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EVALUATION OF ORGANIC SELENIUM ON PRODUCTIVE PERFORMANCE, BLOOD BIOCHEMICAL PROPERTIES AND ANTIOXIDANT STATUS OF GROWING RABBITS UNDER HOT CLIMATE

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ABSTRACT

The effect of organic selenium (OR-Se) based on Selenomethionine produced by Saccharomyces cerevisiae (Alkosel® NCYC R397) on the growth performance, carcass traits, blood hematological and biochemical indices and antioxidant status of growing rabbits under high ambient temperature. In an 8-week experimental period, a total of 48 New Zealand White rabbits were randomly distributed into 4 groups. Animals were allotted into 4 groups: control (basal diet) and T1, T2, T3 that were fed the basal diet supplemented with 0.4, 0.8 and 1.2 mg OR-Se/kg diet, respectively. Results showed that stressed rabbits in OR-Se-supplemented groups had a significant improvement ($p<0.01$) in growth parameters (except feed intake), dressing percentage and abdominal fat. In addition that, the supplemented groups (T2, T3) recorded higher levels ($p<0.05$) in red blood cells, hemoglobin, and packed cell volume. And these groups had a notable increase ($p<0.05$) in serum total protein and globulin and a decline in total cholesterol and triglycerides. In connection supplemented OR-Se statistically ($p<0.01$) increased serum total antioxidant capacity and declined Malondialdehyde compared with the control. Our findings of this study concluded that the supplementation of growing rabbit diets with OR-Se under hot times can alleviate the adverse effects of heat stress by improvement of the antioxidant status that reflected on growth performance, carcass characteristics and blood parameters.

Keywords: *selenium, stress, rabbits, performance, antioxidants*
Running title: Effect of organic selenium on productive performance of growing rabbits

INTRODUCTION

Lately, the climate change has a great concern for different regions of the world represents negative effects on the global animal agricultural system and causes harmful alterations in the performance and physiological state of animals **(Oladimeji, et al., 2021; Igbal et al., 2022)**. The rabbit industry plays a very vital role in national economies for feed utilization, rapid growth rate, early maturation and use of high-quality meat **(Ayyat et al., 2018)**.

Heat stress (HS) is one of the most important environmental stressors for livestock industry (**Johnson, 2018**). In tropical and subtropical regions which have a high environmental temperature, rabbits reared in open-sided houses are subjected to HS, which results in poor productivity (**Oladimeji et al., 2021**). In particular, rabbits that exposure to a higher temperature than optimal (the upper critical temperature at rest is 27 to 28 °C) are a major stress factor for them due to they have thick insulator fur and a few sweat glands that led to a clear reduction in heat loss (**Ayyat et al., 2018**). In Egypt, the climate has a short cold winter and long hot summer accompanied by high humidity usually over 85% and thus increases heat stress **(Marai et al., 2007; Ayyat et al., 2018)**.

Exposure to high temperatures reduced feed intake and feed utilization which causes disturbances in water, protein and energy, and mineral balances that end with weakness in the reproductive system and production efficiency **(Ayyat et al., 2018; Amer et al., 2019)**. So, HS represents a serious problem for the livestock industry because it wanes the animal performance during the summer months leading to economic losses. HS causes alterations in the temperatures of body and skin, levels of oxygen-derived free radicals, DNA, thyroid hormones, damaged proteins, lipid peroxidation, and immune responses which finally declines growth performance, carcass characteristics and immunity of rabbits **(Abdelnour et al., 2020; Mutwedu et al., 2021;; Oladimeji et al., 2021)**. Accordingly, considerable efforts are required to practical approaches for relieving HS effects on rabbits by management and nutritional strategies **(Johnson., 2018; Abdelnour et al., 2020)**.

Feed additives like trace minerals, vitamins, enzymes, probiotics, herbal plants and their extracts play a vital role in improving the physiological and productive state of animals under HS **(Ayyat et al., 2018; Hassan et al., 2021; Manuelian et al., 2021)**. Trace minerals (microelements) are required as co-factor in the metabolic mechanism and defense against oxidative stress that contribute to the growth and production **(Abdelnour et al., 2020; Hassan et al., 2021)**.

