

## EFFECT OF DIETARY SELENIUM ENRICHED MICRO-ALGAE SUPPLEMENTATION ON GROWTH PERFORMANCE AND ANTI-OXIDATIVE STATUS OF RABBITS UNDER HIGH AMBIENT TEMPERATURE IN SUMMER SEASON

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### SUMMARY

This study was carried out to investigate the effect of different levels of dietary selenium enriched micro-algae supplementation on growth performance, carcass characteristics, blood biochemical constituents, and anti-oxidative status of rabbits under Egyptian summer conditions. Total of 90 male growing New Zealand White rabbits, six weeks old with an average initial body weight 757.5 g were used in this study. Rabbits were randomly allocated to six experimental groups, with 15 rabbits in each group. The first was a control group, the other five groups offered feed containing, 0.05, 0.1, 0.2, 0.4 and 0.5 mg Se-algae /kg diet, respectively. The results showed that final body weight and average body weight gain were not affected ( $P>0.05$ ) by selenium enriched micro-algae supplementation. Feed contain Se-algae at 0.2 mg significantly ( $P<0.011$ ) improved feed conversion ratio, the best feed conversion ratio (2.28 g feed/g gain). Treatment with Se-algae caused significant increase in serum total protein, and globulin concentration while reduce albumin concentration, rabbits fed diet supplemented with 0.1 and 0.2 mg Se-algae were the highest groups in High density lipoprotein (HDL) concentration (55.26 and 54.33 mg/dl, respectively). Dietary treatments with Se-algae significantly ( $P<0.0001$ ) reduced total cholesterol, Low density lipoprotein (LDL) and total lipids. There was a significant increase in total antioxidant capacity (TAC), Glutathione Peroxidase (GSH-Px), Superoxide dismutase (SOD) and Catalase (CAT) as Se-algae supplementation increased, additionally, rabbit fed diets supplemented with 0.2 and 0.4 mg Se-algae were the highest in T-AOC, (3.28 and 3.19 mMol/L, respectively). Also, rabbit fed diet supplemented 0.2 mg Se-algae recorded the best serum GSH-Px, SOD and CAT (2.68, 47.04 and 640.67mU/ml, respectively). Dietary selenium enriched algae significantly ( $P<0.0001$ ) reduced thiobarbituric acid reactive substance (TBARS), compared with the control group. As rabbit fed diet supplemented with 0.4 mg Se-algae achieved the best hot carcass weight (1498.79g), dressing (63.20%), edible giblets (3.80%) and total edible parts (67.02%). In conclusion, selenium enriched *spirulina* supplementation improved growth performance, anti-oxidative status and rabbit utilized Se more efficiently in *spirulina* as organic form of selenium under hot conditions. Accordingly, rabbit meat can be fortified with selenium through dietary supplementation of selenium enriched micro-algae.

**Keywords:** rabbit, growth, carcass, anti-oxidative status, selenium, algae

### INTRODUCTION

Rabbit meat may be excellent to produce specific functional foods since its good properties such as the fatty acid profile, mineral and vitamin contents which could be further enriched via feeding (Surai, 2002; Marounek *et al.*, 2009; Dalle Zotte and Szendrő, 2011). Selenium enriched meat could be achieved through the fortification of diets with organic Se (selenomethionine) as it is incorporated into proteins in place of methionine (Rayman, 2004). In fact, Selenium (Se) is a trace element known to play a pivotal role in the antioxidant defense system, protecting the animal from oxidative stress (Zoidis *et al.*, 2010). Moreover, Se is a cofactor of glutathione peroxidase, the enzyme that catalyzes the degradation of peroxides (Castellini *et al.*, 2002; Attia *et al.*, 2010). Reactive oxygen and nitrogen species can cause cell

damage in animal tissues in cases where antioxidant enzymes are deficient. Selenium plays an important role in activating the antioxidative properties via its involvement in the active site of the enzyme glutathione peroxidase (GSH-Px) in blood, liver and edible tissues (Surai, 2002) which might be connected with enhancing the immune response in mammals (Rayman, 2004).

Rabbits are particularly sensitive to heat. As a consequence, exposure to temperatures outside the limits of their thermo neutral zone commonly impairs the growth of the animals as well as their reproductive in summer time. Environmental temperatures above 28 °C cause heat-induced physiological stress. (Marai *et al.*, 2002). It has been shown that the main advantage of organic Se in poultry and animal production is related to its ability to build Se reserves in the body in the form of Selenium methionine which can be used in times of stress to help additional Se-protein production and increased resistance to stress (Surai and Fisinin, 2014). Moreover, organic Se is a highly available form of Se for livestock and provides antioxidant protection at a level greater than inorganic Se (Mahan, 1999; Mahmoud and Edens, 2003; Al-Waeli *et al.* 2013). Also, using dietary Se is beneficial to lipid oxidative stability thus preserving meat quality (Liu *et al.*, 2011).

It is necessary to mention that *Spirulina (Atrhospira platensis)* is a rich source of phycocyanin, as antioxidant biliprotein pigment and carotenoids (Cheong *et al.* 2010). However, scientific information available on performance and antioxidative status in rabbits fed combinations of algae and Se are still limited.

In view of these facts, the present study was conducted on growing rabbits to study the effect of dietary selenium enriched micro-algae *Spirulina (Atrhospira platensis)* supplementation on growth performance, carcass characteristics, blood biochemical constituents, and antioxidative status, under Egyptian summer condition.

## **MATERIALS AND METHODS**

### ***Animals and housing:***

The trial was carried out at Borg-El Arab, Alexandria Governorate, Experimental Station of Animal Production, Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. Ninety (6 weeks of age) New Zealand White male rabbits were divided randomly into six homogeneous groups (n=15 each) with 757.53 g average live body weight. Animals were housed individually in stainless steel cages (35 ×35 ×60 cm<sup>3</sup>) provided with feeders and automatic nipple drinkers. Diet and water were offered *ad libitum*. The experimental period was from May to July, 2014. Temperatures were ranged between 28.5-32.5°C, relative humidity 62-75% and temperature humidity index (THI) was 87.53-92.99.

### ***Feeding:***

The basal diet was formulated to meet recommended nutrient requirements of growing rabbits according to Lebas (2004). Ingredient and chemical composition of the basal diet are presented in Table (1). Treatment groups were the control (basal diet without any supplementation) and the other five experimental groups (I, II, III, IV and V) which were supplemented by algae at 0.05; 0.1; 0.2; 0.4 and 0.5 g / kg diet, respectively. (Algae containing 1 mg Se /g algae). Diets groups I, II, III, IV and V containing 0.05; 0.1; 0.2; 0.4 and 0.5 mg Se-algae / kg diet, respectively. The control diet, thus containing only the endogenous Se contained in the ingredients of the diet. Control was the basal diet containing 0.08mg Se/kg diet.

