EFFECT OF OLIVE OIL SUPPLEMENTATION ON GROWTH, CARCASS TRAITS AND GENERAL HEALTH OF RABBITS UNDER HEAT STRESS CONDITIONS

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SUMMARY

The aim of this experiment is to estimate the effects of olive oil treatment at different levels on growth performance, feed utilization, blood components and immunity indices of weaned New Zealand White (NZW) rabbits. A total of 40 weaned NZW rabbits, aged 5 weeks at the start of the experiment and weighed 702.58±12.70 g live body weight (LBW) were assigned randomly into four similar experimental groups of 10 rabbits in each group (5 males and 5 females). Rabbits in all groups were fed commercial pelleted diet (CPD) containing about 18% CP, 13% CF and DE (2800 Kcal/kg). Rabbits in the 1st group (G1), 2nd group (G2) and 3rd group (G3) were fed CPD supplemented with 0.2, 0.4 and 0.6% olive oil, respectively. Rabbits in 4th group (G4) were fed un-supplemented CPD and served as a control group. Results showed that rabbits fed olive oil diets (G1, G2 and G3) consumed less ($P<0.05$) feeds, had heavier LBW ($P<0.05$), average daily gain and had better ($P<0.05$) feed conversion ratio than those fed control one (G4). Olive oil treatments did not affect ($P\geq0.05$) on carcass traits, and concentration of total proteins, glucose, cholesterol and HDL concentrations, as well as immunity indices. The histological examination indicated normal liver and kidney function of both treatment groups and suggested higher absorptive surface area of small intestine in G3 than in other groups. In conclusion, adding olive oil at different levels to the diet (0.2, 0.4 and 0.6%) had positive effects on growth performance parameters, without adversely effects on blood biochemicals, enzyme activity, carcass traits and general health status of growing rabbits during the age interval from 5 to 13 weeks of age under heat stress conditions. Dietary addition of olive oil at a level of 0.6% showed the best results.

Keywords: *rabbits, olive oil, performance, carcass, blood, immunity*.

INTRODUCTION

Rabbits is one of the largest targets in the feed industries to meet animal protein needs for human protein requirements. Rabbit meat is characterized by low cholesterol contend, which avoid the side effects of animal protein causing hypercholesterolemia.

Olive oil, has been associated with lower incidence of cardiovascular disease (Keys, 1995). Recent findings explained that the beneficial effect of olive oil consumption may be partially return to the positive effect of phenolic compounds that exert antioxidant activities in vitro (Visioli *et al*., 1995) and in vivo (Wiseman *et al*., 1996). Dietary supplementation with virgin olive oil given to rabbits fed an atherogenic diet resulted in reduced vascular thrombogenecity and platelet activation by ADP and collagen (De La Cruz *et al*., 2000). Moreover, olive oil is a good source of monounsaturated fat and antioxidants as chlorophyll, carotenoids and vitamin E. In addition to, healthy influences of olive oil may be return to high concentration of pervious compounds and other polyphenolic antioxidants as tyrosol, hydroxyl tyrosol, which not only inhabit free radicals scavenging formulation, but also protect vitamin E (alpha tocopherol) present in olive oil (Morello et al., 2004).

Scientists have identified a compound in olive oil called oleuropein as an antioxidant compound which protect the low-density lipoproteins (LDL) of total cholesterol from oxidizing. It is the oxidized cholesterol that sticks to the walls of the arteries and forms plaque (Decker, 1995). It was identified that oleic acid as a monounsaturated fatty acid found in olive oil can decrease the effect of an oncogene which causing cancer status. Olive oil showed an increasing the immune response against Newcastle disease. Also, olive oil improved final live BW and daily gain compared to control without affecting triglycerides, LDL, very LDL and saturated fatty acids when compared with the control (El-Bahra and Ahamed, 2012).

This study aimed to evaluate the effect of olive oil treatment at different levels on growth performance, feed utilization, blood components and immunity indices of growing rabbits, under heat stress conditions.

MATERIALS AND METHODS

This study was carried out at a private rabbit farm, Gharbia governorate, during the period from 15 July to 15 September, 2016 in co-operation with Faculty of Agriculture, Animal Production Department, Tanta University.

Animals:

A total of 40 weaned New Zealand White (NZW) rabbits aged 5 weeks at the start of the experiment and weighed 702.58±12.70 g average live body weight (LBW) were assigned randomly into four similar experimental groups of 10 rabbits in each group (5 males and 5 females). All rabbits were kept in community battery cages with 5 replicates (2 rabbits per cage), five replicates for each sex in 25 x 50 x 35 cm wire cages, set up in a close rabbit house with suitable ventilation. All rabbits were managed under the same conditions.

Feeding system and experimental groups:

Rabbits in all groups were fed ad libitum on commercial basal diet (CBD). Rabbits in the 1st group (G1), 2nd group (G2) and 3rd group (G3) were fed CBD supplemented with 0.2, 0.4 and 0.6% olive oil, respectively. Meanwhile, those in 4th group (G4) were fed un-supplemented CBD and served as a control group. Ingredients and chemical composition of the basal diet are shown in Table (1). Water was available through water nipple in each cage. The experimental period lasted from 5 up to 13 wk of age.

Table (1): Ingredients and chemical analysis of the basal diets fed to rabbits in experimental groups.

