry industry (**Griggs and Jacob,**

2005). Thymol and carvacrol, the major components of thyme oil, had been shown to have potent antioxidant properties **(Aeschbach et al., 1994)**, antibacterial activities against a wide range of pathogenic microbial organisms **(Vincent, 2002)** as well as positive effects on nutrient digestibility **(Langhout, 2000 and Madrid et al., 2003)**.

Production of broiler chickens containing excess body fat is a problem in poultry industry. Genetic improvement of and increased nutrient concentration in the diet are among the factors that contribute to the tendency of broilers to accumulate excess body fat. . Therefore, improving carcass composition with additives has become a main focus of nutrition research. L-carnitine is a zwitter ionic compound biosynthesized from lysine and Methionine in liver, brain and kidneys **(Miah et al., 2004)**. This compound is essential for the transport of long chain fatty acids across the inner mitochondrial membrane for β-oxidation **(Borum, 1983)**. Plants and plant-based feedstuffs generally contain very little carnitine compared with animals **(Baumgartner and Blum, 1993)**. Therefore, carnitine supplementation of the diets could be used to augment carnitine supply for use in metabolism and thereby facilitating fatty acid oxidation and reducing the amount of long-chain fatty acid available for storage in adipose tissue **(Xu et al., 2003)**. In addition, carnitine may modulate immune function as evidenced by enhanced antibody responses in L-carnitine supplemented broiler chickens **(Mast et al., 2000)** and pigeons **(Janssens et al., 2000)**. The effects of L-carnitine supplementation to the broiler diets are less clear. Studies with broiler chickens have shown that supplemental dietary L-carnitine increases body weight gain, improves feed conversion ratio, and reduces abdominal fat content **(Rable et al., 1997a &b; Rable and Szilagyi, 1998)** However, there are contradictory studies in which dietary L-carnitine supplementation did not affect growth performance, abdominal fat content, and some internal organ weights **(Barker and Sell, 1994; Carwright, 1986 and Leibetseder, 1995)**. **Petek et al. (2003)** found that addition of 50 mg L-carnitine /kg diet did not affect broiler performance or organ weight. Similarly, **Sarica et al. (2005)** found that supplementing basal diet of quail with 30, 40 or 50 mg L-carnitine /kg diet has no significant effect on body weight gain, feed intake or feed conversion. **Celik et al. (2003)** found that supplementing L-carnitine at 50 mg /kg has significantly improved body weight gain during the first 3 weeks of age in broiler chicks, but did not have effect in the last three weeks. Therefore, this work was carried out to study the effects of long term supplementation of L-carnitine (LC), essential oils mix (EOM) (thyme and clove oils) or L-carnitine plus essential oil mix (LC+EOM) on growth performance, nutrient digestibility, some serum metabolites, lymphoid organs and immune response against Newcastle disease virus vaccine in broiler chickens.

MATERIALS AND METHODS

Birds, management and diets:

One hundred ninety two one-day-old chick of a commercial meat type (Ross) obtained from a local commercial hatchery were used in this study. On arrival, chicks were weighed individually and randomly allocated to four treatment groups. Each treatment group was further sub-divided to three replicates of sixteen chicks each. Chicks were reared in naturally ventilated open house with wheat straw as litter. Isocaloric and isonitrogenous starter (3000 Kcal /kg ME, 23% CP) and grower-finisher (3197 Kcal/kg, ME and 20% CP) diets were formulated (Table 1) to meet the nutrient requirements of broiler chickens **(NRC, 1994)**. The dietary treatments included: (1) control diet, (2) control diet supplemented with L-carnitine (LC) at 150 mg/kg, (3) control diet supplemented with essential oil mix (EOM) consisting of clove oil 200 mg/kg and thyme oil 200 mg/kg, (4) control diet supplemented with L-carnitine and essential oil mix (LC+EOM) at the same previous levels. Starter diets were provided to the chicks from 1-21 days, while grower-finisher diets were provided at period from 22-42 days of age. Feed and water were available at all times. Chicks were vaccinated against Newcastle disease virus using Hitchner and Lasota vaccines at 7 and 14 days of age, respectively.

