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PHYSIOLOGICAL AND IMMUNOLOGICAL PERFORMANCE OF DOMYATI DUCKLINGS FED DIFFERENT LEVELS OF COCONUT OIL.

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ABSTRACT: This study aimed to determine the effect of dietary supplementation of coconut oil levels on some physiological and immunological responses in ducklings during growing period (28-89 day of age). A total number of 120 Domyati ducklings, 28- day old were used, weighted 530-545 g and divided into four experimental groups, each of three replicates to determine the effects of feeding diets contained different levels of coconut oil (CO) as a medium chain fatty acids (MCFA) source. The experimental groups were arranged as follows: The first as a control group (G_1) which received basal diet without any supplementation, while the second, third and fourth groups (G_2, G_3 and G_4) were received diet contained CO by 1.0, 1.5 and 2.0 %, respectively. The results revealed that, percentages of heterophils and lymphocytes were significantly ($P \leq 0.01$) lower and higher, respectively, for Domyati ducklings in G_4 than those in the control group (G_1). Some blood hematological values (Hb and RBCs) did not significantly affected by different CO levels. The ratio of hetrophil to lymphocytes (H/L) was significantly ($P \leq 0.01$) lower for Domyati ducklings in G_2 and G_4 than those in G_1. Spleen and thymus indexes were significantly ($P \leq 0.05$) increased in treated groups compared to the control one. Moreover, dietary CO levels caused to increase the values of plasma IgG, IgM and IgA concentrations than that of the control group. The different dietary levels of CO significantly influence the lipid peroxidation (LPO) by decreasing MDA values. Conclusively, ducklings fed diet supplemented with 1.5 or 2% CO had heavy immune organs weights, and high plasma levels of immunoglobulins, which collectively suggested as an improvement in the immune response.

Keywords: Ducks - coconut oil - immune response - blood parameters.

INTRODUCTION

Enhancing the ability of immunity to resist the diseases of livestock without antibiotics would not only benefit the animal's health, welfare and production efficiency but it is also a crucial strategy in efforts to improve the microbiological safety of poultry products (Huff et al., 2006). Accordingly, a welfare disorder in the duck is observable from three indicators - physiology, production and immune system (Lawrence and Stott 2009; McGrath et al., 2010). Blood is an important component to organize body physiology and serves as a fowl health indicator (El-Badry et al., 2009; Ismoyowati et al., 2012 and Syahruddin and Yoki, 2013). Sejian et al. (2011) stated that animal welfare involves adaptations of normal physiology and behavior leading to health status that ultimately increases productivity. The index of immune organs reflected the growing development of thymus and spleen which was used to estimate the immune state of birds (Shi-bin and Hong, 2012).

The vast majority of fats in duck dietary composed of molecules known as long chain triglyceride (LCT). The most common oil or meal used in duck's diets formulation is the soyabean meal (SBM) (poly unsaturated) that contains LCT. The long-chain fatty acid (LCFA) commonly found in most diets are incorporated into chylomicrons after being absorbed in the intestine where they are subjected to re-esterification and then reach the blood stream via the lymphatic system (Ferreira et al., 2014). Most LCFA are stored in the adipose tissue (Rego Costa et al., 2012). In contrast, medium-chain fatty acids (MCFA) have been reported to reduce fat deposition (Han et al., 2003 and Takeuchi et al., 2006) and improve serum lipid profiles in humans and rats (Han et al., 2003).

Coconut oil (CO) is highly saturated oil and 60% of their total fatty acid compositions are medium-chain fatty acid (MCFA) with a chain length of 6 to 12 carbon atoms (Bhatnagar et al., 2009), which are absorbed directly into the portal circulation without re-esterification in intestinal cells (Ferreira et al., 2014). The MCFA are partly independent of the carnitine transport mechanism into the mitochondria of the liver and are rapidly and exclusively oxidized for the production of energy (Rubin et al., 2000). Coconut oil could improve fat digestion and performance values during the coccidiosis infection Adams et al., 1996). Besides in vitro test showed that several fatty acids in CO are potential as antibacterial (Bergsson et al., 2001), antivirus (Bartolotta et al., 2001), and immune-stimulant (Witcher et al., 1996), which are important to fight infection. The immune system required antioxidants product that maintained the balance of immune cells (haematopoesis), protects cell membranes from ROS, to fight microorganisms cause disease (Tugiyanti1 et al., 2016). Mohammadzade et al. (2013) showed that with application of medium chain fatty acids as a prebiotic there is no need to antibiotic administration. They added that, this method is cost effective and leads to better quality.