Ingredient	%	Chemical analysis (on DM basis)	%
Berseem hay	30.05	Crude protein	17.75
Barley	24.60	Crude fiber	12.38
Wheat bran	21.50	Ether extract	2.27
Soybean meal (44% CP)	17.50	Calcium	1.24
Molasses	3.00	Total phosphorus	0.80
Di-calcium phosphate	1.60	Lysine	0.98
Limestone	0.95	Methionine	0.46
Sodium chloride (NaCl)	0.30	Methionine + Cystine	0.76
Vitamin & Mineral Mixture*	0.30	Sodium	0.16
DL-Methionine	0.20	Digestible energy (Kcal/kg diet)	2500

**Supplied per kilogram of diet: Vitamin A, 6000 IU; Vitamin D3, 900 IU; Vitamin E, 40 mg; Vitamin K3, 2 mg; Vitamin B1, 2 mg; Vitamin B2, 4 mg; Vitamin B6, 2 mg; Pantothenic acid, 10 mg; Vitamin B12, 0.01 mg; Niacin, 50 mg; Folic acid, 3 mg; Biotin, 0.05 mg; Choline, 250 mg; Fe, 50 mg; Mn, 85 mg; Cu, 5 mg; Co, 0.1 mg; Se, 0,1 mg; I, 0.2 mg and Zn, 50 mg.*

Climatic conditions:

Means of estimating the severity of heat stress was proposed using both ambient temperature and relative humidity, termed as the temperature humidity index (THI) (Marai et al., 2007). When the temperature is expressed in 0C, the equation as follows: THI = db0C − {(0.31 − 0.31 RH) (db0C − 14.4)} where db0C is the dry bulb temperature (0C) and RH is the relative humidity (RH%)/100. The values obtained indicate the following: <22.2 = absence of heat stress; 22.2 to <23.3 = moderate heat stress: 23.3 to <25.6 = severe heat stress and ≥25.6 = extreme severe heat stress. Ambient temperature, relative humidity index and thermal-humidity index (THI) values in different months of the experimental period (July-September) presented in Table (2) indicated that rabbits in the experimental groups severed from heat stress during the whole experimental period, because THI values were >25.6 in this period. This indicated that rabbits extremely severed from heat stress throughout all months studied.

Table (2): Thermal-humidity index (THI) values based on ambient temperature, relative humidity during different months of the experimental period (15 July -15 September).

Item	15 July	August	15 September
Ambient temperature (^oC):			
Maximum	36.71±1.40	35.61±1.20	34.91±0.80
Minimum	26.41±1.66	25.17±0.98	25.34±0.53
Relative humidity (%):			
Maximum	79.29±9.99	82.83±2.78	80.38±0.96
Minimum	49.00±13.85	44.67±7.57	50.85±10.13
THI value:			
Maximum	33.56±1.46	32.59±1.08	31.78±0.59
Minimum	24.56±1.89	23.33±0.91	23.68±0.78

Experimental procedures:

Growth performance parameters:

Live body weight and feed intake were weekly recorded from 5 to 13 weeks of age. Daily weight gain and feed conversion ratio were calculated at week intervals. Number of dead bunnies throughout the experimental period was recorded and viability rate was calculated. Relative growth rate (RGR) and performance index (PI) were calculated as the following:

$$RGR\ (\%) = (W2-W1)/½\ (W2+W1) \times 100.$$

Whereas: W1=initial LBW and W2 = final LBW.

$$PI = (Final\ LBW/feed\ conversion\ ratio) \times 100.$$

Blood sampling:

Blood samples were collected, during slaughter, from three male rabbits from each group into centrifuge tubes without anticoagulant. Blood serum was separated by centrifugation of blood samples at 3000 rpm for 15 minutes and kept frozen at -20oC till assayed. Concentration of total proteins, albumin, immunoglobulins (IgG and IgM), glucose, cholesterol, triglycerides, high density lipoproteins (HDL), low density lipoproteins (LDL), creatinine, urea, triiodothyronine (T3) and tetraiodothyronine (T4, thyroxin), as well as activity of aspartate (AST) and alanine (ALT) transaminases were determined in blood serum.

Blood biochemicals were determined spectrophotometrically using commercial kits (Bio-Merieux, Laboratory Reagents and Products, France). Direct radioimmunoassay technique (RIA) was performed for serum triiodothyronine (T3) and thyroxin (T4) hormones using ready antibody coated tubes kits.

Carcass traits:

At the end of the experimental period (13 wk of age), three male rabbits from each group were randomly chosen, fasted for 12 h, weighed and slaughtered to evaluate carcass traits. Carcass and body internal organs were weighed as absolute and calculated relative to LBW of each animal.

Histological study:

Representative samples were taken from the median part of each liver, kidney and small intestine (jejunum), fixed in Bouin's solution (24 h), washed, dehydrated in ascending grades of ethyl alcohol, cleared and embedded in paraffin wax. Thereafter, the samples were sectioned at 5-7 microns, stained by hematoxylin and eosin stains (H&E) and histologically examined using the routine method.

Statistical analysis:

Data of all growth performance parameters, blood parameters and carcass traits were statistically analyzed using one-way design to study the effect of olive oil treatment. General Linear Model Program procedures of SAS (2004) was used, however, Duncan's multiple range tests was performed (Duncan, 1955) to test the significant differences among means. All significant differences were set at a level of $P<0.05$.