### ***Microbiological preparation:***

#### ***Cyanobacterial strains:***

Three strains of *Spirulina platensis (Arthospira platensis)* were obtained from Agric. Microbiology Dept. National Research Centre (NRC), Giza, Egypt, isolate strain NRC1 that isolated from Manzala lake at northeast of Egypt, isolate strain NRC2 that isolated from Burulus lake at north of Egypt and genetically identified strain NRC3 that isolated from Wadi El-Natrun, at Northwest of Egypt (Hoballah *et al.* 2012).

**Table (1): Feed ingredients and chemical analysis of basal diet (%DM basis).**

Feed Ingredient	(%)	Chemical analysis (%DM basis)	
Soybean meal (44% CP)	20.9	Dry matter (DM)	87.88
Barley	32.0	Organic matter (OM)	90.88
Wheat bran	9.20	Crude protein (CP)	17.56
Clover hay	31.0	Crude fiber (CF)	13.26
Molasses	3.00	Ether extract (EE)	1.980
Limestone	0.70	Nitrogen free extract (NFE)	58.08
Di- calcium phosphate	2.20	Ash	9.120
DL-Methionine	0.40	Methionine	0.670
Sodium chloride	0.30	Methionine+cysteine	0.760
Vit.-Min. premix <sup>a</sup>	0.30	Lysine	0.980
Total	100	Calcium	1.290
		Available Phosphours	0.510
		Digestible energy (Kcal/Kg DM)	2790
		Selenium (mg/kg DM)	0.08

<sup>a</sup> Mineral and vitamin mixture supplied per kg of diet: Vitamin A 10,000 IU, Vitamin D3,1,800 UI; Vitamin E, 15 mg; vitamin K3, 4.5 mg; Vitamin B1, 0.5 mg; Vitamin B2, 4 mg; Vitamin B12, 0.001 mg; Folic acid, 0.1 mg; Pantothenic acid, 7 mg; Nicotinic acid, 20 mg; I, 1 mg; Mn, 60 mg; Cu, 5.5 mg, Zn, 75 mg; Fe, 40 mg; Co, 0.3 mg; ; Robenidine, 52.8 mg.

#### **Selection of alga used for selenium enrichment process:**

For obtaining selenite resistant algal strain that used for selenium enrichment process in raceway ponds, in lab experiment, selenium was added, as sodium selenite, at a concentration of 25 mg Se L<sup>-1</sup> (54.762 mg L<sup>-1</sup> of Na<sub>2</sub> SeO<sub>3</sub> 172.96 g. Mol<sup>-1</sup>) in 3 replicates to Erlenmeyer flasks 250 ml contained 150 ml of modified BG 11 medium for growing the tested cyanobacterial three strains NRC1, NRC2 and NRC3 for obtaining the more selenite resistant strain of them that required for producing selenium enriched cyanobacterium alga (Cases *et al.*, 2002 and Huang *et al.*, 2006). The initial pH of the medium was set at 9.5, and no adjustments were made throughout the cultivation process. The cultures were incubated in incubator shaker at 60 rpm under light regime at 16 h. day and 8 h. night for 3 weeks (illuminated by Tungsram Lamp F18W/74-765 daylight 950 Lumen) at temperature of 28°C (Hoballah *et al.*, 2012). Finally, we selected the strain able to grow on selenite Se that gave the most strain enriched in total selenium content; high chlorophyll content and growth yield (Cases *et al.*, 2002).

#### **Algal fortification in lab and raceway ponds:**

The selected cyanobacterium *S. platensis* (*Arthrospiraplantensis*) from National Research Centre (NRC, Cairo, Egypt) is commercialized grown for 25 days by the company El-Nabarawy (El-Farafra Oasis, Al-Wadi Al-Jadid governorate) that has raceway ponds (2 meter width \* 20 meter length \* 0.6 meter depth) with paddle wheel as stirring system with speed of 40 rpm, algal separating unit (GEA Westfalia centrifugal Separator- GEA Mechanical Equipment Canada, Inc.) and finally algal drying unit that was local hot air (60°C) shelved drying pox. Modified medium containing some chemicals in commercial grade was used for growing alga under study (Raouf *et al.*, 2006, Xin *et al.*, 2010, Hoballah *et al.*, 2012 and Arumugam *et al.*, 2013). BG-11 culture medium modified by the addition of 2.0 g L<sup>-1</sup> NaHCO<sub>3</sub> was selected and prepared for the growing cyanobacterium *Spirulina platensis* without adding citric acid as carbon source and some elements that replaced by commercial grade chemical of super phosphate (1.25 g l<sup>-1</sup>), Urea 46.5%N (32.1mgL<sup>-1</sup>) was added instead of sodium nitrate as nitrogen and carbon sources, Potassium chloride (0.98 g l<sup>-1</sup>), Sodium chloride (0.5 g l<sup>-1</sup>), Magnesium sulphate (0.15 g l<sup>-1</sup>), Calcium chloride (0.04 g l<sup>-1</sup>), and Sodium bicarbonate 5 g l<sup>-1</sup>. The water used was drinking water well described by Aly (2014) in Table (2) and the raceway location's temperature was 32°C in March 2014.

Finally, sodium selenite was added before inoculation process to raceway water at concentration of 25 mg Se L<sup>-1</sup> (54.762 mg. L<sup>-1</sup> of sodium selenite [Na<sub>2</sub> SeO<sub>3</sub>]172.96 g. Mol<sup>-1</sup>). The initial pH of the medium was set at 9.5, and no adjustments were made throughout the cultivation process. Polyethylene bags containing 10 L of grown alga in BG-11 modified medium were used as raceway algal inoculants, aeration was continuously to bags used for growing alga provided from compressed air from the tube end, then incubated under light regime at 16 h. day and 8 h. night for 3 weeks (illuminated by Tungsram Lamp F18W/74-765 daylight 950 Lumen) at the raceway location's temperature that was 32°C.

**Table (2): Description of Farafra oasis groundwater chemical composition (Aly, 2014).**

Item	pH	EC (dS/m)	Cations (milli equivalent /L)				Anion (milli equivalent/L)				TDS (mg/L)
			Ca <sup>++</sup>	Mg <sup>++</sup>	Na <sup>+</sup>	K <sup>+</sup>	CO <sub>3</sub> <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>-</sup>	
Mean values	7.2	0.2	1.1	1.1	0.7	0.4	0.0	1.1	1.8	0.4	157.9

**Algal growth estimation:**

Algal growth was estimated by measuring algal biomass (dry weight basis g/100 ml) by drying algal growth yield at 60°C in oven over night and chlorophyll was estimated by acetone using spectrophotometer method (El-Sayed *et al.*, 2011, Lee *et al.* 1995 and APHA, 1998).