Growth performance and digestibility :

Body weight and feed intake were measured during each feeding phase and feed conversion ratios were calculated. At end of the growth trial fifteen chickens from each group were randomly selected to carry out to carry out the digestibility trial. Chromic oxide was used as indicator and included at 0.3 % of the diet. A plastic sheet was placed over the bedding materials to facilitate fecal collection. The birds were fed their respective diet for 5 days adaptation period followed by another 5 days collection period, during which representative fecal samples were collected at intermittent times during the day. Samples of fresh fecal excreta were collected separately for each replicate. Efforts were made to remove every bit of feathers or any other contaminants from the feces. Fresh collected samples of each replicate were pooled, mixed, dried in forced air oven at 60°C for 48 h, allowed to equilibrate at room temperature and milled (1 mm screen) before analysis. Triplicate samples of feed and fecal matter were analyzed for dry matter and ether extract according to **AOAC (1990)**. Fecal nitrogen was separated from urinary nitrogen by applying trichloro acetic acid method according to **Jackobson et al. (1960)**. Dry matter digestibility was calculated according to **McDonald et al. (1981)**. Digestibility of crude protein and ether extract was calculated according to **Maynard et al. (1979)**.

Serum metabolites :

At end of the experiment, blood samples were collected (through wing vein puncture) from six birds in each treatment group (two bird/replicate), centrifuged and the clear sera were harvested and used for determination of glucose **(Trinder, 1969)**, total protein **(Cornel et al., 1949)**, total cholesterol **(Melattini, 1978)** and high density lipoprotein **(Clark et al., 1983)** using the available commercial kits.

Lymphoid organs and immune response :

Collection of the samples :

At 21 and 42 days of age, six chickens from each group were randomly chosen, killed by decapitation and blood samples were collected to determine haemagglutinating antibodies titer using haemagglutination inhibition test. Thymus, spleen and bursa were removed, individually weighed and expressed as a percent of live body weight.

Haemagglutination inhibition (HI) test :

Antigen of NDV was diluted in HI buffer to contain 10 haemagglutinating unites (HA) in 50 µl. One hundred µl of antigen was deposited in all wells. Twenty five µl of serum was deposited in the first well using 25 µl microtiter diluter. Fifty µl from each well was serially passed from each well using a microtiter transfer diluter. The plates were incubated for 20-30 minutes at room temperature and 50 µl of chicken red blood cells (CRBC) 0.5% was added to all wells. The plates were agitated gently and let stand for 45 minutes at room temperature. The HI titer was determined according to **Villegas (1991)**.

Statistical analysis :

The data were statistically analyzed by analysis of variance using general linear model procedure (GLM) in a window-based statistical package program, **SAS (1985)**.

RESULTS AND DISCUSSION

Growth performance :

Growth performance of broiler chickens fed the experimental diets is shown in Table 2. Supplementation of LC had no significant effect on body weight, weight gain, feed intake or feed con-

version during the starter period as compared to the control. However, the allover performance data revealed that LC supplementation had significantly ($P < 0.05$) increased body weight (2016.33 g) and weight gain (47.13 g/day) as compared to the control (1876.66 g and 43.82 g/day, respectively), while feed intake and feed conversions were not significantly affected. On the other hand, supplementation of the diets with EOM or LC+EOM had significantly ($P < 0.05$) increased body weight, weight gain during the starter and grower-finisher periods. Throughout the whole feeding period, broiler chickens fed the diets supplemented with LC+EOM had significant ($P < 0.05$) higher values of body weight and daily gain when compared to chicken fed the control diet. Supplementation of the diet with LC+EOM had significantly ($P< 0.05$) reduced feed conversion ratios during starter and grower-finisher periods (Table 2). The dietary treatments had no significant ($P > 0.5$) effect on feed intake. The allover performance data (Table 2) had shown that broiler chickens fed diets supplemented with either LC or EOM had significant higher body weight (2016.66 and 2093.33 g, respectively) and daily gain (47.13 and 48.92 g, respectively) when compared to the control (1876.66 g and 43.82 g/day). These results are in agreement with those reported by **Lettner et al. (1992)** who showed that dietary supplementation with LC from 20 to 60 mg/kg tended to improve growth performance of broiler chickens. **Rabie et al. (1997)** indicated that the supplementation of dietary LC at 3 levels (50, 100, or 150 mg/kg) to a basal diet had significantly increased body weight gain of broiler chickens compared with those of broilers fed the basal diet. Also, **Rabie and Szilagy (1998)** suggested that supplemental LC improved body weight gain and feed conversion ratio of broilers. However, **Barker and Sell (1994)** reported that the supplementation of dietary LC at 0, 50, or 100 mg/kg diet did not affect body weight gain, feed intake, or feed efficiency of broiler chickens and young turkeys fed low- or high-fat diets. Likewise, **Lien and Horng (2001)** found that feeding diets supplemented with LC at 0 and 160 mg /kg did not significantly affect the performance of broiler chickens. These inconsistent responses of broilers supplemented with LC may be related to period of supplementation, sex, broiler genotype, basal diet composition, levels of L-carnitine or its precursors in the diet and/or environmental conditions **(Sarica et al., 2005)**.