RESULTS AND DISCUSSION

Live body weight:

The influence of olive oil treatment on live body weight of growing rabbits is presented in Fig. (1). Results showed that oil treatment had no significant ($P\geq0.05$) effect on live body weight of the experimental rabbits from 5 up to 9 weeks of age. On the other hand, rabbits were significantly ($P<0.05$) heavier in G3 than in G4, but did not differ significantly from those in G1 and G2, which showed significant ($P<0.05$) differences with G4 only at 12 and 13 weeks of age. It is of interest to note that the beneficial effects of the highest olive oil (0.6%) treatment appeared from 9 up to 13 weeks age. This may be attributed to that growing rabbits at early age post-weaning required a transit period to adapt on increasing level of dietary fats. The present results agreed with Ashraf *et al*. (2017), who investigated the effect of olive oil, blackseed oil and flaxseed oil on growth performance of broiler chicks. They found that, the heaviest weight was observed in the treatment having flaxseed oil 0.5%, followed by the treatment group having olive oil at levels of 1.0 and 0.5%, respectively.

In addition, El-Sayed et al. (2013) revealed that dietary supplementation of dried guava leaves and/or olive oil significantly improved live body weight of broiler. In the present study, the improvement in body weight may be due to the improved digestibility as a result of presence of oils in diets of broilers (Iftikhar et al., 2015).

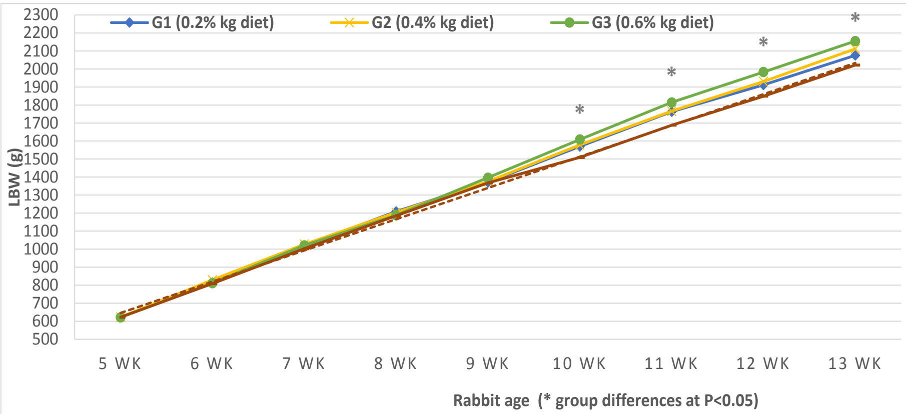

Fig. (1): Change in live body weight of growing rabbits in experimental groups at different ages.

Average daily feed intake:

The effect of olive oil treatment on average daily feed intake (ADFI) of rabbits at weekly age intervals is presented in Fig. (2). There were significant differences (P<0.05) in average daily feed intake among all experimental groups at all age intervals. Control rabbits in G4 achieved significantly (P<0.05) higher ADFI than those in treatment groups did, while the lowest ADFI was detected by rabbits in G3 at most age intervals. In agreement with our findings, Maroufyan et al. (2012) observed that feeding broiler on diets containing omega-3 and omega-6 fatty acids from various oil sources significantly decreased feed intake. On the other hand, Rattanaphol and Rattanaphol (2009) showed that supplementation of 0.5 and 2% olive oil to broiler chick diet had no significant effect on feed intake as compared to control. The observed reduction in ADFI of rabbits fed diets supplemented with olive oil, particularly, at a level of 0.6% may be due to that increasing olive oil in diet of rabbits increased energy intake, which had pronounced effect on feed intake of animals.

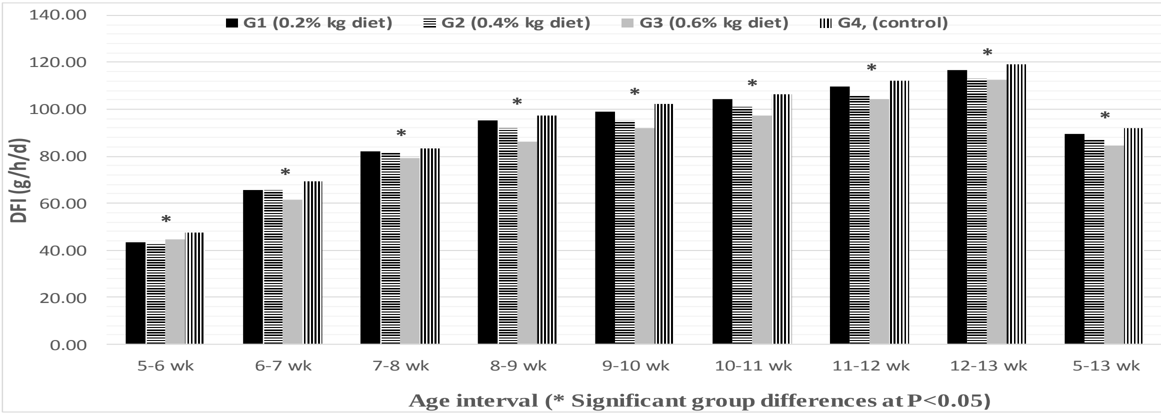

Fig. (2): Average daily feed intake (g) of growing rabbits in experimental groups at different age intervals