Selenium (Se) is one of the essential trace elements in livestock production that has positive effects on the physiological function, and it is required in small quantities however may be harmful in excess. It is a structural component of selenoproteins (at least 25) in the form of selenocysteine (SeCys2) that plays a central role in enzymatic redox reactions at the cellular level and is able to reduce the damage caused by reactive oxygen species (ROS) **(Amer et al., 2019; Kassim et al., 2022)**. It plays an important role in activating the antioxidative properties via its involvement in the active site of the enzyme glutathione peroxidase

(GSH-Px) in the blood, liver and edible tissues, which might be connected with enhancing the immune response in mammals. Also, it has an important role in animal proteins from oxidation and thyroid hormone synthesis and metabolism **(Yatoo et al., 2013; Ayyat et al., 2018)**. Dietary supplementation of Se can be provided using inorganic or organic sources. While, adequate supplementation of Se is of great important to avoid the risk of immune-suppression, liver necrosis, cardiovascular disease and myopathy **(Kassim et al., 2022; Dos Santos et al., 2022)**. Thus, animal health and performance are negatively influenced by Se deficiency. The supplemental inorganic forms of Se are commonly sodium selenite or selenate, while the organic are Se-enriched yeasts. Because of different metabolism, it has been noticed that inorganic forms of Se have lower bioavailability than the organic one **(Ayyat et al., 2018; dos Santos et al., 2022)**. Therefore, this study was conducted to investigate the potential effects of organic selenium (OR-Se) supplementation on growth performance, carcass traits and some blood parameters of growing rabbits.

MATERIALS AND METHODS

The current study was conducted in the Rabbit Research Unit, Agricultural Research and Experimental Center, Minia University, Egypt. All experimental procedures were carried out in accordance with the local Experimental Animal Care Committee and authorized by the Institutional Committee of the Department of Animal Production, Faculty of Agriculture, Minia University, Egypt.

1- Experimental animals, design, and management

Forty-eight weaned male New Zealand White (NZW) rabbits were randomly divided into four homogeneous groups, housed in individual cages (50×45×40 cm) of an open-sided house under similar management, hygienic and environmental conditions throughout the whole experimental period. Animals had free access to feed and water and received *ad libitum* from onset until the end of the experimental period (5-13 weeks). Throughout the experimental period (*April* to June, 2022), each cage was equipped with feeders and mechanized stainless-steel nipples to provide free feed and water access. The droppings of feces and urine from the rabbitry were removed daily. Rabbits were exposed to daylight during the experimental period. Ingredients and chemical analyses of the basal diet are shown in Table (1) that met the nutritional requirements of weaned rabbits **(NRC, 1977)**. During the experimental period, neither coccidiostats nor antibiotics were added to the base diet.

A total of 48 male rabbits at 5 weeks old with nearly identical initial live body weight (628.70±21.19 g) were randomly assigned to four experimental groups (12 rabbits/each) with four replicates (3 rabbits/ each). The control group was fed a basal diet without any addition, the experimental groups T1, T2 and T3 were fed the basal diet supplemented with organic selenium (Alkosel®, selenomethionine produced by saccharomyces cerevisiae NCYC R397 as a nutritional additive, Lallemand Inc., United Kingdom) supplementation 0.4, 0.8 and 1.2 mg organic selenium (OR-Se) /kg diet, respectively.

Ambient temperature (AT) and relative humidity (RH) documented in Table 2. During the experimental, these parameters were noted daily every two hours, however those were noted each hour (from 11:00 am to 6:00 pm) by using electronic digital thermo-hygrometer (Oregon Scientific BAR268HG-w).

2- Growth performance

Body weights (BWs) of rabbits were noted at the beginning of the experiment to determine the average initial body weight. Body weight and feed intake were recorded weekly throughout the experimental period. The average daily weight gain (DWG) and daily feed intake (DFI) were calculated. Feed conversion ratio (FCR) was calculated as a ratio of a gram of feed intake per gram of gain.