Very little information is available on using CO as a source of MCFA for improving physiological and immunological indices of ducklings. Also, no local duck breeds studies showed whether or not it could be used beneficially than other sources of energy

especially during fattening period. Moreover, inclusion level of CO in growing duck's diet is not definitely known. Therefore, the current study was undertaken to investigate the effect of feeding diets contained different CO levels on some physiological and immunological parameters of Domyati ducklings during growing period (28-89 day of age).

MATERIAL AND METHODS

The present experiment was carried out at El-Serw Water Fowl Research Station, Damietta Governorate, which belongs to Animal Production Research Institute (APRI), Agricultural Research Center (ARC), Ministry of Agriculture, Egypt.

Birds management and diets:

A total number of 120 Domyati ducklings aged 28-day old were used and weighted between 530-545 g then divided randomly into four equal experimental groups; each of three replicates. The first as a control group (G_1) which fed a basal diet, while the 2nd, 3rd and 4th groups (G_2, G_3 and G_4, respectively) were fed diets supplemented with three levels of coconut oil (1, 1.5 and 2 %/kg diet, respectively) from 28 days up to the end of experimental period at 89 days of age. Ducklings of each replicate were housed as 3.3 duck /m^2 in a house with windows and received additional artificial light to provide 16 h light and 8 h dark daily. Throughout the experimental period, feed and fresh water were available at all the time. All ducklings were kept under similar environmental and managerial conditions. All ducklings fed on commercial diets. All diets were nearly iso-nitrogenous and iso-caloric on the basis of metabolizable energy and contained similar levels of microelements. Table 2 represents the formulation and nutrient composition of these diets.

Table 1 shows the fatty acids composition in coconut oil.

Data collection:

At marketing age (89 d), twelve ducklings were randomly taken from each experimental group (three from each group) and slaughtered. Ducks were fasted for 12 hours before slaughter. Spleen and thymus weight were recorded and their indexes were calculated according to the formula of Indu et al. (2011): spleen index = spleen weight/body weight, thymus index= thymus weight/body weight.

Immediately after slaughtering, blood samples of ducklings were collected from twelve ducks/ each group. The samples were collected into dry clean centrifuge tubes; the plasma was separated by centrifugation at 3000 r.p.m. for 20 minutes and kept in a deep freezer at -20 ^{0}C until biochemical analysis. Non-coagulated blood was tested shortly after collection for determination of blood pictures including, red blood cells count (RBCs, 10^6/mm^3), white blood cells count (WBCs, 10^3/mm^3); different subclasses of WBC's (eosinophil, monocytes, heterophils and lymphocytes percentages) and hemoglobin (Hb, g/dl) concentration according to Drew et al.(2004). The levels of immunoglobulin G (IgG, µg mL-1), immunoglobulin M (IgM, µg mL-1) and immunoglobulin A (IgA, µg mL-1) were also measured in the plasma by an ELISA reader (SIRIO S, Italy) using ELISA commercial test kits (Cusabio, rat immunoglobulin M, ELISA kit, catalogue number CSB-E07978r ; Cusabio, rat immunoglobulin G, ELISA kit, catalogue number CSB-E079981r, China). Total antioxidant capacity (TAC, mmol/L) were determined using commercial kits. Also, the levels of malondialdehyde (MDA, nmol/ml) were measured by the xanthine oxidase method and thiobarbituric acid (TBA) coloration,

respectively. Commercial kits were purchased from Nanjing Jiancheng Bioengineering Institute, China. All samples were run in duplicate and assayed by the same investigator, who was blind to the experimental situation.

Statistical analysis:

Data were statistically analyzed according to SAS (2000), computer program using the following fixed model: $Y_{ij}=\mu + T_i + e_{ij}$ Where: Y_{ij} = The observation; μ = Overall mean; T_i = Effect of treatments (i = 1, 2, 3 and 4); e_{ij}= Random error component assumed to be normally distributed. Data presented as percentages were transformed to the corresponding arcsine values before being statistically analyzed (Warren and Gregory, 2005). The differences among means were tested using Duncan's New Multiple Range Test Duncan (1955). All data are presented as least square means.