As shown in Table 2, the improved growth performance parameters in broiler chickens fed the LC and EOM supplemented diets could be due to the active ingredients such as eugenol and carvacrol in clove and thymole in thyme. These compounds had been suggested to have digestive stimulating effects **(Ertas, 2005)**. In addition, these active ingredients possess antimicrobial activity against wide range of pathogenic bacterial in gastrointestinal tract of poultry **(Valero and Salmeron, 2003 and Singh, et al. 2002)** and stimulate the growth of beneficial bacteria **(Wenk, 2000)**. It is well known that the pathogenic bacteria increase requirements of energy and protein by competing with the host for dietary energy and protein **(Apajalathi et al., 2004)**. **Lee et al.**

(2003) found that dietary supplementation of eugenol, a component of clove oil, at 100 mg/kg stimulates the secretion of pancreatic digestive enzymes, i.e. amylase, lipase, trypsin and chymotrypsin in female broiler chickens. **Lee et al. (2004)** stated that thyme oil and its major compound, thymole, has a strong antioxidant activity and acts as an effective free radicals scavengers and influences the in vivo antioxidant defense systems such as superoxide dismutase, glutathione peroxidase, and vitamin E. It was suggested that the high antioxidant activity of thymole is due to the presence of phenolic OH groups which act as hydrogen donor to the peroxy radicals produced during the first step in lipid oxidation, thus retarding the hydroxyl peroxide formation **(Farag et al., 1989)**.

Nutrient digestibility of the diets :

Effect of the treatments on the nutrient digestibility of the experimental diets is shown in Table 3. The results revealed that diets supplemented with EOM or LC+EOM significant ($P < 0.05$) higher values of dry matter (78..60 and 79.33 %, respectively) and crude protein digestibility (87.26 and 88.56 %, respectively) compared to that of the control (73.93 and 77.60 %, respectively). Supplementation of the diet with EOM or LC+EOM had significantly ($P < 0.05$) increased ether extract digestibility. Supplementation with LC had non significant ($P > 0.5$) effect on digestibility of dry matter, crude protein or ether extract compared to the control. These results are in agreement with that of **Arslan (2006)** who stated that supplementation of LC has no positive effect on dietary protein utilization in broiler especially under condition of adequate amino acid metabolism. Also the results are in accordance with **Rincker et al. (2001)** who found that supplementation of LC up to 100 mg/kg in diet of weaning pigs had improved whole body composition, tissue accretion, and to a lesser degree, nutrient digestibility.

The significant higher digestibility of nutrients in diets supplemented with LC+EOM is in agreement with **Hernandez et al. (2004)**, who found that supplementation of the diet with EOM containing thyme and rosemary oils had significantly increased apparent digestibility of dry matter and ether extract. These results could be due to increased digestive enzyme activities of intestinal mucosa and pancreas due to supplementation of essential oils as suggested by **(Samabaiah and Srinivasan, 1991)**. It had been reported that the intestinal microflora has a pronounced impact on fat digestion in chickens because of lowered bile acid availability **(Smits et al., 1998)**. Bile salts are known to be a limiting factor for efficient fat digestion **(Krogdahl, 1985)**. Moreover, the intestinal microflora such as Clostridium, Peptostreptococcus, Bifidobacterium, Fusobacterium, Eubacterium, Streptococcus, and Bacteriods can hydrolyse bile salts **(Freigher and Dashkevicz, 1987)**. Consequently, the strong antimicrobial activity of thyme and clove oils reflects

the efficacy of dietary essential oils on fat digestion. Furthermore, there might be a direct effect of essential oils on either bile secretion or cholesterol 7¨-hydroxylase activity **(Srinivasan and Sambaiah, 1991)**.