3- Carcass characteristics

By the end of the experimental study, six rabbits from each group were randomly chosen, fasted (with free water) for 12 hours, individually weighed, and directly slaughtered. The carcass, liver, kidney, heart, spleen, and abdominal fat were weighed and presented as percentage of pre-slaughter weight **(Blasco and Ouhayoun, 1996; Hassan et al., 2021).**

4- Blood parameters

During the slaughter process, blood samples (5 mL from each rabbit) were collected in heparinized (I) and non-heparinized (II) sterile tubes.

4-1: Hematological and biochemical parameters

In tube I: whole blood was analyzed for physical blood characteristics. At automated hematology analyzer (MEK-6510 J/K- Nihon Kohden Middle East, Japan) was used to measure hemoglobin (Hb), packed cell volume (PCV), red blood cells (RBCs), and white blood cells (WBCs). The values of mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated according to **(Benjamin, 1978)** as follows:

$$\text{MCV (F1.)} = \frac{PCV\ (ml/dl)}{RBCS(million/ml)} \times 10$$

$$\text{MCH (pg.)} = \frac{Hb.(g/dl)}{RBCS\ (million/ml)} \times 10$$

$$\text{MCHC (g/dl)} = \frac{Hb.(g/dl)}{PCV\ (ml/dl)} \times 100$$

In tube II: blood samples were allowed to coagulate at normal temperature for 30 minutes, were followed by centrifugation at 3000 rpm for 15 minutes, and then the collected serum immediately was stored at - 20 $^{\circ}$C until assay. Total serum protein (TP), albumin (Alb), and globulin (Glob, calculated by subtracting Alb values from TP values) concentration (g/dl), thereby calculating the Alb/Glob ratio. Urea, creatinine, aspartate aminotransferase (AST), alanine aminotransferase (ALT), glucose, total cholesterol (T.Cholesterol), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), and triglycerides were calorimetrically performed using commercial kits (purchased from Bio-diagnostic, Giza, Egypt). The estimated very low-density lipoprotein cholesterol (VLDL) was obtained using the equation of Friedewald **(Friedewald et al., 1972)** as follows:

VLDL = Triacylglyceroles/5

4-2: Antioxidant indices

The concentrations of total antioxidant capacity (TAC), superoxide dismutase enzyme (SOD), catalase (CAT), glutathione peroxidase enzyme (GSH-Px) and malondialdehyde (MDA) in the serum were verified using a commercial colorimetric assay (Bio-diagnostic, Cairo, Egypt), according to the manufacturer's instructions.

5- Statistical analysis

The obtained data were statistically analyzed by one-way analysis of variance (ANOVA), using the general linear model (GLM) procedure of SAS® software **(Statistical Analysis SAS, 2003)**. Duncan's multiple range tests were used to compare the significant differences at 5% level of significance ($P < 0.05$) in treatment means **(Duncan, 1955).**

RESULTS

1- Growth performance

The effect of dietary supplementation with different levels of OR-Se on growth performance parameters (BW, DWG, DFI and FCR) of growing rabbits throughout the experimental periods is presented in Table 3. These parameters, except for DFI, were significantly changed due to the tested addition. There were no significant differences observed in BW, FCR and DWG in the first 2 or 4 weeks of the experimental period. However, with increasing weight of rabbits under high temperatures, a noticeable improvement has been shown with the addition of OR-Se to the feed of these rabbits compared to those fed on the diet without any addition (control). Groups of rabbits that consumed diets with OR-Se (0.4, 0.8 and 1.2 mg/kg diet) had the heaviest ($p<0.01$) BW at 13 weeks of age and had greater DWG (0.8 and 1.2 mg/kg diet) during 5–13 weeks of age than those in the control group. The animals in OR-Se supplemented groups (T1, T2 and T3) showed a considerably inferior FCR compared with those in the control through the entire period of experiment (5–13 weeks of age).

2- Carcass characteristics

Effect of dietary supplemental OR-Se on carcass yield and relative weights of organs are illustrated in Table 4. OR-Se groups (T2 and T3) had a clear increase ($p<0.001$) in dressing percentage, while heat-stressed rabbits in all supplemented groups had lower ($p<0.05$) abdominal fat than those in the control. However, there were no remarkable changes in liver, heart, kidney and spleen percentages among all trial groups.