**Prepared algal dried yield:**

The company El-Nabarawy (El-Farafra Oasis, Al-Wadi Al-Jadid governorate) mentioned above, collected selenium enriched cyanobacterium growth from raceway ponds after 20-25 days by using the aforementioned commercial separating centrifuge and then the cyanobacterium yield was dried using hot air (60°C) in aforementioned shelved drying pox.

**Growth performance:**

The rabbits were individually weighed at the beginning and the end of the experiment. Weighing was carried out before the morning feeding. Rabbits were fed individually and feed consumption was recorded so, weight gain and feed conversion ratio were easily calculated.

**Slaughter traits:**

At the end of the experimental period (14weeks old), 5 rabbits from each treatment were randomly kept off feed for 12h, weighed and slaughtered for carcass characteristics and meat analysis. Slaughter procedure and carcass analysis were carried out as described by Blasco and Ouhayoun (1996). After complete bleeding, the skin, viscera and tail were removed and the hot carcasses and its components were weighed as edible parts (liver, kidneys and heart) and the non edible parts including lung, spleen, stomach, large intestine, small intestine were also weighed. Dressing percentage was calculated by dividing the hot dressed carcass weight by pre-slaughter weight and expressed as a percentage according to Steven *et al.* (1981).

**Chemical measurements**

Blood samples (5ml from each rabbit) were collected during slaughter to determine blood serum components. Serum was separated by centrifugation at 3000 rpm for 10 min and stored at -20°C until analyzed. Blood serum total protein, albumin, Triglycerides, total cholesterol, HDL- cholesterol and LDL-cholesterol. Triglycerides were colormetrically determined using commercial kits (Stanbio Laboratory, USA) according the manufacturers' instructions. Total cholesterol was estimated according to Richmond (1973). Serum total protein was determined according to Orsonneau *et al.* (1989). Triglycerides were determined accoding to Wahlefeld *et al.* (1974).

Globulins values were obtained by subtracting albumin values from total protein values. Lipid peroxidation in blood serum was measured in the form of thiobarbituric acid reactive substance (TBARS) as described by Richard *et al.* (1992). The activity of the antioxidative enzyme Glutathione Peroxidase (GSH-Px) and total antioxidant capacity (T-AOC) of blood serum were measured according to Paglia and Valentine (1967) and Koracevic *et al.* (2001), respectively, using kits produced by Bio- Diagnostic, Egypt. Superoxide dismutase (SOD) activity was assayed according to Misra and Fridovich (1972) and Catalase (CAT) activity was measured according to Aebi (1984). Selenium concentrations in diets and meat were analyzed by the method of Brown and Watkinson (1977) using a semi-automated fluorometer. Chemical analyses of the experimental diets, *spirulina* and hind leg meat were carried out according to AOAC (2000) for crude protein (CP), ether extract (EE), crude fiber (CF) and ash. Total selenium determination according to (Shaltout *et al.*, 2013), the analytical procedure was performed using an ICP-MS (Perkin Elmer-SCIEX, Thornhill, Canada), the concentration of total selenium was read from the calibration curve.

**Statistical analysis**

The differences among experimental groups were statistically analyzed using the General Linear Model procedures of SAS (2001), applying a one-way analysis of variance (ANOVA). The significant

differences among treatments means of treatments were compared using Duncan's multiple range test (Duncan, 1955).

## RESULTS AND DISCUSSION

### *Selenium enriched algae cultivation:*

The obtained results from the laboratory experiment in (Table 3) showed that the selected *Spirulina platensis* strain NRC3 has ability to grow on selenite Se (IV) that considered the most of the tested strains enriched in total selenium content; high chlorophyll content and growth yield. The total selenium content of the selenium enriched *Spirulina platensis* used in feeding the experimental animals was 1000 mg selenium Se (IV)/kg dried algal weight. The selenate toxicity caused algal cell growth inhibition as well as a block of cell division and bleaching of chloroplasts (Umysová, *et al.*, 2009).

**Table (3): Parameters used for selecting from three obtained algae strains that able to be the most strain enriched in total selenium content.**

Parameter used	Non-treated with selenite			Treated with selenite		
	NRC1	NRC2	NRC3	NRC1	NRC2	NRC3
Chlorophyllmg/g dry weight (fresh alga)	11.1	12	12.9	9.1	8.54	12.3
Growth yield g /L dry weight	0.29	0.31	0.39	0.22	0.20	0.32
Total selenium mg/kg dry weight	0.6	0.4	1.3	659.9	720	1000

The chemical composition of *Spirulina* was presented in Table (4). It could be noticed that crude protein was lower than the values reported by Kulpys *et al.* (2009) who found that total protein was (54 vs. 65 g/100DW, respectively). However, Ether extract (6.70%) was higher than the value reported by Kulpys *et al.* (2009). In addition, Zahroojian *et al.*, (2013) reported that *Spirulina* had protein within range of (55-69%), carbohydrates (15-25%), fats (5-6%) and minerals (6-9%). In this connection, Indira and Biswajit (2012) reported that microalgae can be used to produce a wide range of metabolites such as proteins, lipids, carbohydrates, carotenoids or vitamins for health, food and feed additives. Nowadays, there are numerous commercial applications of micro algae can be used to enhance the nutritional value of food and animal feed owing to their chemical composition.

**Table (4): Chemical composition of *Spirulina platensis* (%DM basis).**

Item (%)	DM	OM	CP	CF	EE	NFE	Ash
<i>Spirulina platensis</i>	85.01	94.00	54.0	3.50	6.70	25.60	10.2

This research work has demonstrated that adding sodium selenite to the culture media of *Spirulina platensis*, led to enhance the growth rate and magnitude of organic selenium content. This also suggests that a selenium enriched feed with notable market value may be produced efficiently as a *Spirulina* powder as well as selenium enriched protein, lipids and polysaccharides and other components.

### **Growth Performance:**

The effect of dietary Se-algae supplementation on growth performance of growing rabbits is presented in Table (5). Supplemented dietary Se-algae significantly ( $P < 0.0037$ ) increased body weight at 8 week and 10 week at levels of 0.05, 0.4 mg Se-algae, respectively compare to the control group. However, body weight at 12 and 14 week of age were not affected by Se-algae supplementation at each tested level. In addition, dietary Se-algae increased ( $P < 0.0001$ ) body weight gain at (6-8 week) compare to the control group. Also supplementation of 0.1 and 0.5 mg Se-algae increased body weight gain at (12-14 week) compare to the control group. While, no significant differences were observed in body weight gain among rabbits groups fed Se-algae diets and the control diet at (8-10 weeks) and (10-12week). Concerning to feed intake, feeding growing rabbits on 0.2 and 0.4 mg Se-algae diets significantly ( $P < 0.0011$ ) decreased the average feed intake compared to the control group at 12-14 week of age. However, there insignificant differences in average feed intake among rabbit groups fed the tested diets (included control group).