Serum metabolites :

The effect of dietary treatments on serum biochemical parameters of broiler chickens is shown in Table 4. The results showed that broiler fed diets supplemented with LC, EOM or LC+EOM had significant ($P < 0.05$) lower values of serum glucose (173.33, 176.33 and 163.30 mg/dl, respectively) compared to that of the control (202.0 mg/dl).In addition, broiler fed the diet supplemented with LC+EOM had significant lower value of serum glucose as compared to that of the chickens fed the diet supplemented with EOM. Serum total protein was not significantly ($P > 0.05$) affected by the dietary treatments.

Supplementation of the diets with LC, EOM or LC+EOM had significantly decreased total cholesterol (94.33, 101.33 and 91.67 mg/dl) compared to the control (112.30 mg/dl), while HDLP was significantly ($P < 0.05$) increased due to supplementation of the diets with LC or LC+EOM. The obtained results are in agreement with that of **Rezaei et al. (2007)** who found that dietary supplementation with LC at level of 250 mg/kg had significantly decreased the level of serum triglyceride and cholesterol and VLDLP in broiler chicks. In addition, **Adabi et al. (2006)** found that dietary addition of LC at level of 60 mg/kg had significantly decreased both serum and egg yolk cholesterol levels in broiler breeder. Moreover, LC had been shown to produce a pronounced drop in serum cholesterol in rats **(Palmero et al., 1999)**. In the study of **Lien and Horng (2001)** supplementation of the diet with 160 mg/kg LC had significantly reduced triacyglycerol and non esterified fatty acids concentration in serum of broiler chieckens.

The relationship between LC and fat metabolism in broilers had been reported by **Xu et al (2003)**. Higher doses of LC (> 50mg/kg) induced partial inhibition of the glucose-6-phsphatase dehydrogenase, malicdehydrogenase, isocitric dehydrogenase and lipoprotein lipase in the subcutaneous fat and also of carnitine palmitoyltransferase I in breast muscles **(Arslan, 2006)**. Consequently, LC would reduce subcutaneous fat deposit and enhance intramuscular fat. Lipoprotein lipase catalyzes the conversion of triglycerides to glycerol and fatty acids. With the decrease of its activity, lipoprotein lipase increases hydrolysis of very low density lipoproteins, which have been suggested to play a major role in regulating the deposition of fat in subcutaneous tissues **(Griffin and Whitehead, 1982)**.

The significant lower serum total cholesterol in this study in accordance with the results of **Bolukbas et al. (2006)** who found that the thyme oil supplementation at 100 mg/kg had de-

creased plama levels of triglycerides, LDL-cholesterol and HDL-cholesterol in broilers. Cholesterol lowering properties of herbs and their essential oils has been reported **(Elson et al., 1989)**. The pure components of essential oils were found to inhibit 3-hydroxy-3-methyl glutaryl coenzyme A (HMG-CoA) reductase activity which is a key regulatory enzyme in cholesterol synthesis **(Crowel, 1999). Elson (1996)** stated that thymole and carvacrol, main components of thyme oil, could induce regulatory non-sterol products from mevalonate which are proposed to inhibit cholesterol synthesis **(Goldstein and Brown, 1990)**.