3- Hematological and biochemical blood parameters

Results found in Table 5 revealed that rabbits which fed on diets supplemented with Alkosel under HS had a significant difference in Hb, PCV and RBCs values; however these animals did not appear any changes ($P>0.05$) in WBCs, MCV, MCH and MCHC values compared with those in the control group. Supplemented groups (T1, T2 and T3) had a significant increase in Hb and PCV, also these groups (except T1) recorded the highest ($p<0.05$) levels of RBCs than the control group.

As shown in Table 6, serum TP, Glob, AST and glucose values were higher ($p<0.05$) in growing rabbits fed on diets supplemented with different OR-Se levels (0.8 and 1.2 mg/kg diet), but no significant effect on Alb, Alb/Glob ratio and ALT was observed among these animals and those in the control group. In contrast, supplemented groups (T2 and T3) have the lower levels ($p<0.05$) in serum urea, creatinine, T.Cholesterol, LDL, VLDL and triglycerides, while these groups recorded the significant increase in serum HDL compared with un-supplemented group (control).

4- Antioxidant indices

As depicted in Table 7, rabbits that received OR-Se (0.8 and 1.2 mg/kg) under hot conditions showed a significant increase in blood serum antioxidative properties as measured by TAC, SOD, CAT, GSH-px and MDA. Supplemented rabbits had high levels ($p<0.05$) of SOD, CAT, TAC and GSH-px, however these animals had low levels ($p<0.05$) of MDA in the serum compared with others in the control group.

DISCUSSION

1- Growth performance

Adding Se to rabbit diets has been shown a positive effect on the growth performance, particularly in animals reared under HS **(Sheiha Asmaa et al., 2020; Hassan et al., 2021; Bashar et al., 2022)**. The differences in supplementation Se effects may be due to dose, duration, and organic or organic form **(Fernández-Lázaro et al., 2021)**. In general, more studies have revealed that, adding Se from an organic source can be more efficient than in organic source by improving the bioavailability, rates of tissue retention and utilization for the synthesis of selenoproteins under HS conditions **(Wang and Xu, 2008; Briens et al., 2013; Qazi et al., 2019)**.

Similar to our presented findings, **Hassan et al. (2021)** indicated that dietary OR-Se (0.5 mg/kg diet) for rabbit diets under summer season (AT: 33.7 - 34.8 ºc and RH: 83.8 - 84.4%) significantly increased BW and DBWG and markedly improved FCR but did not affect DFI during the entire period (6-14 weeks of age). In parallel, **Ayyat et al. (2018)** showed that dietary supplementation with 0.03 mg OR-Se (Bio-Mos® or Bactocell) for stressed animals (AT: 31.5±0.51°C and RH: 79.07± 1.03%) can be able to statistically increased performance of those growing rabbits. Besides, adding selenium nanoparticles (50 mg/kg diet) for growing rabbit exposed to high temperatures (HS) led to remarkably improve in all growth indices **(Bashar et al., 2022)**. On contrary, **Habibian et al. (2014)** indicated that, adding 0.5 or 1 mg Se (selenomethionine) per 1 kg diet for broiler reared under HS thorough the overall experimental period (1-49 days of age) did not present any remarkable improvements on growth performance.

In the present study, the enhancement of supplementation OR-Se on growth performance of stressed rabbits may be due to the supportive effect of antioxidant activities of OR-Se by increasing Se concentration and the activity of glutathione peroxidase in the duodenal mucosa that can be able to protect the small intestine and pancreas against oxidative stress, which was reflected in a better digestibility and absorption of nutrients **(Habibian et al., 2015; Chen et al., 2022)**. Additionally, OR-Se is connected with the thyroid activity, indeed the activity deiodinases and selenoenzymes of thyroid which catalyze the activation of triiodothyronine (T3) from thyroxine (T4) which describes the beneficial effect of Se on growth parameters **(Stapleton, 2000)**. On the contrary, high ambient temperature in unsupplemental group has been documented to reduce growth performance, possibly due to extreme ROS that oxidize and destroy biological molecules of the cells, prohibit some ATPase activities, and lastly cause many disturbances to intestinal tissues and altered growth and feed utilization **(Surai and Kochish, 2017)**.