RESULT AND DISCUSSION

Effect of dietary coconut oil levels on Hematological indices:

Data in Table 3 shows that, heterophils and lymphocytes percentages were significantly ($P\leq0.01$) lower and higher, for Domyati ducklings in G_4 than those of the control group, respectively. However, these values are still within normal ranges. On contrary of the present results, Khatibjoo et al. (2017) reported that supplementing MCFA to broiler's diet resulted in significantly increased and decreased percentages of heterophils and lymphocytes, respectively. Some blood hematological values (Hb and RBCs) did not significantly affected by feeding different CO levels in duckling,s diets.

Our results shows that total leucocyte count in Domyati ducklings were relatively similar to the results obtained by (Tugiyanti et al., 2016). Leucocyte counts of G_3 and G_4 groups were significantly differed ($P\leq0.05$) as compared to G_1 (see Table 3). These results are in good agreement with El-Kholy et al. (2014) indicating that the inclusion levels of CO in the diet are very effective on humoral immunity and immune cells of poultry. These results suggest that CO inclusion may enhance immune system activity through several fatty acids, which are potent as immune stimulants (Tugiyanti1 et al., 2016); and phenolic compounds in CO, such as caffeic, p-coumaric and ferulic acids and catechin, which improve antioxidant capacity (Kapila and Dissanayake, 2008). These changes could be attributed either to a direct stimulating effect of CO on the lymphoid organs or to the production of specific or non-specific antibodies against different antigens. Furthermore, these results confirm that supplementing CO improve the immune system by increasing lymphocyte count which produces antibody to help disease prevention (Lawhead and Baker, 2015).

The heterophil to lymphocytes ratio (H/L) was significantly ($P\leq0.01$) lower for Domyati ducklings in G_3 and G_4 than those of the G_1. This can be interpreted based on the increase of CO could increase the amount of lymphocyte that improve antibody production, and hence the ducks immunity. Ismoyowati et al. (2012) stated that the fowl comfort may be indicated by measuring the H/L ratio. The H/L ratio is more liable as a fowl comfort than blood corticosterone level (Mohammadzade et al., 2013). McGrath et al. (2010) stated that fowl in a good welfare or normal physiological condition and thermoneutral zone is indicated with a lower H/L value than that of distress environment.

Lymphatic organs:

Data in Table 4 showed that spleen and thymus indexes significantly ($P\leq0.05$)

increased in treated groups compared to control one. These results are in disagreement with findings of Khatibjoo et al. (2017) that showed that dietary MCFA addition to broiler's diet did not significantly influenced spleen and thymus weight. The main immune organ such as thymus and spleen as secondary immune organ in avian species perform greatly significant roles in immunity of birds, including the main local sites for the maturation, differentiation and proliferation of lymphocytes. The Thymus is a main immunity organ. It is also the main place of differencing, maturing T lymphocyte and excreting thymus hormone (Fu-Chang et al., 2004). The spleen, a crucial non-specific peripheral lymphoid organ, has a dominant role in the generation of immune responses because of the absence of well-developed lymph nodes in most avian species, including the chickens (Mast and Goddeeris, 1999).

Immune proteins in poultry are dependent on lymphatic organs which are essential for transformation of IgM to IgG or functional IgA (Sang-Oh and Byung-Sung, 2011). Therefore, increased production of cells containing immune proteins and increased blood concentration of immune proteins "as mentioned later" can be considered as a reciprocating act of lymphatic organs found in ducks fed with CO.

In our study, we found that ducklings fed diets contained different levels of CO had significantly ($P \leq 0.05$) increased the relative weights of spleen and thymus as reflected by indices of these main immune organs. From the above observations, we could elementarily postulate that CO had immune enhancing effects.

Immunoglobulins concentration:-

Data in Table 5 cleared that, dietary CO levels in the diets increased values ($P \leq 0.05$) of plasma IgG, IgM and IgA concentrations than that of the control group. However, there were insignificant differences in these immunoglobulin concentrations of the ducklings received 1% CO (G_2) compared with that of the control group (G_1). Increased and stimulation of immunoglobulins concentrations with CO supplementation as observed in the present study may be an indication of CO induces earlier maturation of the humoral immune responses and that effect is evened out upon the maturation of the immune system. Also, a high plasma IgG level in ducklings treated with CO is evidence that CO are effective in improving humoral immunity (Park, 2008). Since, Meissonnier et al. (2008) showed that determinations of the concentrations of serum immunoglobulin such as IgA, IgG, and IgM are the most common methods of testing humoral immune responses.