Lymphoid organs and immune response :

The effects of dietary treatments on weight of lymphoid organs (as % of live body weight) and immune response against Newcastle disease virus are presented in Table 5. During the starter period, the dietary treatments had non significant ($P > 0.05$) effect on weight of lymphoid organs expressed as a percent of live body weight. However, during the grower-finisher period broiler chickens fed the diets supplemented with LC+EOM mix had significant ($P < 0.05$) higher weight of thymus and bursa relative to body weight compared to the control. In addition, chickens fed diet supplemented with EOM had significant higher weight of bursa compared to the control. These results are consistent with that of **Deng et al. (2006)** who found that supplementation of LC at 100 and 1000 mg/kg to leghorn-type chickens had no significant effect on weight of spleen or bursa relative to body weight, while weight of thymus relative to body weight had significantly increased only at level 1000 mg/kg supplemented for 12 weeks. In the present study, the significant higher relative thymus weight in birds fed LC+EOM supplemented diet than the control may indicate a synergistic effect between the two additives. The interpretation of this result is unknown, but both additives could had modified lipid metabolism or enhanced secretion of hormones , such as insulin, insulin-like growth factor-I **(Musser et al., 1999)** or triiodothyronine (T_3) **(Buyse et al., 2001)** as many lipid and hormones are immunomodulators **(Miles and Calder, 1998 and Marsh, 1994)**.

During starter phase, broiler chickens fed diet supplemented with LC+EOM had a significant ($P<0.05$) higher value of antibody titer than those fed the control or LC supplemented diets. Additionally, antibody titer in the sera of birds fed diets supplemented with LC, EOM or LC+EOM during the grower-finisher phase were non significantly ($P > 0.005$) different, while birds fed diet supplemented with LC+EOM mix had significant higher antibody titer than that of the birds fed the control diet. Although, supplementation of LC or EOM did not influence the antibody titer, the obtained results confirmed a favorable effect on immune response when both additives were supplemented together. Beneficial effects of LC supplementation on immune response of broiler

were reported when supplementary LC at 100 mg/kg in diet of broiler chicken had enhanced the primary and secondary responses of immunoglobulin G to bovine serum albumin **(Mast et al., 2000)**. Also, serum immunoglobulin G was significantly improved when diet of broiler chickens was supplemented with LC at 75 or 100 mg/kg **(Geng et al., 2007)**. Similarly, addition of LC to drinking water at 1 g/l enhanced both bovine serumalbumin-specific immunoglobulin G and immunoglobulin M responses in adult female pigeons **(Janssens et al.., 2000)**. With regard to its role in cellular immunity, LC was found in lymphocytes at high concentration, inhibited apoptosis of lymphocytes **(Moretti et al., 1998)** and enhanced the proliferative response of human lymphocytes to antigens **(De Simone et al., 1994)**. Herbs and plant extracts minimize pathogenic bacterial activity and stimulate the growth of beneficial bacteria which has a role in acquired mucosal immunity in the gastrointestinal tract of poultry **(Cebra, 1999; Langhout, 2000; and Wenk, 2000)**. Thyme and clove are two herbs that have been proposed as alternative to antibiotics for organic poultry industry **(Griggs and Jacob, 2005)**. Thymole and carvacrol, the major components of thyme oil, had been shown to have potent antioxidant properties **(Aeschbach et al., 1994)**. The improved immune response of broiler chicken because of essential oil could be attributed to improved hepatic antioxidant status due to decreased lipid peroxidation and increased hepatic glutathione and superoxide dismutase activities **(Al-Ankari et al., 2004)**.

Table (1) : Ingredients and calculated composition of the experimental diets[1].

	Diets	
Ingredients	**Starter**	**Grower-finisher**
Yellow corn, ground	55.67	62.00
Soybean meal, 44%	32.20	23.00
Corn gluten meal, 60%	4.30	5.20
Fish meal, 65%	2.80	2.80
Soybean oil	1.80	3.60
Lysine-HCl, 78%	0.13	0.15
DL-Methionine, 99%	0.15	0.16
Limestone	1.15	1.24
Dicalcium phosphate	1.20	1.25
Vitamin and mineral premix[2]	0.30	0.30
NaCl	0.30	0.30
Calculated composition[3]		
ME, Kcal/kg	2998	3197
CP, %	22.98	20.0
EE, %	4.49	6.336
CF, %	3.47	3.04
Ca, %	1.10	1.11
Total P, %	0.66	0.65
Lysine, %	1.41	1.18
Methionine, %	0.58	0.55

[1] diets included: (1) control diet, (2) control diet supplemented with L-carnitine (LC) at 150 mg/kg, (3) control diet supplemented with essential oil mix (EOM) (200 mg/kg thyme oil + 200 mg /kg clove oil), (4) control diet supplemented with L-carnitine plus essential oil mix (LC+EOM).