2- Carcass characteristics

In the current study, compared with the control group, OR-Se added groups improved carcass yield and decreased abdominal fat but did not affect liver, heart, kidney and spleen percentages of rabbits reared under high ambient temperatures.

These results are in agreement with the results of **Sheiha et al. (2020)** who showed that adding biological Se (50 mg/kg diet) for rabbit diets that were exposed to thermal stress improved carcass yield (%) and did not show any difference in values of liver, heart, kidney and spleen percentages. Additionally, dietary supplementation with organic selenium (0.3 mg/kg, Sel-Plex™) for NZW rabbits under HS statistically decreased abdominal fat however there were no significant differences in liver, heart and kidney percentages compared to the control values **(El-Badry et al., 2019)**. On the other hand, **Ayyat et al. (2018)** indicated that rabbits that fed diets with 0.03 mg OR-Se (Sel-Plex®) during the summer season did not record any significant changes in dressing (%) compared to those in the non-supplemented group.

This finding of the present study of improving carcass yield may be attributed to the significant enhancement in the growth parameters (Table 3) of supplemented groups. Also, the significant reduction in total cholesterol, LDL and triglycerides (Table 6) of supplemented groups could be associated with a significant decrease in the relative weight of abdominal fat that reflects the positive effect of adding OR-Se on lipid metabolism of stressed rabbit

3- Hematological and biochemical blood parameters

Similar results were shown that growing rabbits fed on diets with Se nanoparticles (50 mg/kg diet) supplementation under thermal stress had a high level ($p<0.005$) in Hb concentration and did not have differences in MCV and MCH compared with those in the control **(Bashar et al., 2022)**. Furthermore, OR-Se addition (0.3 mg/kg diet) to Japanese quail diets under high temperatures increased PCV, Hb and RBCs concentration compared to the un-supplemented birds **(Abdelhady et al., 2017)**. Moreover, **Elnaggar et al. (2020)** indicated that dietary supplementation with selenium yeast (saccharomyces cerevisiae) for broiler significantly increased RBCs, Hb and PCV and did not differ in WBCs concentration.

In general, hematological parameters are good indicators of the physiological state of animals that reflects the positive or negative effect of nutritional status on these animals **(Dalia et al., 2020)**. From the present study, the increasing of RBCs and Hb concentration under heat stress of supplemented groups as a result of the helpful effect of Se can able to improve the stability, activity of enzymes and synthesis in hematopoietic pathway **(Raza et al., 2018)**. Besides, HS leads to a high generation of ROS and increasing oxidative stress damage in RBCs **(Zheng et al., 2019)**. Therefore data of this study

(Table 6) showed that OR-Se can promote antioxidant enzymes like glutathione peroxidase, which can protect erythrocytes and hemoglobin in RBCs against free radicals and oxidative stress **(Huang et al., 2012)**.

Regarding the effect of OR-Se on serum biochemistry indices of stressed rabbits as presented in Table 6, supplemented groups presented a positive effect on serum biochemistry indices. These results are balanced with those of **Ayyat et al., (2018)** showed that stressed rabbits fed diets including OR-Se had high levels in serum TP, Glob and did not have changes in serum ALT compared with those in the control group. Similarly, supplemental Se to diets of the growing rabbits under summer conditions statistically increased TP, Glob, HDL and declined T.Cholesterol, LDL, VLDL and triglycerides **(Hassan et al., 2021)**. In addition, adding Se to growing rabbit diets that were reared under thermal stress significantly decreased urea and triglycerides concentration in serum **(Sheiha et al., 2020)**. Furthermore, dietary supplementation with Se (0.1 and 0.2 mg/kg) for stressed broilers is presented a clear increase in serum glucose and a significant reduction in T.Cholesterol, LDL, VLDL and triglycerides compared with birds in the control group **(Abdel-Moneim et al., 2021)**. On the other hand, **Habibian et al. (2014)** showed that, stressed broilers that were received diets with 0.5 or 1 mg Se per 1 kg diet did not have any differences in glucose, Alb, triglycerides, LDL and HDL levels compared with others in the control group.