Through an increase in the digestion and absorption of nutrients by dietary CO inclusion (El-Kholy et al., 2014) dietary CO levels in the present study is expected to increase the availability of circulating amino acids for immunoglobulin synthesis by B lymphocytes. Since blood IgA or IgM concentrations were altered on G_2 and G_3 seem to have mainly impact on mucosal antibody response in this experimental setting.

Immunoglobulins are produced in B-cells in bone marrow and the biological characteristics of IgG, IgA and IgM in poultry are similar to those of immunoglobulins in mammals. Since IgG is present at the highest concentration and is responsible for immunologic competence, the immunopotency of

plasma IgG can be used as an index of humoral immunity (Sang-Oh and Byung-Sung, 2011). Another possible explanation is that the dietary CO made ducks more immunostimulant.

Lipid peroxidation and antioxidant defense system:

Data presented in the Table 6 revealed that the different dietary levels of CO influence significantly the lipid peroxidation (LPO) by decreasing MDA values. This result is in agreement with findings of El-Kholy et al. (2014) in rabbits. The low levels of lipid peroxidation for treated groups (G_3 and G_4) compared to those in G_1 confirmed the presence of low amount of fatty acids in treated groups compared to G_1. In this respect, Ferreira et al. (2014) showed that energy derived from MCTs is used directly by organs and muscles, instead of being stored as fat. Moreover, the CO supplementation into the duck's diet decreased MDA content may be related to reduce fat deposition by decreasing the activities of lipoprotein lipase and malate dehydrogenase activities or increasing the activity of hormone-sensitive lipase in the adipose tissue (Lu et al., 2007).

The effect of CO levels in the diet on total antioxidant capacity (TAC) was so clear, where treated groups with high levels (G_3 and G_4) showed significant ($P \leq 0.05$) increase in their TAC by about 4.6 and 17.6% on averages, respectively (Table 6). So, CO may possess a noticeable source of compounds with health protective potential and antioxidant activity. In this respect, Kapila and Dissanayake (2008) observed phenolic compounds in CO, such as caffeic, p-coumaric and ferulic acids and catechin, result in improvement of antioxidant related to health benefits.

Carotenoids, an important constituent of CO, play an important role in protection against photo-oxidative processes by acting as oxygen and peroxyl radical scavengers. Their synergistic action with other antioxidants makes them more potent compound. It has been suggested that different individual compounds exhibiting a variety of antioxidant activities which may provide additional protection against oxidative stress when ingested simultaneously (Zhang et al., 1995). They demonstrated that a combination of lipophilic antioxidants present in MCFA results in an inhibition of lipid peroxidation which is significantly greater than the sum of the individual effects of other oxidative factors. So, this suggests that a cocktail of antioxidants may have more profound anti-oxidative effect due to the synergistic action more than the individual compounds.

The antioxidant properties of CO has been attributed to the synergistic actions of carotenoids and vitamin E in the presence of lycopene in natural food and this might provide the ultimate dietary supplement to fight disease associated with oxidative stress (El-Kholy et al., 2014 and Van Rooyen et al., 2008).

CONCLUSIVELY

Domyati ducklings fed diet supplemented with 1.5 or 2% CO had high plasma immunoglobulins levels, which collectively suggest an improvement in the immune response**.**

Table 1: Fatty acids composition of coconut oil*.

Common name	Composition	%	
Caproic acid	C 6:0	0.4 - 0.6	Medium Chain Triglycerides (MCTs) 65 %
Caprylic acid	C 8:0	4.6 – 10	
Capric acid	C 10:0	5.0 - 8.0	
Lauric acid	C 12:0	45.1 - 53.2	
Myristic acid	C 14:0	16.8 - 21.	
Palmitic acid	C 16:0	7.5 – 10	
Stearic acid	C 18:0	2.0 - 4.0	
Oleic acid	C 18:1	5.0 - 10.0	
Linoleic acid	C 18:2	1.0 - 2.5	
Other	C 18:3 C 24:1	< 0.5	

*Source: Rossell, (1985).

Table 2: Ingredients and calculated chemical analysis of experimental diets.

