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EFFECT OF DIETARY POLYUNSATURATED FATTY ACIDS AND ANTIOXIDANTS SUPPLEMENTATION ON PRODUCTIVE PERFORMANCE, IMMUNE RESPONSE AND BLOOD PARAMETERS OF BROILER CHICKENS

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SUMMARY

This study conducted to investigate the effects of dietary linseed oil (LO) or fish oil (FO) and/or antioxidants on productive performance, immune response, carcass traits and blood parameters of broiler chickens. A total of 168 one-day-old, Cobb broiler chicks were obtained from a local commercial hatchery. The birds were randomly divided into seven groups with three replicates, eight chicks each. Birds of the seven groups were fed on iso-caloric and iso-nitrogenous diets containing the same ingredients (basal diet) except the source of oil and addition of antioxidants. The first group was fed on the basal diets containing 2% soya oil (control), the 2nd , 3rd and 4th groups were given the basal diets containing 2% LO, 2% LO + 200 mg vitamin E (vit E)/ kg or 2% LO + 0.2% Sweet Chestnut Tannin (SCT), respectively. While the 5th, 6th and 7th groups were offered the basal diet containing 2% FO, 2% FO + 200 mg vit E/ kg or 2% FO + 0.2% SCT, respectively. During the whole period, adding FO without or with antioxidants significantly ($p \leq 0.05$) increased live body weight, body weight gain compared to control. Feed intake was not significantly ($p > 0.05$) affected by the dietary treatments. All dietary treatments had ($p \leq 0.05$) lower feed conversion ratio than the control. Moreover, the best FCR were recorded for the FO + 0.2% SCT dietary group, followed by the LO + 2% SCT, FO and FO + 200 mg vit E/ kg groups. No significant ($P \geq 0.05$) difference among treatments was observed in carcass traits of broilers. Inclusion of FO with or without antioxidants in broiler diets improved antibody titer against SRBCs in immune response ($p \leq 0.05$) compared to control. A significant decrease in plasma total lipid concentration was observed with all dietary treatments. The best HDL value were observed for the FO + 0.2% SCT dietary group, followed by the FO and FO + 200 mg vit E/ kg groups. It could be concluded that the inclusion of 2% FO and/or antioxidants of the broiler diets improved the productive performance, immune response and plasma lipid of broilers. Moreover, the addition of 2% fish oil with 0.2% SCT as antioxidants recorded the best productive performance, immune response and plasma lipids of broilers.

Keywords: *Broilers, polyunsaturated fatty acids, antioxidants, performance, immune response and plasma lipids.*

INTRODUCTION

Several studies had been conducted to increase the content of polyunsaturated fatty acids (PUFAs) in chickens and eggs by using dietary fat sources such as natural oil containing PUFAs (Kim *et al.*, 2007). The oil supplement in diets is a very important resource of either long chain omega-3 PUFAs, as in fish oil (FO) or as a form of its precursor fatty acid, α-linolenic (ALA), as in linseed oil (LO). (Zelenka *et al.*, 2006). The utilization of diets rich in omega-3 PUFAs, such as FO and LO, can affect blood serum metabolites, such as triglycerides and total cholesterol (Safamehr *et al*., 2008; Viveros *et al*., 2009 and Velasco *et al*., 2010). Diets rich in PUFAs, can reduce triacylglycerol synthesis and fatty acids in liver, decreasing the concentration of plasma triglycerides in the broilers (Sanz *et al*., 2000). Supplementation of dietary FO improved the immune system (Tobarek *et al*., 2002). From broilers health aspect, omega-3 PUFAs improve performance, lipid profile besides increasing in marketing weight (Al-Zuhairy and Alasadi, 2013 and Sahib, 2013).

Polyunsaturated fatty acids are prone to oxidation since they are the first targets for free radical strike at initiating peroxidation (Scislowski *et al*., 2005). PUFAs in poultry meat make it sensitive to oxidative

changes affecting smell and taste (Lopez-Ferrer *et al*., 1999). Lipid oxidation is a major cause of meat quality deterioration which lowers the functional, sensory and nutritive values of meat products; and therefore, consumer's acceptability (Bou *et al.,* 2004). The notable strategies for diminishing lipid oxidation of meat are by adding antioxidants to poultry diets. Currently, the interest in natural antioxidants has increased because they are considered to be safer than the synthetic antioxidants, and have greater application potential for consumers' acceptability, palatability, stability and shelf-life of meat products (Park and Kim, 2008).