From the present study, the enhancement in growth performance (by a significant increase in DBW and feed efficiency) of supplemented groups may be contributed to the enhancement of nutrient absorption that can be considered an explanation for a notable improvement in serum protein profile **(Briens et al., 2013; Hassan et al., 2021)**.

Generally, under HS conditions, the primary mechanism that contributes to lipid disorders such as hyperlipidemia (hypercholesterolemia and/or hypertriglyceridemia) occurs, also changes in fatty acid distribution **(Habibian et al., 2014; Guo et al., 2020)**. The obtainable results from this experiment showed the benefits of OR-Se supplementation on lipid profile and antioxidant enzymes (Table 7) that may be reflected by the positive effect of Se that able to protect the lipoproteins from oxidative stress, while Se supplementation led to the inhibition of adipose tissue lipolysis, decreases free fatty acids released into the circulatory system and prevent LDL oxidation as part of the enzyme phospholipid-hydroperoxide GPx that is transported in the bloodstream by HDL **(Miyamoto et al., 2010; Guo et al., 2020)**.

4- Antioxidant indices

Under normal management and nutritional conditions, animals can depend on their own antioxidant enzymes (SOD, CAT, GSH-Px) to retain cellular redox balance and protect the tissues and cells to prevent ROS damage **(Surai,2016)**. However, HS causes oxidative stress (imbalance between oxidation and anti-oxidation) by increasing oxygen-derived free radicals and reducing cellular antioxidant levels that led to DNA damage, lipid peroxidation and protein oxidation **(Saenz-de-Viteri et al., 2014)**.

The level of MDA in serum is dependent on the antioxidants levels and its level reflects the sensitivity to oxidant stress and lipid peroxidation **(Oladimeji et al., 2022)**. CAT enzyme can detoxify hydrogen peroxide (H_2O_2) to water (H_2O) and oxygen (O2) which increased in production by the increased dismutation of O_2 by SOD **(Bosch et al., 2015)**. Additionally, it has been confirmed that for modulation of antioxidant activities of GPXs under oxidative stress conditions, selenocysteine, derived from selenomethionine that controls the gene expression and activates the GPX system. OR-Se could be utilized for the synthesis of selenoproteins under stress conditions **(Qazi et al., 2019; Liu et al., 2021)**.

In the present study, TAC, SOD, CAT, GSH-px markedly increased, and MDA reduced with dietary supplementation. The reduction in MDA level shows that the effect of oxidative stress condition on the cell is deceased. The improvement in antioxidant indices led to an enhancement in the productive performance of growing rabbits under hot conditions (Table 3). In this connection, **El-Badry et al. (2019)** showed that adding 0.3 mg OR-Se /kg diet (Sel-Plex™) for NZW rabbits under HS improved antioxidative properties, and caused a significant enhancement in TAC in blood and alleviated the harmful effects of HS via reducing the MDA content in the blood. Also, **Hassan et al. (2019)** reported that adding 0.2 mg Se-yeast (selenium yeast) for growing rabbit diets can able to enhance the antioxidant status by decreasing plasma MDA and increasing ($P<0.05$) in the activity of catalase enzyme. Besides, birds fed diets supplemented with 0.2 mg selenium nanoparticles presented higher levels ($p<0.001$) of SOD and GPx and lower level ($p<0.001$) of MDA compared to those fed un-supplemented diets **(Abdel-Moneim et al., 2021).** Moreover, **Abdelhady et al. (2017)** showed that supplemented OR-Se to stressed birds resulted in a decline ($P<0.05$) in oxidative stress marker MDA with a notable improvement in antioxidant biomarkers GSH-Px and TAC compared to un-supplemented birds.

In conclusion, based on the present results of this study, it can be indicated that dietary supplementation with 0.8 or 1.2 mg of OR-Se (based on yeast)/ kg diet for growing rabbits under hot conditions had a positive effect on growth performance, carcass yield, hematological and biochemical indices and antioxidant status.