[2] provide per kg diet: vitamin A (palmitate), 12,000 IU; vitamin D (cholecalciferol, 2,500 IU; vitamin E (L-tocopherol) 12 mg; itamin K_3 (menadione), 2.5 mg; vitamin B_1, 1.2 mg; vitamin B2, 6 mg; pantothenic acid, 12 mg; folic acid, 1.2 mg; niacin, 36 mg; pyridoxine, 2 mg; vitamin B_{12}, 0.01 mg; biotin, 0.06 mg; , Choline, 500 mg; iron, 36 mg; copper, 5 mg; manganese, 72 mg; zinc, 60 mg, iodine, 0.45 mg,; selenium, 0.12 mg.

[3] Calculated according to feed composition tables NRC (1994).

Table (2) : Effects of L-carnitine and essential oil mix supplementation on growth performance of broiler chickens (Means ± SE).

	Dietary treatments			
	Control	LC-diet	EOM-diet	LC+EOM-diet
Starter period (0-3 weeks)				
Average initial body weight, g	36.0 ± 1.15	37 ± 2.08	38.33 ± 1.76	38.0 ± 2.06
Average final body weight, g	723.33 ± 27.3^{c}	762 ± 21.4^{bc}	806.33 ± 15.9^{ab}	863.33 ± 17.6^{a}
Average weight gain, g	687.33 ± 26.4^{c}	725 ± 22.9^{bc}	768.33 ± 14.2^{ab}	825.33 ± 17.5^{a}
Average daily gain, g/day	32.73 ± 1.25^{c}	34.52 ± 1.09^{bc}	36.59 ± 0.70^{ab}	39.30 ± 0.84^{a}
Average feed consumption, g/day	50.69 ± 1.21	52.12 ± 1.43	52.28 ± 1.30	55.06 ± 2.09
Average feed conversion ratio	1.55 ± 0.037^{a}	1.51 ± 0.046^{ab}	1.43 ± 0.047^{ab}	1.40 ± 0.034^{b}
Grower-finisher period (3-6 weeks)				
Average final body weight, g	1876.66 ± 37.1^{c}	2016.66 ± 40.4^{b}	2093.33 ± 34.6^{b}	2215 ± 34.1^{a}
Average weight gain, g	1153.33 ± 23.3^{c}	1254.66 ± 28.3^{bc}	1286.66 ± 18.7^{ab}	1351.66 ± 19.2^{a}
Average daily gain, g/day	54.92 ± 1.11^{c}	59.74 ± 1.3.5^{bc}	61.27 ± 0.90^{ab}	64.36 ± 0.91^{a}
Average feed consumption, g/day	127.9 ± 4.7	130.43 ± 4.11	131.5 ± 2.15	136.51 ± 4.53
Average feed conversion ratio	2.32 ± 0.037^{a}	2.18 ±0.073^{ab}	2.15 ± 0.064^{ab}	2.12 ± 0.045^{b}
Allover performance				
Average final body weight, g	1876.66 ± 37.1^{c}	2016.66 ± 40.4^{b}	2093.33 ± 34.6^{b}	2215 ± 34.1^{a}
Average weight gain, g	1840.66 ± 36.9^{c}	1979.66 ± 42.5^{b}	2055 ± 32.9^{b}	2177 ± 33.1^{a}
Average daily gain, g/day	43.82 ± 0.88^{b}	47.13 ± 1.01^{b}	48.92 ± 0.78^{b}	55.162 ± 2.7^{a}
Average feed consumption, g/day	89.30 ± 2.12	91.27 ± 2.53	91.90 ± 1.46	95.78 ± 3.34
Average feed conversion ratio	2.03 ± 0.024^{a}	1.94 ± 0.046^{ab}	1.88 ± 0.055^{b}	1.85 ± 0.044^{b}

^{abc} **Means in the same row with different superscripts are significantly different (P < 0.05)**

Table (3) : Effects of L-carnitine and essential oil mix supplementation on nutrient digestibility of the diets fed to broiler chickens.