Vit E is considered as a very potent antioxidant in biological systems and found to be beneficial in counteracting the adverse effect of oxidative stress (Panda and Cherian 2014). In addition, one of the primary functions of vit E is to maintain membrane integrity, which it does via preventing oxidation of PUFAs in membrane phospholipids (Gropper *et al.,* 2009). Also vit.E is essential for such body functions as growth, immune function enhancement, tissue integrity, reproduction, disease prevention, and antioxidant function in biological systems (DalleZotte and Szendro, 2011).

Tannins are a heterogeneous group of phenolic polymers. According to their chemical structure, they can be divided into hydrolyzed tannins and condensed tannins. Hydrolysable tannins are multiple esters of gallic acid with glucose and products of their oxidative reactions .Altogether, tannins are reported to have various physiological effects like antioxidant and antiradical activity (Arapitsas *et al*. 2012). Sweet chestnut is an important source of hydrolyzed tannins "phenolic compounds'' (Ribeiro *et al*., 2007). Many studies have been carried out examining the role of tannins in the prevention of lipid oxidation (Cherian *et al.,* 2002; Schiavone *et al*., 2008; Wang *et al*., 2008; Liu *et al*., 2009).

Therefore, the current study aimed to study the effects of feed containing PUFAs and antioxidants on productive performance, immune response, carcass traits and blood parameters of broiler chickens.

MATERIALS AND METHODS

A total of 168 one-day-old, Cobb broiler chicks were obtained from a local commercial hatchery. The birds were randomly divided into seven groups with three replicates, eight chicks each. Birds of the seven groups were fed on isocaloric and isonitrogenous diets containing the same ingredients (basal diet) except the source of oil and the added antioxidants.The first group was fed on the basal diets containing 2% soy oil, the 2nd, 3rd and 4th groups were given the basal diets containing 2% linseed oil (LO), 2% LO + 200 mg vit E/ kg or 2% LO + 0.2% Sweet Chestnut Tannin (SCT). While the 5th, 6th and 7th groups were offered the basal diet containing 2% fish oil (FO), 2% FO + 200 mg vit E/ kg or 2% FO + 0.2% SCT. Chicks of all groups were fed starter diets from 1-14 day of age (DOA) and grower diets from15-35 DOA. Basal control diets were formulated according to the recommendation of the National Research Council (NRC, 1994). Feed and water were offered *ad-libitum* during the experimental period, which lasted for five weeks. The composition and calculated chemical analyses of the basal diets are presented in Table 1.

Vitamin E supplied by Adisseo Inc. French, it contain 50% α-tocopherol. Sweet Chestnut Tannin (supplied by Silva Team, San Michele di Mondov, Italy) is extracted from chestnut wood by a heat and low-pressure treatment; only the water-soluble fraction is retained and subsequently dehydrated. The product is commercially available as a fine brown powder (92 to 95% dray matter) with a pure tannin content of 77% on a dray matter basis (Tabacco *et al*., 2006). Chemical composition of the SCT was as follows: 2.9% water, 77.8% tannin, 17.7% nontannin, 1.6% insoluble, 0.24% crude fiber and 1.7% ash, (pH 3.26, 10% solution).

Growth performance parameters:

Live body weight (LBW) of each chicks and feed intake (FI) for each group were recorded during the experimental period. Body weight gain (BWG) and feed conversion ratio (FCR), (FI / BWG) were calculated.

Carcass characteristics:

At the end of the experimental period, (35 DOA) two birds per replicate (6birds/treatment) were randomly selected, weighed individually, sacrificed by severing the jugular vein, Feathers were removed manually. Giblets percentage was calculated by dividing the accumulative weight of liver, heart and gizzard by LBW. The empty eviscerated yield carcasses were weighed and dressing percentage calculated. Abdominal fat, breast, wings and femur were also recorded and calculated as a percentage of LBW. Weights of bursa of Fabricius, thymus and spleen were recorded; the relative weights (as a percentage of live body weight) of lymphoid organs were calculated.