Results demonstrated that there were significant effects on FCR at (6-8 week), (8-10 week) and (12-14 weeks). Moreover, no significant effect was found on FCR at (10-12 week).

**Table (5): The effect of different levels of dietary Se-algae on the growth performance of experimental rabbits (n = 15).**

Item	Se-algae supplementation (mg/kg DM)						SEM	P value
	Control	0.05	0.1	0.2	0.4	0.5		
Average body weight, g	760.40	762.67	759.67	758.33	752.07	752.27	27.10	NS
at 6 week	1006.00 <sup>b</sup>	1167.47 <sup>a</sup>	1137.20 <sup>a</sup>	1189.87 <sup>a</sup>	1178.40 <sup>a</sup>	1129.53 <sup>a</sup>	34.02	0.0037
at 8 week	1477.07 <sup>b</sup>	1622.13 <sup>a</sup>	1550.20 <sup>ab</sup>	1598.33 <sup>ab</sup>	1607.80 <sup>a</sup>	1551.33 <sup>ab</sup>	41.30	0.05
at 10 week	1908.79	2008.27	1984.64	2007.60	1995.33	1976.43	46.19	NS
at 12 week	2252.42	2403.64	2384.00	2337	2337.14	2381.43	55.81	NS
at 14 week								
Body weight gain, g								
6-8 week	245.60 <sup>b</sup>	404.80 <sup>a</sup>	377.53 <sup>a</sup>	431.53 <sup>a</sup>	426.33 <sup>a</sup>	377.27 <sup>a</sup>	21.23	0.0001
8-10 week	471.07	454.67	413.00	408.47	429.40	421.80	28.55	NS
10-12 week	431.72	386.13	434.44	409.27	387.53	425.10	23.45	NS
12-14 week	343.63 <sup>b</sup>	395.38 <sup>ab</sup>	399.36 <sup>a</sup>	329.54 <sup>ab</sup>	341.81 <sup>ab</sup>	405.00 <sup>a</sup>	22.42	0.05
Feed Intake, g								
6-8 week	492.20	476.99	443.41	455.52	485.85	459.69	15.48	NS
8-10 week	836.36	752.37	768.35	761.25	768.41	759.02	35.16	NS
10-12 week	1267.93	1220.30	1291.16	1178.59	1154.36	1184.55	50.73	NS
12-14 week	1453.08 <sup>a</sup>	1375.00 <sup>ab</sup>	1416.10 <sup>a</sup>	1102.29 <sup>c</sup>	1235.29 <sup>bc</sup>	1435.34 <sup>a</sup>	41.28	0.0011
FCR, % <sup>(1)</sup>								
6-8 week	2.00 <sup>a</sup>	1.18 <sup>b</sup>	1.17 <sup>b</sup>	1.06 <sup>b</sup>	1.14 <sup>b</sup>	1.22 <sup>b</sup>	0.10	0.0001
8-10 week	1.78 <sup>ab</sup>	1.65 <sup>b</sup>	1.86 <sup>ab</sup>	1.86 <sup>a</sup>	1.79 <sup>ab</sup>	1.80 <sup>ab</sup>	0.11	0.05
10-12 week	2.98	3.16	2.97	2.88	2.98	2.79	0.17	NS
12-14 week	4.23 <sup>a</sup>	3.48 <sup>b</sup>	3.55 <sup>b</sup>	3.34 <sup>b</sup>	3.61 <sup>b</sup>	3.54 <sup>b</sup>	0.18	0.01
Duration period, 56 days								
Average daily FI, g	72.31 <sup>a</sup>	68.29 <sup>ab</sup>	69.98 <sup>a</sup>	64.06 <sup>c</sup>	65.06 <sup>bc</sup>	68.54 <sup>ab</sup>	1.46	0.0019
Average daily G, g	26.64	29.30	29.01	28.19	28.30	29.09	0.88	NS
Average FCR	2.73 <sup>a</sup>	2.36 <sup>b</sup>	2.38 <sup>ab</sup>	2.28 <sup>b</sup>	2.38 <sup>b</sup>	2.33 <sup>b</sup>	0.05	0.0110

a, b, c and d: Means in the same row having different superscripts differ significantly ( $P < 0.05$ ), NS = not significant.  
(1) Feed conversion ratio (FCR) = feed intake (kg)/body weight gain (kg).

During the experiment period, it was shown that Se-algae supplementation reduced daily feed intake compared with the control group, and there were significant differences in average feed intake between the control group and rabbits fed diets supplemented with 0.2 and 0.4 mg Se- algae. Also, rabbit fed diet supplemented with 0.2 mg Se-algae recorded the lowest feed intake (64.06 g/d), while the control group was the highest group (72.31 g/d) in feed intake. No significant ( $P > 0.05$ ) effect of Se-algae on average body weight gain was observed during the experimental period. While rabbit fed diet supplemented with 0.05 mg Se-algae was the highest group in daily gain (29.30 g/d) followed by rabbit fed diet supplemented with 0.5 mg Se-algae (29.09 g/d) and rabbit fed diet supplemented with 0.1 mg Se-algae (29.01 g/d). While, the lowest one was the rabbit fed diet supplemented with 0.2 mg Se-algae (28.19 g/d). Supplementation with Se-algae significantly improved FCR, as well as there were significant ( $P < 0.011$ ) differences in average FCR between the control group and all the rabbit fed diets supplemented with Se-algae. The best FCR (2.28 g feed/g gain) was achieved when the dietary Se-algae supplementation was 0.2 mg Se-algae.