Average daily gain:

The effect of olive oil treatment on average daily gain (ADG) of growing rabbits at different age intervals is presented in Table (3). The present data explained that there was no significant influence (P>0.05) of olive oil treatment on average daily gain at 5-9 or 9-13 weeks of age. During entire length of experimental period (5-13), oil treatment at a level of 0.6% affected significantly on ADG of growing rabbits, being the highest for G3, followed by G2 and G1, respectively. In accordance with our results, El-Sayed et al. (2013) revealed that dietary supplementation of dried guava leaves and/or olive oil significantly improved weight gain of broiler. The recorded improved ADG might be due to the presence of poly-unsaturated fatty acids (PUFA) in vegetable oils. These PUFA decrease the rate of passage of digesta in the digestive system and consequently increased absorption of nutrients, resulting in improved digestibility, which ultimately improved the body weight and gain (Sultan *et al*., 2015; Awaad *et al*., 2016).

Table (3): Average daily gain (g/h/d) of growing rabbits at different age intervals as affected by treatment.

Item	Average daily gain (g/h/d)		
	5-9 wk	9-13 wk	5-13 wk
G1 (0.2% kg diet)	26.71±0.84	25.17±1.17	25.94±0.9١ [ab]
G2 (0.4% kg diet)	26.89±0.70	26.3٣±1.53	26.61±0.68 [ab]
G3 (0.6% kg diet)	27.67±1.04	27.0٩±0.94	27.3٨±0.44 [a]
G4 (control)	26.63±0.86	23.35±1.41	24.99±0.36 [b]

Means denoted with different superscripts within the same column are significantly different at P<0.05.

Feed conversion rate and performance index:

The effect of olive oil treatment on feed conversion ratio (FCR) and performance index (PI) of growing rabbits at different age intervals is presented in Table (4). Results showed that oil treatment showed significant effect on FCR at 5-9, 10-13 and at 5-13 weeks of age and PI during 5-13 weeks of age. During the whole experimental period (5-13 weeks), rabbits in G3 showed significantly (P<0.05) the best feed conversion rate and the highest PI, while the inferior trends was detected by control group (G4). In this respect, Ashraf *et al*. (2017) found the best FCR in broiler fed olive oil 1.0% diet, followed by those fed flaxseed oil 0.5% and black seed oil 0.5%, respectively. Also, some authors found that vegetable oils improved performance of birds (Sultan *et al*., 2015; Awaad *et al*., 2016). The observed improvement in FCR of rabbits in G3 was mainly related to significantly the highest ADG and the lowest feed intake as compared to other treatment groups and even control group.

Table (4): Feed conversion rate of growing rabbits at different age intervals as affected by treatment.

Item	Feed conversion ratio (kg diet/kg gain)			PI
	5-9 wk	10-13 wk	5-13 wk	
G1 (0.2% kg diet)	2.70±0.09^{ab}	4.34±0.18^{ab}	3.48±0.12^{ab}	60.61±3.65^{ab}
G2 (0.4% kg diet)	2.63±0.07^{ab}	4.08±0.27^{b}	3.29±0.09^{bc}	64.80±2.70^{bc}
G3 (0.6% kg diet)	2.49±0.09^{b}	3.79±0.14^{b}	3.09±0.04^{c}	69.73±1.73^{a}
G4 (control)	2.81±0.09^{a}	4.86±0.29^{a}	3.68±0.06^{a}	55.00±1.38^{c}

Means denoted with different superscripts within the same column are significantly different at P<0.05.

Viability rate:

Effect of olive oil treatment on viability rate of growing rabbits at different age intervals is presented in Table (5). Results showed that viability rate of rabbits was 100% for all treatment groups versus 90% for control one during 5-9 weeks of age. However, during 10-13 wk of age, viability rate was 100% in G1 versus 90% in other groups. These results were reflected viability rate, being the highest in G1 (100%), moderate in G2 and G3 (90%), and the lowest in G4 during the whole feeding period.

Increasing viability rate of treatment groups, particularly in G1, as compared to control (G4) may be attributed to the effect of omega 3 and omega 6 in olive oil which have an antioxidant action, leading to improvement of health status of growing rabbits.

Table (5): Viability rate (%) of growing rabbits at different age intervals as affected by treatment.

Item	Viability rate (%) at age intervals		
	5~9 wk	10~13 wk	5~13 wk
G1 (0.2% kg diet)	100	100	100
G2 (0.4% kg diet)	100	90	90
G3 (0.6% kg diet)	100	90	90
G4 (control)	90	90	80

Carcass traits of male rabbits:

Effect of oil treatment on carcass traits of male rabbits in different experimental groups at 13 weeks of age is presented in Table (6). All carcass traits studied were not affected by olive oil treatment. However, there was a tendency of higher percentages of carcass weight and dressing for rabbits in treatment groups (G1, G2 and G3) than in controls (G4, Table 8). In accordance with the present results, Abo Omar and Zaza (2016), who found no effect of oil source (olive oil sediments and soybean soap stock oil) on carcass components weights.

Table (6): Carcass traits of male rabbits in different experimental groups slaughtered at 13 weeks of age.