Humoral Immune Response:

At the 3rd week of age, six broiler chicks from each treatment were intramuscularly injected with 0.5 ml sheep red blood cells (SRBCs) suspension (0.05 ml packed SRBCs mixed with 0.95 ml phosphate buffered saline. Seven days post (4th week) SRBCs antigen challenge, blood samples were collected from wing vein centrifuged (4000 rpm/5min), sera were decanted and stored frozen at -20ºC until used for determination of primary immune response. At the 4th week of age, second injection was done for the same chicks in a similar manner, then blood samples were collected after seven days (after slaughtering) for the measurement of secondary immune response. The antibody production (Abs) was measured using microtitre plate U-shape of 96 wells according the method of Hitchner *et al.* (1980).

Table (1). Composition and calculated analyses of the basal diets.

Ingredients (%)	Starter	Grower
Yellow corn	54.7	63.1
Soybean meal 44%	33.3	26
Corn gluten meal 62%	6.1	5.2
Soy oil*	2	2
Di calcium phosphate	1.8	1.68
Calcium carbonate	1.3	1.2
Premix**	0.3	0.3
DL-methionine 99%	0.12	0.08
L-lysine HCl	0	0.09
Salt	0.38	0.35
Total (%)	100	100
Calculated analysis		
DM	83.3	84
CP %	23.1	20.03
ME (Kcal/ Kg)	2996	3081
CF %	3.61	3.28
EE%	2.71	2.9
Calcium%	1.01	0.92
Av.Phosphorus %	0.46	0.43
Methionine %	0.51	0.43
Methionine + Cystine %	0.9	0.77
Lysine %	1.1	1.01

**soy oil was replaced by linseed oil in the experimental group 2, 3 and 4, and by fish oil in the experimental group 5, 6 and 7.*

*** Each 3 Kg contains: vit A 12000.000 IU, vit D3 5000.000 IU, vit E 60.000 mg, vit K3 3000 mg, vit B1 2000 mg, vit B2 8000 mg, vit B6 4000 mg, vit B12 15 mg, Nicotinic acid 50.000 mg, Biotin 200 mg, Folic acid 2000 mg, Pantothenic acid 12000 mg, Choline 4000 mg, Manganese 100.000 mg, Iron 40.000 mg, Copper 15000 mg, Iodine 1000 mg, Selenium 300 mg, Zinc 100.000 mg.*

Plasma lipids parameters:

At the end of the experimental period, blood samples (6 samples/ treatment) were collected in heparinzed tubes, centrifuged (4000 rpm) for 10 minutes and plasma was then decanted in Eppendorf tubes and stored at -20ºC until biochemical analysis. Plasma total lipids (mg/dl) were determined according to the method of (Knight *et al.*, 1972).Triglyceride and cholesterol were determined according to Tietz (1995) and HDL- cholesterol was determined according to Burstein (1970). The concentration of LDL- cholesterol can be calculated according to Friedewald formula:
LDL (mg/dl) = Total cholesterol - (Triglycerides/5) - HDL- cholesterol (Friedewald, 1972).

Statistical analysis:

Data were subjected to the analysis of variance by using the General Linear Models Procedure (GLM) of the Statistical Analysis System (SAS, 1994). Differences among treatment means were detected using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Productive performance:

Results concerning the productive performance of broiler chickens fed different sources of oils and antioxidants are presented in Table 2. Initial live body weight (LBW) of broiler chicks was similar for all treatments. Adding fish oil (FO) without or with antioxidants and linseed oil (LO) plus 0.2% Sweet Chestnut Tannin (SCT) significantly ($p \leq 0.05$) increased LBW compared to control at 21 and 35d of age (DOA).

Table (2). Effect of dietary supplementation with different sources of oils and antioxidants on productive performance of broiler chicks.