Nutrient digestibility, %	Dietary treatments			
	Control-diet	LC-diet	EOM-diet	LC+EOM-diet
Dry matter	73.93 ± 1.28[b]	75.83 ± 1.30[ab]	78.60 ± 1.24[a]	79.33 ± 1.11[a]
Crude protein	77.60 ± 1.02[b]	78.61 ± 1.63[ab]	81.96 ± 0.81[a]	82.66 ± 1.38[a]
Ether extract	82.83 ± 1.13[b]	86.73 ± 1.26[ab]	87.26 ± 1.04[a]	88.56 ± 0.76[a]

[1] Means ± SE

[ab] Means in the same row with different superscripts are significantly different (P < 0.05)

Table (4) : Effects of L-carnitine and essential oil mix supplementation on serum metabolites parameters of broiler chickens (Means ±SE).

	Dietary treatments			
	Control-diet	LC-diet	EOM-diet	LC+EOM-diet
Glucose (mg/dl)	202.0 ± 4.16[a]	173.33 ± 3.52[bc]	176.33 ± 1.45[b]	163.30 ± 2.90[c]
Total protein (g/dl)	4.56 ± 0.26	4.90 ± 0.28	5.10 ± 0.17	5.25 ± 0.13
Total Cholesterol (mg/dl)	112.30 ± 3.38[a]	94.33 ± 3.17[b]	101.33 ± 2.40[b]	91.67 ± 3.18[b]
High density lipoprotein (mg/dl)	63.0 ± 2.31[b]	70.30 ± 1.67[a]	68.0 ± 1.73[ab]	72.29 ± 1.45[a]

[abc] Means in the same rows with different superscripts are significantly different (P < 0.05)

Table (5) : Long-term effects of L-carnitine and essential oil mix supplementation on lymphoid organs and immune response[1].

	Dietary treatments			
	Control-diet	**LC-diet**	**EOM-diet**	**LC+EOM-diet**
Weight of lymphoid organs, % of body weight				
Starter period				
Thymus	0.44 ± 0.04	0.56 ± 0.06	0.48 ± 0.6	0.49 ± 0.03
Spleen	0.1 ± 0.01	0.11 ± 0.014	0.09 ± 0.02	0.10 ± 0.02
Bursa	0.17 ± 0.02	0.16 ± 0.04	0.18 ± 0.016	0.19 ± 0.012
Grower-finisher period				
thymus	0.29 ± 0.041^{b}	0.36 ± 0.07^{ab}	0.38 ± 0.05^{ab}	0.52 ± 0.02^{a}
Spleen	0.045 ± 0.002	0.08 ± 0.01	0.05 ± 0.006	0.056 ± 0.008
Bursa	0.09 ± 0.002b	0.10 ± 0.006^{b}	0.13 ± 0.12^{a}	0.136 ± 0.14^{a}
Haemagglutinating antibody titer*				
Starter period	1.12 ± 0.91^{b}	1.36 ± 0.87^{b}	1.8 ±1.01^{ab}	2.42 ±1.16^{a}
Grower-finisher period	1.30 ± 0.98^{b}	1.52 ±1.21^{ab}	1.52 ±1.18^{ab}	1.77± 1.21^{a}

[1] Means ± SE

* Log geometric mean of antibody titer ± SD.

^{ab} Means in the same rows with different superscripts are significantly different ($P < 0.05$)

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الملخص العربى

أثر إضافة الـ - كارنتين ومخلوط من زيت الزعتر والقرنفل على معدلات النمو والهضم، بعض مكونات مصل الدم، الأعضاء الليمفاوية والاستجابة المناعية فى دجاج التسمين