Trait	Olive oil level (%)			
	G1 (0.2% kg)	G2 (0.4% kg)	G3 (0.6% kg)	G4 (control)
Pre-slaughter weight (g)	2271.67±89.7٤	2240.00±88.4٦	1985.00±140.74	2141.67±77.26
Carcass (%)	49.49±2.34	49.75±0.73	49.70±1.19	48.19±0.29
Edible organs:				
Head weight (%)	5.44±0.19	5.64±0.20	6.01±0.38	5.30±0.1٩
Liver (%)	2.37±0.14	2.67±0.25	2.59±0.23	2.48±0.19
Heart (%)	0.36±0.03	0.35±0.03	0.31±0.04	0.28±0.03
Kidney (%)	0.51±0.03	0.48±0.01	0.54±0.00	0.55±0.03
Total	8.68±0.21	9.14±0.29	9.45±0.41	8.61±0.25
Dressing percentage	58.17±2.30	58.89±0.75	59.15±1.20	56.80±0.31
Inedible organs (%)*	41.83±2.25	41.11±0.81	40.85±1.22	43.20±0.33

** Inedible organs included fur, legs, full GIT, body fats, lungs.*

Concentration of blood biochemical:

Effect of oil treatment on concentration of some biochemicals in blood serum of growing rabbits in experimental groups at the end of the experiment is presented in Table (7).

Table (7): Concentration of biochemicals, thyroid hormones and immunoglobulins (IgG and IgM), and enzyme activity (AST and ALT) in blood serum of growing rabbits in experimental groups at 13 weeks of age.

Parameter	Olive oil level (%)			G4 (Control)
	G1 (0.2% kg diet)	G2 (0.4% kg diet)	G3 (0.6% kg diet)	
Biochemicals:				
Total protein (g /dl)	5.93±0.13	6.00±0.11	5.13±0.68	5.53±0.37
Albumin (g /dl)	4.18±0.43	4.87±0.04	4.08±0.75	4.60±0.06
Glucose (mg/ dl)	96.67±4.42^{b}	109.33±3.18^{b}	107.00±0.58^{b}	121.67±2.03^{a}
Cholesterol (mg /dl)	137.00±2.52^{a}	101.00±5.57^{b}	90.00±0.58^{b}	130.67±8.57^{a}
Triglycerides (mg/ dl)	115.33±8.09	125.67±12.25	111.67±2.40	127.67±10.74
HDL (High density lipids)	32.77±2.91	26.40±2.12	26.67±5.08	30.43±1.75
LDL (Low density lipids)	81.17±2.30^{a}	49.47±2.22^{b}	41.00±4.49^{b}	68.03±15.17^{ab}
Creatinine (mg/dl)	1.63±0.15	1.51±0.10	1.31±0.16	1.41±0.06
Kidney function:				
Urea (mg/ dl)	71.60±9.77	69.03±7.93	58.60±6.68	70.10±9.22
Liver function:				
AST (U/L)	29.33±2.03	29.00±5.85	27.33±3.53	25.00±1.53
ALT (U/L)	66.67±8.35	59.33±13.11	87.33±3.67	90.33±13.38
T3 (triiodothyronine)	0.96±0.38	0.74±0.09	0.94±0.09	0.69±0.04
T4 (thyroxin)	3.27±1.27	2.10±0.11	2.83±0.37	2.37±0.47
Immunoglobulins (mg/dl):				
IgG	301.67±10.14	313.33±70.61	316.00±37.07	291.00±20.59
IgM	30.33±0.88	31.67±6.38	35.00±3.61	29.67±3.84

Means denoted with different superscripts within the same row are significantly different at P<0.05.

Current experiment revealed that, no significant influence was found with oil treatment on blood serum parameters of growing rabbits, including total proteins, albumin, triglycerides, HDL, creatinine, urea, IgG, IgM, T3 and T4 concentrations as well as activity of AST and ALT. On the other hand, oil treatment affected significantly (P<0.05) on cholesterol, glucose and LDL concentrations in blood serum of rabbit's groups. Concentration of serum glucose and cholesterol significantly (P<0.05) decreased by about 11.5 and 30.7% in G3, 9.9 and 22.0% in G2, while only glucose concentration significantly (P<0.05) decreased by about 20.5% in G1. Yet, the differences in LDL among experimental groups were significant ($P<0.05$), each of treatment group did not differ significantly from that in control group (G4, Table 7).

In agreement with the obtained results in our study, Ashraf *et al*. (2017) found that supplementation of olive oil, black seed oil and flaxseed oil on serum biochemicals of broiler chicks, involving lipid profile (serum cholesterol, triglycerides, HDL and LDL). This reduction may be due to presence of omega 6 fatty acids which have the ability to decrease the cholesterol level in blood serum, while omega 3 fatty acids decrease cholesterol and triglycerides levels (An et al., 1997). In contrast to the present results, El-Sayed *et al*. (2013) showed that, feeding dried guava leaves and/or olive oil reflected higher bird immunity guarded by higher concentrations of total protein, globulin and higher values of total leukocytic count besides significant improvement in activity of antioxidant and liver enzymes.