Items	Control	LO	LO + 200mg/kg Vit.E	LO + 0.2 % SCT	FO	FO + 200mg/kg Vit.E	FO + 0.2 %SCT	MSE	P-value
Live body weight (g/bird)									
one day	41.06	41.38	41.50	40.50	40.12	41.78	41.90	1.21	0.52
21 day	602.25^{d}	624.91^{bcd}	622.50^{cd}	633.25^{bc}	640.00^{abc}	659.75^{a}	647.58^{ab}	12.87	0.002
35 day	1677.14^{d}	1701.35^{cd}	1717.33^{bcd}	1750.92^{ab}	1721.25^{bc}	1739.60^{abc}	1775.51^{a}	22.66	0.002
Weight gain (g/bird/period)									
1 -21 day	561.19^{d}	583.53^{bcd}	580.99^{cd}	592.75^{bc}	599.88^{abc}	605.80^{ab}	617.84^{a}	12.46	0.001
21-35day	1074.89	1076.43	1094.83	1117.67	1081.25	1092.01	1115.76	22.38	0.15
1- 35 day	1636.08^{d}	1659.96^{cd}	1675.83^{bcd}	1710.42^{ab}	1681.13^{bc}	1697.82^{abc}	1733.61^{a}	22.33	0.002
Feed intake (g/bird/period)									
1 -21 day	949.95	912.03	857.53	858.99	937.16	910.47	889.74	50.81	0.25
21-35day	1977.19	1857.00	1861.33	1930.25	1838.08	1889.83	1843.83	76.87	0.30
1- 35 day	2927.15	2769.03	2718.87	2789.24	2775.25	2800.31	2733.57	93.42	0.22
Feed conversion (feed intake/weight gain)									
1 -21 day	1.69^{a}	1.56^{ab}	1.48^{b}	1.45^{b}	1.56^{ab}	1.50^{b}	1.44^{b}	0.08	0.02
21-35day	1.84^{a}	1.72^{ab}	1.70^{b}	1.73^{ab}	1.70^{b}	1.73^{ab}	1.65^{b}	0.06	0.04
1 -35 day	1.79^{a}	1.67^{b}	1.62^{bc}	1.64^{b}	1.65^{b}	1.65^{b}	1.58^{c}	0.05	0.007

^{a,b,c,d} *Means within rows with different superscripts differ significantly.*

LO - Linseed oil; FO - Fish oil; SCT - Sweet chestnut tannins

Body weight gain (BWG) was significantly ($p \leq 0.05$) increased by LO + 0.2% SCT, FO, FO + 200 mg vit E/ kg and FO + 0.2 % SCT for broiler diets compared to control during the experimental period from 1-21 and 1-35 DOA. While during 21-35 d of age, BWG was not affected ($p > 0.05$) with the tested treatments. At all the experimental period, feed intake (FI) was not significantly ($p > 0.05$) affected by the dietary treatments.

Inclusion of LO or FO with antioxidants in broiler diets reduced ($p \leq 0.05$) feed conversion ratio (FCR) than the control during the period from 1 - 21 DOA, the lowest value was recorded for FO + 0.2% SCT. Birds fed FO + 0.2% SCT had the best FCR compared to other dietary treatment at 21-35 DOA. During the whole period, the all-dietary treatments had significantly ($p \leq 0.05$) higher FCR than the control. Moreover, the best FCR were recorded for the FO + 0.2% SCT dietary group, followed by the LO + 2% SCT, FO and FO + 200 mg vit E/ kg groups.

The enhancement of productive performance by feeding broilers FO may be due to increase diet digestibility, which stimulate growth and feed efficiency (Saleh *et al.*, 2009; Chekani-Azar, 2010 and

Hosseini 2011). Because of activation of bile, which lead to increase digestion of fats in the intestine, and increase efficiency of digestion and absorption of diets in intestine lead to more useful from the diet (Al-Zuhairy and Alasadi, 2013; Al-Zuhairy and Jameel, 2014 and Jameel and Sahib, 2014). Omega-3 long chain polyunsaturated fatty acids (PUFAs) in FO has been shown, to reduce the catabolic response induced by immune stimulation and may be effective in promoting growth (Rymer and Givens, 2005).

The improvement of productive performance by feeding broilers FO and antioxidants may be attributed to highly susceptible to oxidative process of oils rich in long chain omega-3 PUFAs like FO and vit E is a good defender against lipid oxidation (Surai and Spark, 2000). Cortinas *et al*. (2005) observed improvement in oxidation stability of chicken muscles fed PUFAs together with 200 or 400 mg vit E/ kg diet. Rocha *et al.* (2012) reported that supplemental levels of vit E might act as an antioxidant by inhibiting lipid peroxidation of the membrane, maintaining its integrity and the gut health of turkey fed oxidized oil. The DPPH radical scavenging activity of gallic acid showed 4-folds higher than that of α-tocopherol (Jang *et al.,* 2009). Chestnut tannins (source of gallic acid) limiting the development of some unfavorable bacteria, improving the health of the broiler and consequently stimulating growth performance (Schiavone *et al.,* 2008). Liu *et al.* (2009) showed that chestnut tannins significantly enhanced the activity of α-amylase in rabbit small intestinal.