Table (1): Feed ingredients and chemical analysis of the control diet fed to rabbits (% DM basis)

Ingredients	%	Ration calculated analysis (%)*	
Yellow corn	20.90	Crude protein, CP	16.95
Soybean meal (44% CP)	14.00	Metabolizable Energy, ME (Kcal/kg)	2470.20
Wheat bran	23.30	Crude fiber, CF	8.66
Barley	24.60	Ether extract, EE	2.53
Alfalfa meal	14.00	Calcium	1.10
Dicalcium phosphate	1.80	Available phosphorus	0.51
Limestone	0.60	Lysine	0.77
DL-Methionine	0.20	Methionine	0.45
Vit-min premix**	0.30	Methionine+ cysteine	0.77
Food salt	0.30		
Total	**100.00**		

* Calculated based on the composition of the ingredients and according to feed composition tables for animal and poultry feedstuffs used in Egypt (2001).
** Each 1kg of premix of vitamins, minerals (Vit-min) mixture contains: Vit. A: 4,000,000 IU; Vit. D3: 1,000,000 IU; Vit. E:3.3 mg; Vit. K3: 1.0 mg; Vit. B1: 66.7 mg: Vit. B2: 1.7 mg Vit. B6: 1.0 mg: Vit. B12: 5.0 mg; Biotin: 16.7 mg; Folic acid: 0.3 mg; Nicotinic acid: 11.7 mg: Pantothenic acid: 3.3 mg; Mn: 26.7 g; Cu: 2.9 g; Zn: 23.3 g; Fe: 11.7 g; I: 3.3 g; Co: 0.05g and Se: 0.1g.

Table (2): Ambient temperature (AT) and relative humidity (RH) throughout experimental period

Weeks	Mean ambient temperatures			Mean relative humidity		
	Maximum AT (°C)	Minimum AT(°C)	Average AT(°C)	Maximum RH (%)	Minimum RH (%)	Average RH (%)
1st	36.14	25.14	30.64	58.29	44.29	51.29
2nd	30.71	22.00	26.36	58.43	39.71	49.07
3rd	32.29	23.00	27.65	57.86	42.57	50.22
4th	33.43	23.00	28.22	58.57	40.57	49.57
5th	36.00	24.71	30.36	61.43	40.43	50.93
6th	33.57	22.00	27.79	59.57	39.00	49.29
7th	35.86	24.14	30.00	59.86	42.43	51.15
8th	33.43	23.14	28.29	60.14	39.86	50.00

Table (3): Effect of organic selenium (Alkosel) supplementation on growth performance of growing rabbits

Item	Groups				SEM	p-value
	Control	T1	T2	T3		
Average body weight, BW (g):						
5 weeks	623.90	633.77	649.60	607.51	14.23	0.2184
7 weeks	999.00	1031.40	1050.73	1013.27	17.87	0.2087
9 weeks	1409.83^{b}	1469.80^{a}	1489.83^{a}	1458.45^{a}	16.28	0.0090
11 weeks	1802.70^{c}	1864.54^{bc}	1935.73^{a}	1897.99^{ab}	22.26	0.0011
13 weeks	2125.91^{b}	2219.90^{a}	2272.83^{a}	2260.57^{a}	18.88	<0.0001
Average daily weight gain, DWG (g/rabbit/day):						
5-7 weeks	26.79	28.40	28.65	28.98	0.81	0.2416
7-9 weeks	29.34	31.31	31.36	31.80	0.73	0.0943
9-11 weeks	28.06^{b}	28.20^{b}	31.85^{a}	31.40^{a}	0.81	0.0012
11-13 weeks	23.09^{b}	25.38^{a}	24.08^{ab}	25.90^{a}	0.69	0.0260
5-13 weeks	26.82^{c}	28.32^{b}	28.99^{a}	29.52^{a}	0.22	<0.0001
Average daily feed intake, DFI(g/rabbit/day):						
5-7 weeks	81.66	82.41	81.08	81.97	0.92	0.7717
7-9 weeks	102.05	102.82	102.13	99.82	1.10	0.2532
9-11 weeks	113.26	113.39	110.01	110.04	1.68	0.2918
11-13 weeks	123.96	124.22	120.97	121.13	1.69	0.3619
5-13 weeks	105.23	105.71	103.55	103.24	0.94	0.1860
Feed conversion ratio, FCR (g feed/g gain)						
5-7 weeks	3.08	2.91	2.89	2.85	0.10	0.4421
7-9 weeks	3.52^{a}	3.30^{ab}	3.26^{ab}	3.16^{b}	0.09	0.0458
9-11 weeks	4.11^{a}	4.08^{a}	3.46^{b}	3.54^{b}	0.16	0.0047
11-13 weeks	5.40^{a}	4.93^{bc}	5.05^{b}	4.70^{c}	0.10	0.0002
5-13 weeks	3.93^{a}	3.73^{b}	3.57^{c}	3.50^{c}	0.04	<0.0001

a,b,c Within the same rows, means have similar letter(s) are not significant different at 0.05.
SEM = standard error of mean.