The results of present study clearly indicated that dietary supplementation of Se-algae at 0.05, 0.1, 0.2, 0.4 and 0.5 mg Se-algae had a positive effect on growth performance of growing rabbits. Similar results were observed by (Ebeid *et al.*, 2013) who found that Se addition at 0.3 mg organic Se/kg diet resulted increased the final body weight, daily gain while feed conversion ratio was reduced in the growing rabbits. Saleh *et al.* (2013) reported that Linseed oil plus 0.3 ppm organic selenium increased body weight gain significantly ( $P < 0.05$ ) while reduced significantly ( $P < 0.05$ ) feed intake. Likewise, Zhang *et al.* (2011) reported that the dietary Se level significantly affected average daily gain and feed/ gain ratio in

meat rabbits from weaning to 2 months old, the group of rabbits fed with the diet of 0.24 mg/kg Se showed significant improvement of body weight gain and feed conversion efficiency. However, the level of dietary Se had no significant effect on the average feed intake ( $P>0.05$ ) of the rabbits. As well as better daily gain and feed/ gain ratio were achieved when the dietary Se level was more than 0.24 mg/kg. Moreover, dietary organic Se improved body weight and feed conversion ratio of broiler chicken (Wang and Xu, 2008). A potential reason for this may be the profile of organic compounds of Se in the Se-algae (Larsen et al. 2001). These compounds act as natural antioxidants and can protect mucosa against oxidative damage and pathogens so, it prevents diarrhea (Kermauner and Laurencic, 2008). In addition, and also organic Se build Se reserves in the body in the form of Se Met which can be used in times of stress to help additional Se-protein production and increased resistance to stress (Fisinin et al. 2008; Surai, and Fisinin, 2014). Selenium as a part of various selenoproteins can help maintain antioxidant defenses preventing damages to tissues and affectively respond to environmental changes (Surai and Fisinin., 2014). Also, Yang *et al.* (2012) stated that the beneficial nutrient utilization due to the positive effects of Se is its role as an antioxidant agent which protect nutrients from oxidation particularly vitamin A and D<sub>3</sub>. Selenium has important biological functions and is an essential element for animal growth. Selenium is an important auxiliary factor for the key enzyme of 5'-deiodinase, which synthesizes triiodothyronine (T<sub>3</sub>) in animals. Triiodothyronine is a main hormone that regulates animal growth by controlling the body's energy and protein anabolism. Se deficiency can cause the reduction of T<sub>3</sub> synthesis and growth inhibition (Preter, 2000). On the contrary, Marounek *et al.* (2009) did not show significant effect of Se supplementats on rabbit growth, feed intake and feed conversion. Moreover, Dokoupilová *et al.* (2007) confirmed that no effect of Se at 0.50 mg/kg was observed on growth and feed conversion. Abdel-Khalek *et al.* (2013) stated that total weight gain and feed conversion were not affected significantly by dietary Se levels (zero, 0.05, 0.1, 0.2, 0.4 and 0.8 mg/kg diets). Although, feed intake was significantly ( $P<0.05$ ) affected especially with feeding the highest dietary Se level. These results are in correspondence with other authors in Lambs (Antunović *et al.*, 2014) and chicken (Payne and Southern, 2005; Spears *et al.*, 2003).

#### **Blood constituents:**

The effects of dietary Se-algae supplementation levels on blood constituents of growing rabbits are presented in Table (6). The results of present study demonstrated that dietary Se-algae supplementation caused a significant increase in total protein and globulin while decrease albumin concentration and A/G ratio when compared with the control group. Supplementation of Se-algae at 0.1 mg was the highest ( $P<0.05$ ) group in total protein and globulin (7.06 and 3.75 g/dl). These findings are similar to Ebeid *et al.* (2013) who stated that dietary treatment with organic Se at 0.3 mg/kg diet increased globulin concentration and found that globulin findings were in agreement with immune responses.

The results of this study showed an increase in total protein and globulin which may be partly due to Se-algae supplementation. In this connection, McConnell and Hoffman (1972) demonstrated that selenomethionine was incorporated into liver polypeptides via the methionine pathway. Furthermore, Selenium is present in two biologically active forms, Se-containing enzymes and Se-containing proteins in animals (Zhang *et al.*, 2011). While, the control group without the supplementation of Se-algae had the lowest total protein and globulin, this reduction might be due to oxidative damage in proteins ranges from specific amino acid modifications and peptide breakage to loss of enzyme activity (Stadtman and Levine, 2003). Little information on the selenium form in Se-enriched *Spirulina* is available for the time being. Selenium is assumed to be built into the protein structure similarly like it is into Se-enriched yeast (Machat *et al.*, 2005), so Se-enriched *spirulina* may be used as a potential form of organic selenium supplemented to sows diets (Kotrbaček *et al.*, 2004).

Se-algae supplementation reduced plasma triglycerides content compared with the control group. Rabbit fed diet supplemented with 0.2 mg Se-algae was the lowest group in triglycerides content (41.84 mg/dl). Similarly, Ebied *et al.* (2012) stated that rabbit fed diets supplemented with 0.15 or 0.3 ppm organic Se significantly reduced triglycerides. While, dietary treatments with Se-algae significantly reduced cholesterol, LDL and total lipid compared with the control group. Dietary supplementation with 0.5 mg Se-algae was the lowest in cholesterol.

Concerning to HDL concentration, there was a significant increase ( $P<0.05$ ) as Se-algae supplementation increased. Rabbits fed diet supplemented with 0.1 and 0.2 mg Se-algae were the highest groups in HDL concentration (55.26, 54.33 mg/dl, respectively), while the control group was the lowest one (44.10 mg/dl). In agreement with our results, Ryu *et al.* (2005) used 8 mg Se /kg DM in broiler diet and reported that the cholesterol concentration was reduced. This result was in accordance with Colla *et al.* (2008) who observed that the serum levels of HDL-cholesterol were higher in the rabbit fed with *Spirulina*. These results showed the potential of biomass *Spirulina* to decrease the serum levels of total

cholesterol. In addition, Cheong *et al.* (2010) reported that *spirulina* intake can cause the reduction of total triglycerides, total cholesterol and LDL-cholesterol and an elevation of HDL-cholesterol level. In the contrast, Ebeid *et al.* (2013) postulated that dietary treatments with Se at 0.3 mg/kg diet did not modify serum total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, total protein or albumin. Additionally, Ebeid *et al.* (2012) found that the dietary treatment with organic Se did not affect total cholesterol content, LDL-cholesterol, total protein and albumen in serum while serum triglycerides and globulins were significantly affected.

These findings suggested that dietary Se-algae supplementation reduced the plasma lipid concentration, although there are limited cases of studies that show direct evidence of the efficacy of Se-algae. These results may be related to effect of Se as it has an anabolic role on fat deposition. The effects of this supplementation were to modulate fatty acid composition in the whole body. Or, these alterations could be due to The *Spirulina* components such as polyunsaturated fatty acids, phycocyanin which are thought to be compounds with antioxidant abilities according to Nagaoka *et al.* (2005).