The results are in agreement with Das *et al.* (2014) who found that the highest cumulative BWG in the 2.5% FO-receiving group than 2.5% soybean oil-receiving group. Safamehr *et al.* (2008) and Hosseini and Bahrami (2011) showed that the levels of 2% FO had best significant effects on broiler productive performance. Dietary FO at 1.5, 3 and 4.5 % levels significantly improved performance compared to control treatment. Chashnidel *et al*. (2010). Saleh *et al.* (2009); Chekani-Azar (2010) and Hosseini (2011) they reported that highest final LBW, highest daily BWG and the best FCR in broilers were recorded for the 1.5% FO dietary group followed by the 3 % FO group.

Chae *et al.*, (2006); Koreleski and Swiatkiewicz (2006) and Rebole *et al.* (2006) reported that the broilers fed 200 mg vit.E/ kg had the largest BWG and the best FCR. Furthermore, Starcevic *et al.* (2014) reported that the inclusion of phenolic compounds enhanced growth performance in broilers. Gai *et al.* (2010) reported that feed conversion efficiency was increased in broilers according to dietary tannin level, up to 15 g/ Kg diet. Schiavone *et al.* (2007) reported that the inclusion of SCT at 0.20% in broilers had a significant influences on LBW, and BWG and a favourable influence on FCR in comparison with the other three groups (0%, 0.15% and 0.25% SCT). Schiavone *et al.* (2008) reported that the use of up to 0.20% SCT had a positive influence on growth performance but, the inclusion of more than 0.20% SCT led to undesirable effects as all the measured parameters were the lowest in chick fed 0.25% chestnut tannin added diet.

Carcass traits:

The effect of dietary oils and antioxidants supplementation on carcass traits are shown in Table 3. No significant (P≥0.05) difference among treatments was observed in carcass traits (carcass %, liver %, heart %, gizzard %, abdominal fat %, breast %, wings % and femur %) of broilers.

Table (3). Effect of dietary supplementation with different sources of oils and antioxidants on carcass traits of broiler chicks.

Items	Control	LO	LO + 200mg/kg Vit.E	LO + 0.2 % SCT	FO	FO + 200mg/kg Vit.E	FO + 0.2 % SCT	MSE	P-value
Carcass, %	71.06	71.2	71.59	71.36	72.12	71.75	72.58	1.59	0.66
Liver , %	2.86	2.72	2.71	2.45	2.69	2.42	2.43	0.34	0.17
Heart, %	0.58	0.57	0.53	0.55	0.56	0.59	0.58	0.09	0.94
Gizzard , %	1.81	1.68	1.55	1.67	1.49	1.53	1.47	0.25	0.20
Giblets, %	5.25	4.97	4.79	4.67	4.74	4.53	4.47	0.48	0.12
Abdominal fat, %	1.95	1.89	1.99	1.62	1.45	1.58	1.50	0.40	0.09
Breast, %	24.16	24.37	25.08	24.8	24.5	25.09	25.14	0.90	0.36
Wings, %	7.05	6.88	6.70	6.73	7.13	6.57	6.3	0.52	0.12
Femur, %	22.17	22.82	23.03	22.97	22.95	23.44	23.7	0.85	0.09

LO - Linseed oil; FO - Fish oil; SCT - Sweet chestnut tannins

Similar results were also obtained with Das *et al.* (2014) who showed that no significant differences on all carcass parameters and dressed yield the in the 2.5% FO-receiving group than 2.5% soybean oil-

receiving group. Safamehr *et al.* (2008) found that fed male broiler 2% and 3% FO had no significant effects on weight of carcass yield, abdominal fat, thighs, breast, liver, gizzard, and heart among the treatment. Chekani-Azar *et al.* (2010) observed that carcass traits and in other parts of carcass, such as breast, thigh, liver, gizzard and heart and also, the amount of abdominal fat did not showed significant elevated when levels of dietary fish oil were increased (0, 1.5, 3, or 6 %) in broiler diets. Also, Chashnidel *et al.* (2010) found that no significant differences on percent of carcass to live body weight and abdominal fat percentage to carcass weight in diet contained FO up to 4.5%. Inclusion of vit E in the diets did not significantly influence the proportions of various carcass organs of the rabbits (Eiben *et al.*, 2011 and Ebeid *et al.*, 2013). No significant effects on carcass weight and liver, heart, breast, thigh and wing yields in broilers given LO compared to other lipid sources (Qi *et al*., 2010).