Histological study:

Liver:

The histological examination of liver samples taken from hepatic lobe of rabbits in all experimental groups revealed that hepatic lobules were consisted of central hepatic vein within each lobule, and polyhedral hepatocytes were arranged in radiated cords around each central hepatic vein allowed of blood sinusoid between them. Slaughtered rabbits in all groups showed normal architecture without connective tissues between the hepatic lobules, indicating no marked effect on liver structure in all groups (Plate 1).

The magnification power at x100 revealed some histometric observations in liver of rabbits in each group as affected by treatment. In this line, the histological examination cleared that central hepatic vein was the widest in G1 and G2 as compared to that in G3 and G4, respectively (Plate 1).

Kidney:

The histological examination of kidney samples taken from the renal cortex of rabbits in all experimental groups cleared intact renal cortex containing normal Malpigian corpuscles and proximal convoluted renal tubules. There were marked difference in Malpigian corpuscles and renal tubules, regarding density and shape in different groups (Plate 2).

These findings may indicate intact histological architecture of kidney in rabbits of treated groups (G1, G2 and G3) as compared to control one (G4). In association with the effect of PR on the histological structure of rabbit kidney in G1, G2 and G3.

Small intestine:

The histological examination of small intestine samples taken from jejunum of rabbits in all experimental groups cleared different thicknesses of tunica musculosa (TML), tunica submucosa (TSM), villi characteristics (Plate 3), and thickness of tunica mucosa laminae, including thickness of lamina muscularis mucosa (LMM), lamina propria and lamina epithelialis mucosa (LEM, plate 4).

Thickness of TML decreased markedly in G1 and G3, while thickness of TSM increased in G1 and G3. Such results may indicate a negative relationship thickness of TML and TSM, reflecting nearly similar thickness of small intestine wall in all groups. Also, the present examination revealed that feeding growing rabbits on diet containing olive oil showed pronounced effect on increasing thickness of TSM and decreasing TML as affected by retention time and rate of passage of digesta within small intestine (Table 8).

In addition, feeding rabbits on olive oil diet led to significant effect on villi shape, being cylindrical in G1 and G2, tertiary in G3 and Flattened in G4, which mean increasing absorptive surface area of small intestine in rabbits of G3 as compared to other groups. It is of interest to note that rabbits of G3 showed the longest and densest villi (Table 8), reflecting also higher surface area of villi within the same area of small intestine in G3 as compared to other groups. Moreover, increasing thickness of propria and LEM allowed rabbits in G3 to have the highest absorptive surface area among all experimental groups. Based on these results, improving absorptive area in G3 was associated with the highest growth performance parameters for rabbits in G3.

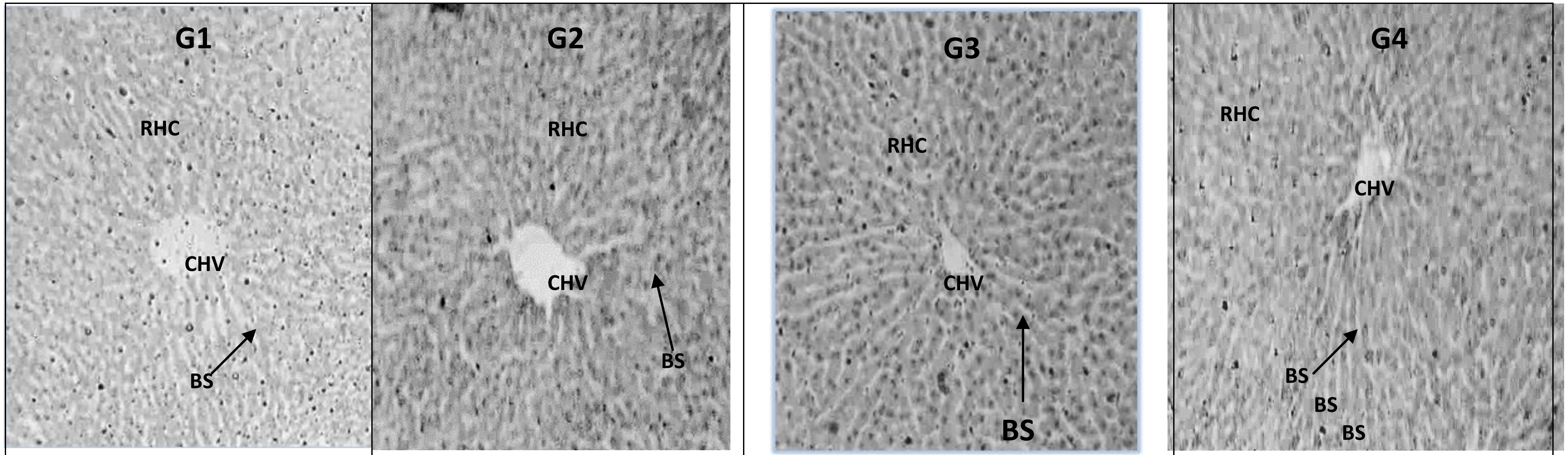

Plate (1): Sections in livers of growing rabbits in experimental groups showing intact hepatic lobules with normal central hepatic vein (CHV), radiated hepatocytes (RHC) and blood sinusoids (BS) in G1, G2, G3 and G4. Wide difference in shape and size of CHV was seen with polyhedral hepatocytes and more radiated arrangement was observed in G3 as compared with G1, G2 and G4. (H & E stain, x 100)