**Table (6): Effect of dietary Se-algae supplementation on blood constituents.**

Item	Se-algae supplementation (mg/kg DM)						SEM	P value
	Control	0.05	0.1	0.2	0.4	0.5		
Total Protein (g/dl)	5.63 <sup>c</sup>	6.55 <sup>b</sup>	7.06 <sup>a</sup>	6.81 <sup>ab</sup>	6.6 <sup>b</sup>	6.65 <sup>b</sup>	0.16	0.0002
Albumin (g/dl)	3.3	3.22	3.30	3.18	3.01	3.02	0.10	NS
Globulin (g/dl)	2.33 <sup>c</sup>	3.33 <sup>b</sup>	3.75 <sup>a</sup>	3.613 <sup>ab</sup>	3.59 <sup>ab</sup>	3.63 <sup>ab</sup>	0.19	0.0001
A/G ratio	1.22 <sup>a</sup>	0.96 <sup>ab</sup>	0.88 <sup>b</sup>	0.87 <sup>b</sup>	0.83 <sup>c</sup>	0.83 <sup>c</sup>	0.09	0.0194
Triglycerides (mg/dl)	61.50 <sup>a</sup>	45.74 <sup>b</sup>	42.90 <sup>b</sup>	41.84 <sup>b</sup>	43.84 <sup>b</sup>	42.23 <sup>b</sup>	6.06	0.05
Total Cholesterol (mg/dl)	100.21 <sup>a</sup>	93.24 <sup>b</sup>	92.17 <sup>b</sup>	90.79 <sup>b</sup>	91.91 <sup>b</sup>	88.71 <sup>b</sup>	1.60	0.0001
HDL- cholesterol (mg/dl)	44.10 <sup>b</sup>	51.93 <sup>ab</sup>	55.26 <sup>a</sup>	54.33 <sup>ab</sup>	51.78 <sup>ab</sup>	53.62 <sup>ab</sup>	3.17	0.196
LDL- cholesterol (mg/dl)	47.02 <sup>a</sup>	34.07 <sup>ab</sup>	32.91 <sup>ab</sup>	33.73 <sup>ab</sup>	32.41 <sup>b</sup>	30.85 <sup>b</sup>	1.78	0.270
Total Lipid (mg/l)	374.09 <sup>a</sup>	322.69 <sup>ab</sup>	267.62 <sup>b</sup>	299.32 <sup>b</sup>	317.10 <sup>ab</sup>	270.84 <sup>b</sup>	17.34	0.0071

*a, b, c* : Means in the same row having different superscripts differ significantly ( $P < 0.05$ ), NS = not significant.

#### **blood Serum antioxidative status:**

The effect of Se-algae levels on antioxidative status of growing rabbits are presented in table (7). Dietary Se-algae supplementation resulted in a significant effect on serum blood antioxidative properties as measured by total antioxidant capacity (T-AOC) and TBARS as an indexes of oxidation and antioxidant enzymes such as glutathione peroxidase (GSH-Px), superoxide dismutase (SOD) and Catalase (CAT). It could be observed that there was a significant increase in TAC, GSH-Px, SOD and CAT as Se-algae level increased. Rabbits fed diets supplemented with 0.4 and 0.2 Se-algae were the highest in TAC, (3.28 and 3.19 mMol/L, respectively). Also, rabbits fed diet supplemented with 0.2 Se-algae recorded the highest GSH-Px, SOD and CAT (2.68, 47.04 and 640.67mU/ml, respectively) as compared with the control group. In addition, dietary Se-algae significantly ( $P < 0.0001$ ) reduced TBARS, compared with the control, rabbits fed diet supplemented with 0.2 mg Se-algae was the lowest ( $P < 0.05$ ) in TBARS concentration (2.70 nmol/l) and reduced serum TBARS to level about 57.4 % lower than in the control group. These results are in agreement with Ebeid *et al.* (2013) demonstrated that dietary Se for growing rabbit resulted in a significant increase of GSH-Px activity and TAC to more than three times the corresponding value of the control. Furthermore, Zhang *et al.* (2011) stated that the dietary Se level had a cubic relationship with the serum GSH-Px and CAT activities, with the greatest serum GSH-Px and CAT activities observed in the rabbits fed the diet with 0.24 mg/kg Se. Also, Ebeid *et al.* (2012) found that inclusion of 0.15 or 0.3 ppm Se in the growing rabbits' diets elevated serum total antioxidant capacity and reduced the lipid peroxidation expressed as serum malondialdehyde. Similarly, Ebeid (2009) indicated that serum lipid peroxidation decreased significantly in a dose-dependent manner when dietary organic Se level was increased in cockerels.

These results confirmed that supplementing rabbit diets with Se-algae enhanced the antioxidative status as it is an efficient scavenger of free radicals (McDowell, 1992) stated that Se is an essential constituent of glutathione peroxidase (GSH-Px). This enzyme aids in protecting cellular membranes from

oxidative damage. Several studies showed that increase of (GSH-Px) activity in animal exposed to oxidative stress as a mechanism to ward off lipid peroxidation. (Maraschiello *et al.*, 1999, Dalle Zotte and Szendrő, 2011), reducing lipid peroxidation in serum blood and increasing the antioxidant defense system, which resulted in enhancing growth performance of rabbit under hot conditions. Selenium contributes to the protection of cells from oxidative damage via the activity of GSH-Px, which is an enzyme that catalyzes the reduction of hydrogen peroxide and organic peroxides (Behne *et al.*, 2009). A possible reason for this may be the different profile of organic compounds of Se in the Se-algae (Larsen *et al.*, 2001). Kim *et al.*, (2010a) suggest that dietary supplementation with *Spirulina* of New Zealand White rabbit may be useful to protect the cells from lipid peroxidation, oxidative DNA damage and oxidative stress biomarkers such as glutathione, glutathione peroxidase, glutathione reductase, and glutathione S-transferase which were significantly improved in the liver.

The T-AOC reflects the total antioxidant capacity of the body. Although, Se is not a component of SOD or CAT, the ability to synthesize various antioxidant enzymes declines under Se-deficient conditions in animals, while the increase of lipid peroxidation affects vitality. Therefore, increases in GSH-Px and CAT activity enhance the ability to eliminate free radicals. A decrease of the MDA content in the tissues is related to the enhancement of antioxidant enzymatic activity that results from the provision of supplemental dietary Se. Improvement in antioxidant capacity is attributed to inducible Se dependent antioxidant enzymes (Surai, 2002).

It can be concluded that Se-algae supplementation which representing a natural organic bound form enhance antioxidative status and protect the tissues against oxidative damage which included protein and fat oxidation of growing rabbit under hot conditions. A reduction in oxidation level by inclusion of selenium enriched algae into the diets was observed and was associated with the higher activity of glutathione peroxidase, SOD and catalase.