د/ محمد حسين سليمان

قسم التغذية والتغذية الإكلينيكية - كلية الطب البيطرى - جامعة الزقازيق - مصر

تم إجراء هذا البحث لدراسة أثر إضافة كل من الـ-كارنتين ومخلوط من زيت الزعتر والقرنفل على معدلات النمو والهضم، بعض مكونات مصل الدم، الأعضاء الليمفاوية والاستجابة المناعية ضد لقاح فيروس مرض النيوكاسل فى دجاج التسمين، أستخدم عدد مائة واثنان وتسعون كتكوت عمر يوم من سلالة Ross قسمت عشوائياً إلى أربعة مجموعات متساوية بكل منها 3 مكررات كل مكررة بها 16 كتكوت. تم تغذية الكتاكيت على علائق (بادى لمدة 3 أسابيع، ونامى - ناهى لمدة 3 أسابيع أخرى) متساوية فى محتوى الطاقة (3000 كيلو كالورى / كجم عليقة ناهى) والبروتين (23% بروتين خام عليقة بادى و 20% بروتين خام عليقة ناهى). كانت المعاملات الغذائية كالتالى : 1- عليقة ضابطة، 2- عليقة ضابطة أضيف إليها الـ-كارنتين (150مجم/كجم)، 3- عليقة ضابطة أضيف إليها مخلوط من الزيوت الأساسية (200مجم من زيت الزعتر + 200مجم من زيت القرنفل / كجم من العليقة)، 4- عليقة أضيف إليها الـ-كارنتين مع مخلوط الزيوت الأساسية بنفس التركيزات السابقة.

تم تحصين الطيور ضد فيروس مرض النيوكاسل باستخدام لقاحى Hitchner و Lasota عند عمر 7 أيام و 14 يوماً على الترتيب، تم وزن الكتاكيت مرة كل 3 أسابيع وحساب متوسط وزن الجسم، معدل الزيادة اليومية فى وزن الجسم، معدل إستهلاك العلف ومعامل التحويل الغذائى. فى نهاية التجربة تم إختيار 6 طيور عشوائياً من كل مجموعة وذبحها للحصول على الدم لقياس تركيز كل من الجلوكوز، البروتين الكلى، الكوليستيرول الكلى، والبروتينات الدهنية عالية الكثافة وكذلك لإجراء إختبار منع التلازن وقياس معدل إنتاج الأجسام المناعية ضد لقاح فيروس مرض النيوكاسل. وكذلك تم وزن كل من الغدة التيموثية، الطحال وكيس فابريشى لتلك الطيور.

ويمكن إيجاز أهم النتائج فيما يلى :

- إضافة كل من الـ-كارنتين، مخلوط الزيوت الأساسية أو الـ-كارنتين مع مخلوط الزيوت الأساسية أدى إلى زيادة معنوية فى وزن الجسم ومعدل الزيادة اليومية، بينما لم يتأثر معدل إستهلاك العلف معنوياً بأى من المعاملات الغذائية.
- إنخفض معامل التحويل الغذائى فى المجموعات التى أضيف إليها مخلوط الزيوت الأساسية أو الـ-كارنتين مع مخلوط الزيوت الأساسية.
- إضافة كل من مخلوط الزيوت الأساسية أو الـ-كارنتين مع مخلوط الزيوت الأساسية أدى إلى زيادة معنوية فى معامل هضم كل من المادة الجافة، البروتين والمستخلص الأثيرى.
- إنخفض تركيز كل من الجلوكوز والكوليستيرول الكلى فى المجموعات التى أضيف إليها كل من مخلوط الزيوت الأساسية أو الـ-كارنتين مع مخلوط الزيوت الأساسية، بينما لم يتأثر مستوى البروتين الكلى بأى من المعاملات الغذائية. إضافة كل من الـ-كارنتين أو الـ-كارنتين مع مخلوط الزيوت الأساسية أدى إلى زيادة معنوية فى تركيز البروتينات الدهنية عالية الكثافة.
- إضافة الـ-كارنتين مع مخلوط الزيوت الأساسية أدى إلى زيادة معنوية فى كل من الوزن النسبى لكل من الغدة التيموثية وكيس فابريشى وكذلك المعيار الكمى للأجسام المناعية ضد لقاح فيروس مرض النيوكاسل.

أظهرت نتائج هذه الدراسة إن إضافة كل من مخلوط الزيوت الأساسية (200مجم من زيت الزعتر + 200مجم من زيت القرنفل / كجم من العليقة) أو الـ-كارنتين (150مجم / كجم من العليقة) مع مخلوط الزيوت الأساسية له تأثير معنوى إيجابى على معدلات النمو واعتدال بعض قياسات التمثيل الغذائى. إضافة الـ-كارنتين مع مخلوط الزيوت الأساسية له تأثير إيجابى محفز على كل من الغدة التيموثية، كيس فابريشى والاستجابة المناعية.