Immunological parameters:

The effects of dietary oils and antioxidants supplementation on immune response are shown in Table 4. Inclusion of FO with or without antioxidants in broiler diets improved antibody titer against sheep red blood cells (SRBCs) in primary immune response ($p \leq 0.05$) compared control. Broiler fed LO + 0.2% SCT, FO, FO + 200 mg vit E/ kg and FO + 0.2% SCT and diets had significantly increased antibody titer against SRBCs in secondary immune response compared to other treatments. No significant ($P \geq 0.05$) difference among treatments was observed in Thymus % and Spleen %. The addition of FO + SCT to broiler diets significantly ($p \leq 0.05$) increased bursa % compared to other treatments.

Table (4). Effect of dietary supplementation with different sources of oils and antioxidants on immunological parameters of broiler chicks

SRBCs antibody titer (1/log 2) titre	Control	LO	LO + 200mg/kg Vit.E	LO + 0.2 % SCT	FO	FO + 200mg/kg Vit.E	FO + 0.2 % SCT	MSE	P-value
Primary (4th wk)	2.40^{c}	2.80b^{c}	3.00^{bc}	3.00^{bc}	3.60^{b}	4.60^{a}	4.80^{a}	0.632	<.0001
Secondary (5th wk)	5.00^{c}	5.80b^{c}	6.00^{bc}	6.40^{b}	6.60^{b}	8.20^{a}	8.20^{a}	0.775	<.0001
Lymphoid organs , %									
Bursa, %	0.207^{cb}	0.215^{b}	0.220^{b}	0.218^{b}	0.220^{b}	0.225^{b}	0.278^{a}	0.038	0.04
Thymus, %	0.323	0.363	0.358	0.357	0.325	0.348	0.387	0.049	0.32
Spleen, %	0.107	0.113	0.112	0.122	0.103	0.118	0.128	0.023	0.55

^{a,b,c,d} *Means within rows with different superscripts differ significantly.*

LO - Linseed oil; FO - Fish oil; SCT - Sweet chestnut tannins; SRBCs - Sheep red blood cells

Supplementation of dietary FO improved the immune system (Tobarek *et al*., 2002), these results could be due to omega-3 which considered to be a substrate for the generation of prostaglandin, leukotriene and interleukin levels (Kidd, 2004). Also the length and degree of saturation of the specific omega-3 PUFAs have a major impact on the effects of dietary supplementation on immune function (Wall *et al*., 2010). Chekani-Azar (2010) found that the chickens fed FO (0, 1.5, 3, or 6 %) rich in omega-3 fatty acids showed an increase in humoral immune activity in response to the injection of SRBCs, the amount and type of PUFAs released in response to inflammatory stimuli depends on the cell membrane phospholipid fatty acid content. This is similar to Hosseini and Bahrami (2011) they indicated that the highest response to primary and secondary injections of SRBCs was observed in 4% FO group, followed by 2% FO group compared to 0 % and 1% FO groups.

A significant increase in humoral immune responses against SRBCs when chickens were provided with higher concentrations of dietary α-tocopherol (200-300 mg/ kg) (Boa-Amponsem *et al.*, 2006). Because of the antioxidant effect of vit E for protect from long chain omega-3 PUFAs of high susceptible to lipid oxidation, can be help for a appropriate depot of Eicosapentaenoic (EPA) and docosahexaenoic (DHA) fatty acids in body by direct transfer from diet or liver conversion and therefore, a higher immune system response of body will actually achieve against diseases types by lipid defense of broiler diet.(Sijben *et al.* 2002 and Jeun-Horng *et al.* 2002). In addition, dietary vit E supplementation at 110 or 220 mg/ kg of feed enhanced phagocytic activity of macrophages toward opsonized SRBCs (Konjufca *et al.*, 2004). Singh *et al.* (2006) reported that chicks receiving supplements of 200 mg vit E/ kg produced significantly higher antibody titres. This was associated with an increased serum concentration of total immunoglobulin and circulatory immune complexes. Moreover, Ebeid *et al. (*2013) reported that dietary

vit E caused an improvement in the antibody titers against SRBCs of growing rabbits. Maroufyan *et al*. (2012) reported that there was no effect of dietary fats on the bursa of Fabricius weight. The increase of bursa % may be attributed to added antioxidants in broilers diets. The chicks given 200 mg vit E/ kg had significantly heavier bursa (Singh *et al.*, 2006).