Ingredients, %	**Treatments (coconut oil levels, %)**			
	0.0 (G_1)	**1.0 (G_2)**	**1.5 (G_3)**	**2.0 (G4)**
Yellow corn	66.83	64.33	63.05	61.85
Soybean meal	18.41	18.21	18.21	18.11
Coconut oil	00.00	01.00	01.50	02.00
Wheat bran	11.28	12.98	13.76	14.56
Calcium carbonate	01.25	01.25	01.25	01.25
Dicalcium phosphate	01.35	01.35	01.35	01.35
DL.-Methionine	00.13	00.13	00.13	00.13
Vit. and mineral premix*	00.30	00.30	00.30	00.30
NaCl	00.35	00.35	00.35	00.35
Sodium Bicarbonate	00.10	00.10	00.10	00.10
Calculated analysis:				
Crude protein (%)	15	15	15	15
ME (Kcal/Kg)	2800	2800	2800	2800
Lysine (%)	0.75	0.75	0.75	0.75
Crude fiber (%)	3.28	3.28	3.28	3.28
Methionine (%)	0.35	0.35	0.35	0.35
Methionine +Cystine(%)	0.60	0.60	0.60	0.60
Threonine (%)	0.27	0.27	0.27	0.27
Calcium (%)	0.85	0.85	0.85	0.85
Available Phosphorus(%)	0.40	0.40	0.40	0.40
Chlorine (%)	0.22	0.22	0.22	0.22
Sodium (%)	0.17	0.17	0.17	0.17

*Vit+Min mix. Provided per kilogram of the diet Vit. A : 6000 IU, Vit. E (dl-α-Tocopherylacetate : 10 IU, menadione : 2.5 mg, Vit. D3 : 2000 ICU, riboflavin: 2.5 mg, calcium pantothenate: 10 mg, nicotinic acid :12 mg, Choline chloride: 300 mg, Vit. B12 : 4 µg, Vit. B 6 : 5 mg, thiamine : 3 mg, folic acid :0.50 mg, and biotin :0.02 mg. Trace mineral (mg/ kg of diet :Mn : 80 mg , Zn :60 mg, Fe :35 mg ,Cu : 8 mg and Se: 0.1 mg).

Table 3: Effect of different dietary coconut oil levels on some hematological parameters of Domyati ducklings.

Items[1]	Treatments (coconut oil levels, %)			
	0.0 (G_1)	1.0 (G_2)	1.5 (G_3)	2.0 (G_4)
RBCs (10^6/mn^3)	06.60±0.06	06.70±0.06	06.70±0.06	06.40±0.06
WBCs (10^3/mn)	20.00^{a}±0.58	20.00^{a}± 0.58	16.00^{c}±0.58	18.00^{b}±0.58
Hb (g/dl)	13.20±0.06	13.40±0.06	12.10 ±0.06	12.70 ±0.06
Eosinophils (E, %)	02.00±0.58	02.00 ±0.58	02.00±0.58	02.00±0.58
Monocytes (M, %)	12.00^{bc}±0.58	13.00^{b} ±0.58	11.00^{d} ±0.58	15.00^{a}±0.58
Heterophils (H, %)	14.00^{a}±0.58	12.00^{b}±0.58	14.00^{a}±0.58	11.50^{b}±0.58
Lymphocytes (L, %)	72.00^{c}±0.57	73.00^{b}±0.57	73.00^{b}±0.57	73.50^{a}±0.57
H/L (%)	00.20^{a}±0.01	00.16^{bc}±0.01	00.19^{ab}±0.01	00.16^{c}±0.01

[a,b, c] Means in the same row with different superscript are significantly different(P≤0.05).

[1]RBCs, red blood cells; WBCs, white blood cells; Hb, hemoglobin

Table 4: Effect of different dietary coconut oil levels on immunity index of Domyati ducklings at 89 d of age.

Items	Treatments (coconut oil levels, %)			
	0.0 (G_1)	1.0 (G_2)	1.5 (G_3)	2.0 (G_4)
Live body weight, g (BW)	1801.17^{b}±112.8	1850.00^{b}±112.8	2083.43^{a}±112.8	1960.67^{a}±112.8
Spleen index (weight % BW)	0.020^{c}±0.003	0.021^{c}±0.002	0.033^{b}±0.005	0.041^{a}±0.007
Thymus index (weight % BW)	0.111^{c}±0.015	0.122^{b}±0.018	0.231^{a}±0.013	0.235^{a}±0.019

[a, b, c] Means in the same row with different superscript are significantly different (P≤0.05).