**Table (7): Effect of dietary Se-algae supplementation on antioxidative status of serum.**

Item	Se-algae supplementation (mg/kg DM)						SEM	P-value
	Control	0.05	0.1	0.2	0.4	0.5		
T-AOC <sup>a</sup> (mMol/L)	0.60 <sup>d</sup>	0.93 <sup>cd</sup>	1.16 <sup>c</sup>	3.19 <sup>a</sup>	3.28 <sup>a</sup>	2.04 <sup>b</sup>	0.098	0.0001
TBARS <sup>b</sup> (nmol/l)	6.34 <sup>a</sup>	6.01 <sup>b</sup>	2.90 <sup>c</sup>	2.70 <sup>c</sup>	2.75 <sup>c</sup>	2.84 <sup>c</sup>	0.065	0.0001
GSH-Px <sup>c</sup> (mU/ml)	0.79 <sup>d</sup>	1.05 <sup>cd</sup>	1.19 <sup>c</sup>	2.68 <sup>a</sup>	2.10 <sup>b</sup>	2.06 <sup>b</sup>	0.101	0.0001
SOD <sup>d</sup> (U/l)	27.04 <sup>d</sup>	31.68 <sup>cd</sup>	36.08 <sup>bc</sup>	47.04 <sup>a</sup>	44.64 <sup>ab</sup>	38.64 <sup>abc</sup>	2.475	0.0006
CAT <sup>e</sup> (U/g)	469.90 <sup>b</sup>	568.89 <sup>a</sup>	638.03 <sup>a</sup>	640.67 <sup>a</sup>	626.80 <sup>a</sup>	568.74 <sup>a</sup>	22.73	0.0004

*a* T-AOC, Total antioxidant capacity, *b* TBARS, Thiobarbituric acid, *c* GSH-Px, Glutathione peroxidase, *d* SOD, Superoxide dismutase, *e* CAT, Catalase. *a, b, c* and *d*: Means in the same row having different superscripts differ significantly

**Carcass characteristics:**

Effects of Se-algae supplementation on carcass characteristics are presented in Table (8). The results indicated that supplementation of dietary Se-algae increased hot carcass, dressing (%), edible giblets(%), total edible parts (%) and total non-edible parts (%) compared to control group with rabbits fed diet supplemented with 0.4 mg Se-algae achieved the best hot carcass weight (1498.7g), dressing (63.2%), edible giblets (3.80%) and total edible parts (67.02%) and the same group (0.4 mg Se-algae) was the lowest in total non-edible compared with the other groups.

The results are in agreement with other results that indicated that Se-algae supplementation tended to improve both hot carcass weight and dressing (%) in rabbits (Ebeid *et al.*, 2013). Also, Eibed *et al.* (2012) evaluated the inclusion of organic Se in the diets and found that Supplementation with 0.15 and 0.3 ppm organic Se increased both hot carcass weight and dressing percentage in growing rabbits. On the contrary, other studies have found no significant effect of Se-algae supplementation on carcass yield (Dokoupilová *et al.*, 2007). Marounek *et al.* (2009) reported that no significant difference on hot carcass weight, chilled carcass weight and dressing percentage were observed with different forms of Se-algae supplementation being selenite, Se-yeast and Se-algae. Moreover, Abdel-khalek *et al.* (2013) stated that carcass traits in terms of hot carcass and dressing percentages were not significantly responded to Se level.

**Table (8): Effect of dietary Se-algae supplementation on carcass characteristics in growing rabbits.**

Item	Se-algae supplementation (mg/kg DM)						SEM	P-value
	Control	0.05	0.1	0.2	0.4	0.5		
Pre-slaughter weight (g)	2332.2	2340.6	2413.4	2364.0	2372.0	2339.0	62.5	NS
Hot carcass weight (g)	1340.5 <sup>b</sup>	1406.5 <sup>a</sup>	1469.5 <sup>a</sup>	1450.7 <sup>a</sup>	1498.7 <sup>a</sup>	1468.7 <sup>a</sup>	44.1	0.023
Dressing %	57.5 <sup>b</sup>	60.2 <sup>a</sup>	61.0 <sup>a</sup>	61.3 <sup>a</sup>	63.2 <sup>a</sup>	63.1 <sup>a</sup>	1.70	0.033
Edible Giblets %	3.20 <sup>b</sup>	3.56 <sup>ab</sup>	3.56 <sup>ab</sup>	3.62 <sup>ab</sup>	3.80 <sup>a</sup>	3.74 <sup>a</sup>	0.10	0.05
Total edible parts %	60.7 <sup>b</sup>	63.76 <sup>a</sup>	64.56 <sup>a</sup>	64.92 <sup>a</sup>	67.02 <sup>a</sup>	66.76 <sup>a</sup>	1.80	0.016
Total Non edible parts %	39.3 <sup>a</sup>	36.24 <sup>b</sup>	35.44 <sup>b</sup>	35.08 <sup>b</sup>	32.98 <sup>b</sup>	33.24 <sup>b</sup>	1.79	0.028

a, b: Means in the same row having different superscripts differ significantly ( $P < 0.05$ ), NS = not significant.

#### Chemical composition of meat:

Results in Table (9) clarify that adding of Se-algae affect significantly on meat composition of (DM, CP, EE, Ash and Se content) of hind leg of rabbits. Se supplementation had no effect on the CP. Regarding to EE, data indicated significantly decrease in supplemented groups than the control group as the supplementation of Se-algae increased. Rabbits fed diets supplemented with 0.5 mg Se-algae was the lowest ( $P < 0.0001$ ) group in EE. The reduction of EE may well be caused by different components of Se-algae.

**Table (9): Effect of dietary Se-algae supplementation on meat chemical composition of growing rabbits.**

Item	Se-algae supplementation (mg/kg DM)						SEM	P-value
	Control	0.05	0.1	0.2	0.4	0.5		
Moisture	72.17 <sup>c</sup>	72.68 <sup>ab</sup>	73.36 <sup>a</sup>	73.08 <sup>a</sup>	73.03 <sup>a</sup>	72.93 <sup>a</sup>	0.186	0.0004
DM	28.06 <sup>a</sup>	27.32 <sup>b</sup>	26.63 <sup>c</sup>	26.92 <sup>bc</sup>	26.97 <sup>bc</sup>	27.07 <sup>bc</sup>	0.18	0.0004
CP	22.09	22.22	22.19	22.64	22.42	22.48	0.20	0.424
EE	4.58 <sup>a</sup>	3.56 <sup>b</sup>	2.75 <sup>c</sup>	2.56 <sup>c</sup>	2.47 <sup>c</sup>	2.46 <sup>c</sup>	0.16	0.0001
Ash	1.39 <sup>b</sup>	1.53 <sup>ab</sup>	1.69 <sup>ab</sup>	1.72 <sup>ab</sup>	2.08 <sup>a</sup>	2.16 <sup>a</sup>	0.21	0.0001
SE ( $\mu\text{g/g}$ )	0.096 <sup>c</sup>	0.121 <sup>d</sup>	0.188 <sup>c</sup>	0.200 <sup>c</sup>	0.364 <sup>b</sup>	0.471 <sup>a</sup>	0.004	0.0001

a, b, c, d and e: Means in the same row having different superscripts differ significantly ( $P < 0.05$ ).