Plasma lipids:

Results concerning the plasma lipid concentration of broiler chickens fed different sources of oils and antioxidants are presented in Table 5. Significant decrease in plasma total lipid and total cholesterol concentration were observed with all dietary treatments. The lowest plasma total lipid and total cholesterol concentration were recorded for broilers group fed FO + 0.2% SCT. There was no significant difference in plasma triglyceride concentration of broilers chicks among tested treatments.

High-density lipoprotein (HDL) was significantly increased with inclusion of FO (alone or with antioxidants) and LO plus 0.2% SCT in broiler diets compared with the other treatments. While, plasma low-density lipoprotein (LDL) was significantly lowered with tested treatments compared to control in broilers. The best LDL value were observed for the FO + 0.2% SCT dietary group, followed by the FO and FO + 200 mg vit E/ kg groups.

Table (5). Effect of dietary supplementation with different sources of oils and antioxidants on plasma lipids of broiler chicks.

Items	Control	LO	LO + 200mg/kg Vit.E	LO + 0.2 % SCT	FO	FO + 200mg/kg Vit.E	FO + 0.2 % SCT	MSE	P-value
Total lipid(mg/dl)	471.33^{a}	454.00^{b}	453.00^{b}	452.0^{b}	444.33^{b}	448.67^{b}	443.68^{b}	9.2	0.03
Triglyceride(mg/dl)	55.00	52.33	50.67	51.00	49.00	50.33	48.34	5.7	0.82
Total cholesterol(mg/dl)	116.33^{a}	101.66^{b}	102.33^{b}	101.0^{b}	95.33^{b}	98.31^{b}	95.33^{b}	5.9	0.01
HDL(mg/dl)	54.66^{d}	58.66^{bcd}	58.33^{cd}	63.33^{ab}	62.33^{abc}	63.00^{abc}	64.31^{a}	2.6	0.004
LDL(mg/dl)	50.67^{a}	32.53^{b}	33.86^{b}	27.46^{bc}	23.20^{c}	25.26^{c}	21.34^{c}	3.9	<.0001

^{a,b,c,d} *Means within rows with different superscripts differ significantly.*
LO - Linseed oil; FO - Fish oil; SCT - Sweet chestnut tannins
HDL - high-density lipoprotein; LDL - low-density lipoprotein

The inclusion of FO in the broilers diet improved plasma lipoprotein concentrations may be due to the reduction of hepatic synthesis and secretion of triglycerides by decreasing activity of synthetic enzymes, increasing proximal beta oxidation, increasing in the expression of hepatic receptor for LDL which caused by longer chain omega-3 PUFAs such as EPA and DHA (Belzung *et al.*, 1993 and Schumann *et al.*, 2000).

The present results are accordance with Saleh *et al.* (2009) who found that broilers fed FO (0.0%, 1.5%, 3.0 % and 6%) had lower levels of serum cholesterol compared with the control. Also, Safamehr *et al.* (2008) showed that increasing different levels of FO 2% and 3% indicated highest HDL and lowest LDL concentrations in serum than control treatment. Chashnidel *et al.* (2010) found that serum cholesterol and LDL concentrations were significantly reduced by FO as dietary supplements at levels (.5, 3 and 4.5 % than the control diet, but serum HDL concentrations were significantly increased by using diets containing FO. In addition, Hosseini and Bahrami (2011) who used the FO as dietary supplements at levels (0, 1, 2, or 4%) and indicated that the serum cholesterol and triglyceride levels significantly decreased in the FO groups at the 42 DOA. The addition of FO with different levels 1.5, 3, or 6 % significantly decreased in serum cholesterol levels than the control (Hosseini, 2011). Starcevic *et al.* (2014) reported that the inclusion of phenolic compounds decreased cholesterol value.