Table 5: Effect of different dietary coconut oil levels on plasma immunoglobulins concentration of Domyati ducklings.

Items	Treatments (coconut oil levels, %)			
	0.0 (G_1)	**1.0 (G_2)**	**1.5 (G_3)**	**2.0 (G_4)**
IgG (µg mL^{-1})	5.78^{b}±0.25	5.85^{b}±0.25	6.09^{a}±0.25	6.22^{a}±0.25
IgM (µg mL^{-1})	2.50^{b}±0.12	2.54^{b}±0.12	2.70^{ab}±0.12	2.92^{a}±0.12
IgA (µg mL^{-1})	3.24^{b}±0.15	3.35^{b}±0.15	3.39^{a}±0.15	3.30^{b}±0.15

^{a,b} Means in the same row with different superscript are significantly different (P≤0.05).

Table 6: Effect of different dietary coconut oil levels on some oxidative status parameters of Domyati ducklings.

Items	Treatments (coconut oil levels, %)			
	0.0 (G1)	**1.0 (G2)**	**1.5 (G3)**	**2.0 (G4)**
MDA(n mol/ml)	31.63^{ab}±2.67	33.43^{a}±2.67	29.90^{bc}±2.60	23.00^{d}±2.67
TAC(mmol/L)	1.08^{c}±0.06	0.99^{c}±0.06	1.13^{b}±0.06	1.27^{a}±0.06

^{a,b,c,d} Means in the same row with different superscript are significantly different (P≤0.05).
[1]MDA,malondialdehyde; TAC,total antioxidant capacity

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الملخص العربي

الأداء الفسيولوجي والمناعي لكتاكيت البط الدمياطي المغذاه على مستويات مختلفة من زيت جوز الهند

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أجريت هذه الدراسة في محطة بحوث السرو بمحافظة دمياط التابعة لمعهد بحوث الإنتاج الحيواني-مركز البحوث الزراعية. تهدف هذه الدراسة إلى تقييم إضافة مستويات مختلفة من زيت جوز الهند لعلائق البط الدمياطي على الأداء الفسيولوجي والمناعي عند عمر 89 يوم. أستخدم في هذه التجربة عدد 120 من كتاكيت البط الدمياطي الغير مجنس عمر 28 يوم والتي وزعت على أربع معاملات، بكل منها 30 كتكوت موزعة على 3 مكررات، وزعت المعاملات التجريبية كالتالي: المجموعة الأولى للمقارنة (كنترول) وتم تغذيتها على العليقة الأساسية بدون إضافة بينما غُذيت المجموعات الثانية والثالثة والرابعة على علائق تحتوي على زيت جوز الهند بمستويات 1 و 1.5 و2% لكل كجم علف.أظهرت النتائج ارتفاع في نسبة الخلايا الليمفاوية في المجموعة الرابعة مقارنة بمجموعة الكنترول. كما أوضحت النتائج أن بعض قيم صورة الدم (الهيموجلوبين و خلايا الدم الحمراء) لم تتأثر معنوياً نتيجة وجود المستويات المختلفة من زيت جوز الهند في العليقة خلال فترة التجربة (من 28 إلى 89 يوم من العمر). وكانت قيم النسبة بين الخلايا المتعادلة إلى الليمفاوية منخفضة بصورة معنوية للبط المتواجد بالمجموعات الثانية والرابعة مقارنة بالمجموعة الأولى. كما اوضحت النتائج وجود إرتفاعاً معنوياً في قيمة دليل لكل من الطحال والغدة الثيموسية في المجموعات المعاملة مقارنة بالمجموعة الكنترول. أدت المستويات المختلفة لزيت جوز الهند في العلائق إلى زيادة معنوية في الجلوبيونات المناعية (IgG, IgM and IgA) مقارنة بالمجموعة الكنترول. كما بينت النتائج أن تأكسد الدهون قد تأثر بصورة معنوية نتيجة وجود المستويات المختلفة لزيت جوز الهند وذلك بإنخفاض قيم الـ MDA. وخلُصت الدراسة إلى أن وجود زيت جوز الهند بعلائق كتاكيت البط بمستوى 1.5 أو 2% يمكن أن يؤدي إلى زيادة أوزان الأعضاء والجلوبيولينات المناعية والتي تلعب دورا في تطور وتحسن الإستجابة المناعية لكتاكيت البط.