These results are consistent with Dalle Zotte *et al.* (2012) who stated that 5% *Spirulina* supplementation seems promising in reducing cholesterol content of fattening rabbit meat, but its inclusion level should be further increased, however, the lipid lowering effect of *Spirulina* was effective on rabbits fed high fat diets only and not on low fat diet group (Meineri *et al.*, 2009). The effect of *Spirulina* on metabolism described by several studies, that the properties of *Spirulina* increases the activity of lipoprotein lipase (Richmond, 1992; Iwata *et al.*, 1990). Additionally, *Spirulina* was confirmed as a rich source of vitamin B12 that was successfully transferred into *Longissimus dorsi* (LD) muscle, thus demonstrating its value as an effective natural supplement in producing food fortified with this vital element (Dalle Zotte *et al.*, 2014).

These results are in contrary with data reported by Ebeid *et al.* (2013) and Ebeid *et al.* (2012) who found that dietary Se had no significant effect on meat composition. These responses were similar to observation by Marounek *et al.* (2009) who revealed that Se supplements had no effect on the CP and of hind leg meat of rabbit supplementation with Se-algae and contained less fat than that of control rabbits. Similarly, Dokoupilová *et al.* (2007) indicated that the content of dry matter in meat was not significantly affected by dietary Se supplementation. There are limited cases of studies that show direct evidence of the efficacy of Se-*Spirulina* in reducing the fat content of meat composition.

The present study was revealed that dietary Se-algae supplementation significantly increased ( $P < 0.0001$ ) Se content and ash content in hind leg. Similar results were reported by Dokoupilová et al. (2007) who found that lion and hind leg meat of rabbit fed the Se-supplemented diet contained four times more Se than meat of control rabbits. Additionally, Marounek *et al.* (2009) reported that Se concentration in meat increased in rabbits fed diets supplemented with Se-algae in which the Se concentration in meat was doubled. Whereas in poultry, the fortification of diets with selenium (0.3 ppm) increased lipid oxidative stability and delayed microbial growth in the thigh muscle (Kim *et al.*, 2010b). Dalle Zotte and Szendrő (2011) reported that supra-nutritional levels of selenium (0.5 mg/kg diet) are able to produce selenium-fortified rabbit meat so as to make a significant contribution to human selenium intake. Additionally, The organic selenium (Se-algae) is more deposited into the muscle tissue and animal organs than inorganic one (Behne *et al.*, 2009).

## CONCLUSION

It could be suggested that dietary supplementation with selenium enriched micro-algae can improve the body weight gain, feed conversion ratio so it had a beneficial effect on health and overall growth performance in growing rabbits. Dietary Se-algae supplementation reduced the blood lipid concentration. As well as, Se-algae supplementation representing a natural organic bound form which enhances anti-oxidative status and protects the tissues against oxidative damage of growing rabbit under hot conditions. Moreover, rabbit meat can be fortified with selenium through dietary supplementation of Se-algae.

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## تأثير إضافة الطحالب الغنية بالسيلينيوم علي أداء النمو والحالة المضادة للتأكسد للأرانب تحت درجات الحرارة المرتفعة في فصل الصيف.

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تبحث هذه الدراسة في تأثير مستويات مختلفة من الطحالب *Spirulina* الغنية بالسيلينيوم علي أداء النمو وصفات الذبيحة ومكونات الدم والحالة المضادة للتأكسد في الأرانب النيوزيلاندى ، وتم التوزيع العشوائي لعدد 90 ارانب عمر 6 اسابيع ذكور إلي 6 مجموعات كل مجموعته بها 15 ارانب، المجموعه الاولى غذيت علي العليقة بدون اى اضافات تمثل المجموعه المقارنه والخمس المجموعات الاخرى غذيت علي علائق تحتوي علي 0,05- 0,1- 0,2- 0,4- 0,5 ملجرام سيلينيوم طحالب/ كجم مادة جافة من العليقة. وكانت النتائج المتحصل عليها كالآتي:

- لم يتأثر متوسط وزن الجسم النهائي ومعدل الزيادة الوزنية للجسم معنويا بإضافة الطحالب الغنية بالسيلينيوم.
- إضافة 0,2 ملجرام سيلينيوم طحالب/ كجم مادة جافة من العليقة قد حسنت معنويا من معامل التحويل الغذائي (2,28 جم علف/جم زيادة وزنية).
- إضافة الطحالب الغنية بالسيلينيوم أدت إلي زيادة معنوية في البروتين الكلي والجلوبيولين في الدم
- الأرانب المغذاه علي عليقة تحتوي علي 0,1 و 0,2 ملجم سيلينيوم طحالب/ كجم مادة جافة من العليقة حققت أعلى تركيز من الكوليسترول عالي الكثافة HDL 54,33-55,26 علي الترتيب.
- لاحظ ان إضافة الطحالب الغنية بالسيلينيوم قللت معنويا من الكوليسترول الكلي و الكوليسترول منخفض الكثافة LDL و الليبيدات الكلية في بلازما الدم.
- وايضا كان هناك زيادة معنوية في TAC، ومستويات الانزيمات المضادة للاكسدة GSH-Px، SOD، CAT في سيرم الدم مع زيادة اضافته الطحالب الغنية بالسيلينيوم.
- حققت الارانب المغذاه علي 0,4- 0,2 ملجم سيلينيوم- طحالب/ كم عليقة أعلى تركيز من T-AOC (3,19-3,28 ملليمول/لتر)، علي الترتيب وكذلك سجلت الأرانب المغذاه علي مستوي 0,2 ملجم سيلينيوم احسن تركيز لأنزيمات GSH-Px، SOD، CAT 2,68-2,04 علي الترتيب.
- حققت الارانب المغذاه علي العلائق المحتوية علي مستوي 0,4 ملجم سيلينيوم-طحالب/كم عليقه افضل وزن ذبيحة (1498,7 جم) ونسبة تصافي (63,2%) واجزاء مأكولة (3,8%) ومجموع الاجزاء الكلية المأكولة (67,02%).
- ونستخلص من النتائج الأتي: قد حسنت اضافة الطحالب الغنية بالسيلينيوم من أداء النمو والحالة المضادة للتأكسد والأرانب استفادت من السيلينيوم في طحالب *Spirulina* بشكل اكثر فعالية تحت تأثير الظروف الحارة بالاضافة إلي أن لحم الأرانب تم تدعيمه بالسيلينيوم من خلال التغذية علي الطحالب *Spirulina* الغنية بالسيلينيوم.