CONCLUSION

It could be concluded that the inclusion of 2% FO and/or antioxidants of the broiler diets improved the productive performance, humoral immune response and plasma lipid of broilers. Moreover, the addition of 2% fish oil with 0.2% SCT as antioxidants recorded the best productive performance, immune response and plasma lipids of broilers.

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تأثير إضافة الاحماض الدهنية غير المشبعة ومضادات الاكسدة للعليقة على الأداء الإنتاجي والاستجابة المناعية ومقاييس الدم لبداري التسمين

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استهدف البحث دراسة تأثير إضافة زيت بذور الكتان أو زيت السمك بالإضافة الى مضادات الاكسدة او بدون مضادات اكسدة للعليقة على الأداء الإنتاجي، الاستجابة المناعية وصفات الذبيحة وبعض مقاييس الدم لبداري التسمين. تم استخدام 168 كتكوت تسمين عمر يوم وتم تقسيمهم عشوائيا إلى سبعة مجموعات كل مجموعة تتكون من ثلاث مكررات وكل مكرر به ثمانية كتاكيت وتم تغذية الطيور لمدة خمسة أسابيع. جميع الطيور تم تغذيتها على عليقة متزنة فى محتواها من الطاقة والبروتين تحتوي على نفس المكونات بخلاف مصدر الزيت المستخدم وإضافة مضادات أكسدة من عدمه. المجموعة الأولى تم تغذيتها على عليقة تحتوى على 2% زيت صويا بدون أي إضافات أخري (مجموعة المقارنة)، المجموعة الثانية تم تغذيتها على عليقة تحتوى على 2% زيت بذور الكتان، والمجموعة الثالثة تم تغذيتها على عليقة تحتوى على 2% زيت بذور الكتان + 200 ملجم/ كجم فيتامين هـ، والمجموعة الرابعة تم تغذيتها على عليقة تحتوى على 2% زيت بذور كتان + 0.2% مستخلص طبيعى من شجرة نبات أبو فروة، المجموعة الخامسة تم تغذيتها على عليقة تحتوى على 2% زيت سمك، والمجموعة السادسة تم تغذيتها على عليقة تحتوى على 2% زيت سمك + 200 ملجم/ كجم فيتامين هـ، والمجموعة السابعة تم تغذيتها على عليقة تحتوى على 2% زيت سمك + 0.2% مستخلص طبيعى من شجرة نبات أبو فروة .

وكانت النتائج كما يلي، إضافة 2 % زيت السمك مع مضادات الأكسدة أو بدون مضادات أكسدة و2 % زيت كتان + 0.2% مستخلص طبيعي من شجرة نبات أبو فروة أدي إلى زيادة وزن الجسم بالمقارنة بالكنترول. لم تؤثر المعاملات المختلفة على معدل استهلاك الغذاء. كل المعاملات الغذائية أدت إلى تحسن فى معامل التحويل الغذائى بالمقارنة بالكنترول، وكانت أفضل معاملة هي إضافة 2% زيت سمك + 0.2 % مستخلص طبيعى من شجرة نبات أبو فروة ثم 2 % زيت كتان + 0.2 % مستخلص طبيعي من شجرة نبات أبو فروة. لم تؤثر المعاملات المختلفة على وزن وخصائص الذبيحة. إضافة زيت السمك مع مضادات الأكسدة أو بدون مضادات أكسدة و2 % زيت كتان + 0.2 % مستخلص طبيعى من شجرة نبات أبو فروة أدي إلى تحسن الإستجابة المناعية للطيور بالمقارنة بالكنترول. كل المعاملات الغذائية أدت إلى إنخفاض تركيز الدهون الكلية فى البلازما مقارنة بالكنترول. أعلى نسبة ل HDL وأقل نسبة ل LDL كانت من خلال إضافة 2 % زيت سمك + 0.2 % مستخلص طبيعي من شجرة نبات أبو فروة. لم تؤثر المعاملات المختلفة على مستوى الدهون الثلاثية فى البلازما.

ومن خلال النتائج السابقة توضح الدراسة أن إضافة 2% زيت سمك مع او بدون مضادات اكسدة أدى الى تحسن الأداء الانتاجى والاستجابة المناعية كذلك بعض مقاييس الدم في بدارى التسمين. ولكن أفضل النتائج كانت باستخدام 2% زيت سمك + 0.2% مستخلص طبيعى من شجرة نبات أبو فروة في علائق بدارى التسمين.