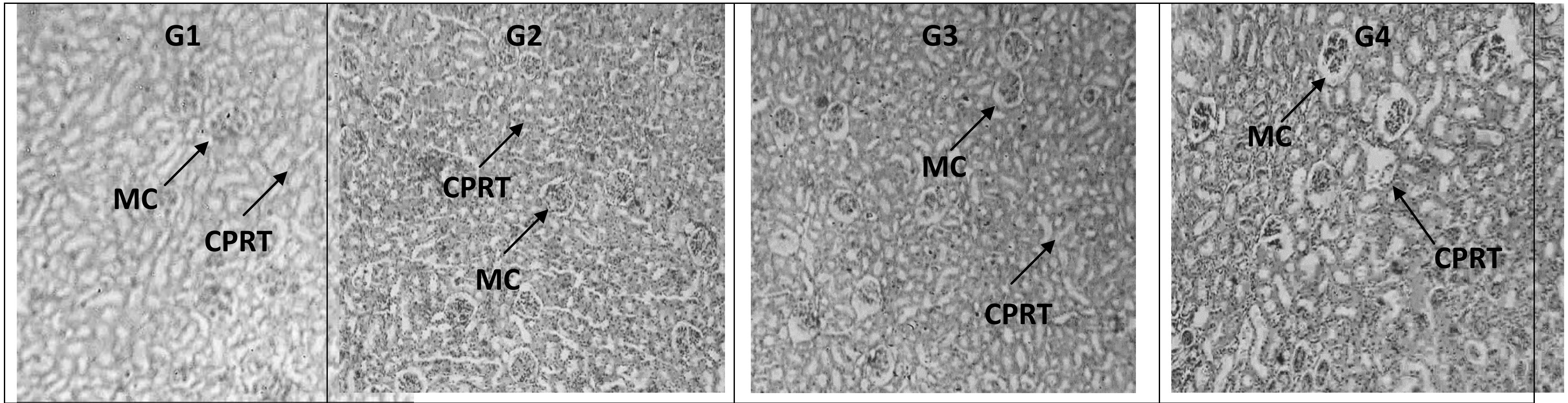

Plate (2): Sections in renal cortex of kidneys in growing rabbits of experimental groups showing normal Malpigian corpuscles (MC), convoluted proximal renal tubules (CPRT) and connective tissue (CT) in G1, G2, G3 and G4. All MC had normal Bowman's capsule with intact capillaries and epithelial single layer of the proximal renal tubules walls in G1, G2, G3 and G4. (H & E stain, x 100)

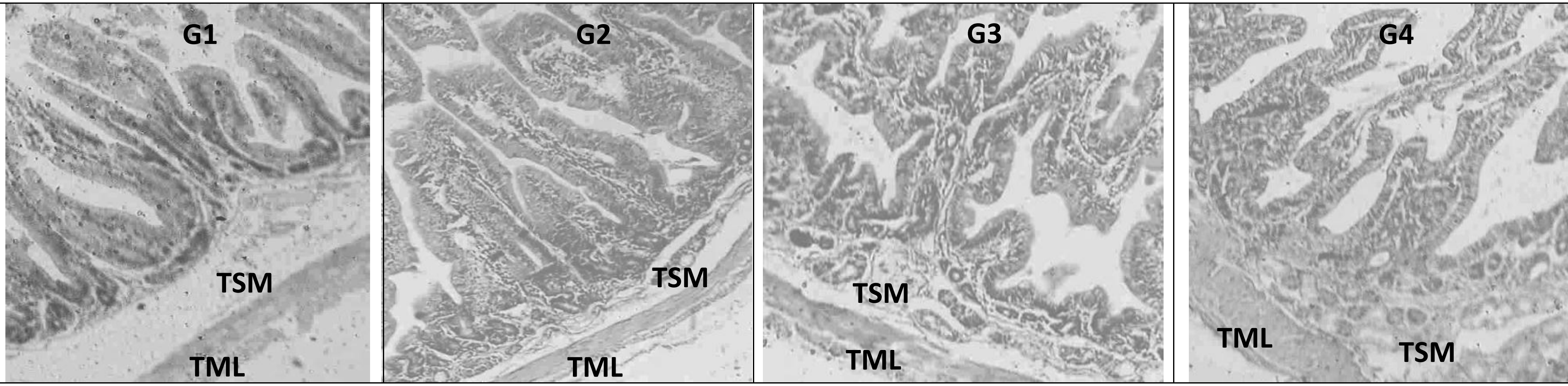

Plate (3): Cross-sections in small intestine (jejunum) showing tumica musculosa (TML), tunica sub-mucosa (TSM), and tunica mucosa (H&E, 100x)

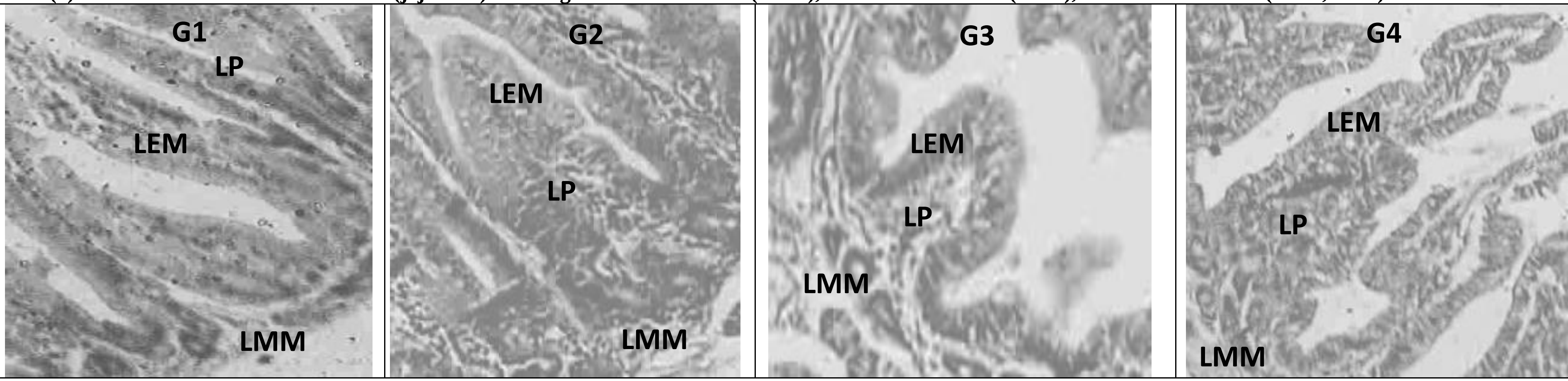

Plate (4): Magnification of the previous sections in small intestine (jejunum) showing lamina muscularis mucosa (LMM), lamina propria (LP) and lamina epithelialis mucosa (LEM) of tunica mucosa. (H&E, 200)

Table (8): Histological characteristics of small intestine wall in rabbits of experimental groups.

Item	G1*	G2*	G3*	G4
Thickness of TML	++	+	++	+++
Thickness of TSM	++	+	++	+
Intestinal villi:				
Shape	Cylindrical	Cylindrical	Tertiary	Flattened
Length	+	+	+++	+
Width	+	+	+	+++
Density	+	++	+++	+
Tunica mucosa:				
Thickness of LMM	+	+	+	+
Thickness of propria	+	++	+++	++
Thickness of LEM	+	++	++	+

TML: Tunica musculosa. TSM: Tunica submucosa. LMM: Lamina muscularis mucosa.
*LEM: Lamina epithelialis mucosa. * Relative to control.*

Generally, the histological examination indicated normal liver and kidney function of both treatment groups and suggested higher absorptive surface area of small intestine in G3 than in other groups.

CONCLUSION

In conclusion, adding olive oil at different levels to the diet (0.2, 0.4 and 0.6%) had positive effects on growth performance parameters, without adversely effects on blood biochemical, enzyme activity, carcass traits and general health status of growing rabbits during the age interval from 5 to 13 weeks of age under heat stress conditions. Dietary addition of olive oil at a level of 0.6% showed the best results.

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تأثير إضافة زيت الزيتون على النمو وصفات الذبيحة والصحة العامة للأرانب تحت ظروف الإجهاد الحراري

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تهدف الدراسة إلى قياس تأثير زيت الزيتون على النمو والكفائة الغذائية ومكونات الدم والمناعة للارانب النيوزيلاندى البيضاء النامية. إستخدم فى الدراسة عدد ٤٠ ارنب مفطوم عمر ٥ اسابيع ومتوسط وزن ٧٠٢ جرام تم تقسيمهم عشوائيا الى أربع مجموعات تحتوي كل مجموعة على ١٠ ارانب (٥ ذكور و٥ اناث). غذيت الارانب فى كل المجموعات على عليقة تجارية أساسية تحتوي حوالي ١٨% بروتين وحوالي ١٣% الياف خام وحوالي ٢٥٠٠ كيلو كالورى/كجم عليقة طاقة مهضومة. تم تغذية الارانب فى المجموعة الاولى والثانية والثالثة على العليقة الأساسية والمضاف اليها زيت الزيتون بمعدلات ٠.٢ و٠.٤ و٠.٦%، على التوالي واستخدمت العليقة الرابعة كعليقة مقارنة. أظهرت النتائج انخفاض فى معدل الغذاء الماكول معنويا، معدل الذيادة فى وزن الجسم مع تحسن معنوى فى معامل التحويل الغذائى فى ارانب المجموعات التى غذيت على علائق مضاف اليها زيت الزيتون بالمقارنة بالعليقة الكنترول. لم تؤثر أضافة زيت الزيتون الى العليقه معنويا على خصائص الذبيحة، مكونات سيرم الدم (البروتين الكلى والجلوكوز والكوليسترول والدهون عالية الكثافة) وقياسات المناعة. أكدت نتائج الفحص الهستولوجى عدم تأثر التركيب الهستولوجى للكبد والكليه مع تحسن فى مسطح الأمتصاص داخل الأمعاء الدقيقه فى الأرانب المعامله عن الكونترول.

نستنتج من هذه الدراسة أن أضافة زيت الزيتون المختبر الى علائق الأرانب بتركيزات ٠,٢ و٠,٤ و٠,٦% له تاثيرات ايجابية على النمو والكفاءه الغذائية بدون التأثير السلبي على مكونات الدم، خصائص الذبيحة والمناعة فى الارانب النامية تحت ظروف الإجهاد الحراري. أعطت الأرانب المغذاه على عليقه محتويه على ٠.٦% زيت زيتون أحسن النتائج.