Table (4): Effect of organic selenium (Alkosel) supplementation on carcass traits of growing rabbits

Item	Groups				SEM	p-value
	Control	T1	T2	T3		
Pre-slaughter weight, g	2163.03[b]	2244.03[a]	2304.27[a]	2282.20[a]	21.84	0.0008
Dressing (%)	55.38[b]	57.53[b]	62.58[a]	62.94[a]	1.36	0.0014
Liver, %	3.58	3.77	3.74	3.82	0.107	0.4360
Heart, %	0.340	0.388	0.402	0.353	0.028	0.3901
Kidney, %	0.738	0.748	0.775	0.790	0.018	0.2044
Spleen, %	0.143	0.148	0.163	0.167	0.009	0.2074
Abdominal fat, %	0.963[a]	0.882[b]	0.853[b]	0.818[b]	0.022	0.0013

a,b Within the same rows, means have similar letter(s) are not significant different at 0.05.
SEM = standard error of mean.

Table (5): Effect of organic selenium (Alkosel) supplementation on hematological parameters of growing rabbits

Items	Groups				SEM	p-value
	Control	T1	T2	T3		
Hb, g/dl	10.55[b]	12.44[a]	12.75[a]	13.30[a]	0.471	0.0077
PCV, %	34.75[b]	39.50[a]	41.00[a]	42.25[a]	1.358	0.0107
RBCs, 10^6 /µL	5.48[c]	5.93[bc]	6.43[ab]	7.04[a]	0.287	0.0132
WBCs, 10^3/µL	6.10	6.25	5.93	5.90	0.219	0.6512
MCV, F1.	63.67	67.03	64.39	60.20	3.234	0.5394
MCH, Pg.	19.27	21.02	20.00	18.99	0.936	0.4530
MCHC, g/ dl	30.26	31.62	31.09	31.74	1.47	0.8871

a,b,c Within the same rows, means have similar letter(s) are not significant different at 0.05. SEM = standard error of mean. Hb = hemoglobin; PCV = peaked cell volume; RBCs = red blood cells, WBCs = white blood cells, MCV = mean corpuscular volume; MCH = mean corpuscular hemoglobin and MCHC= mean corpuscular hemoglobin concentration.

Table (6): Effect of organic selenium (Alkosel) supplementation on serum constituents of growing rabbits

Items	Groups				SEM	p-value
	Control	T1	T2	T3		
TP (mg/dl)	5.60^{c}	5.96^{b}	6.26^{ab}	6.45^{a}	0.113	0.0010
Alb (mg/dl)	3.18	3.26	3.42	3.49	0.099	0.1504
Glob (mg/dl)	2.42^{b}	2.70^{ab}	2.84^{a}	2.96^{a}	0.105	0.0192
Alb/Glob ratio	1.320	1.210	1.203	1.195	0.067	0.5328
AST(U/L)	26.29^{b}	28.34^{ab}	29.07^{a}	30.21^{a}	0.814	0.0325
ALT (U/L)	16.30	17.20	18.97	17.70	0.650	0.0761
Glucose (mg/dl)	97.20^{b}	98.01^{b}	99.16^{ab}	100.28^{a}	0.672	0.0342
Urea (mg/dl)	17.94^{a}	17.32^{ab}	14.09^{c}	15.38^{bc}	0.710	0.0086
Creatinine (mg/dl)	1.16^{a}	1.12^{ab}	0.92^{c}	0.96^{bc}	0.059	0.0381
T.Cholesterol (mg/dl)	111.89^{a}	101.78^{b}	100.41^{b}	99.22^{b}	2.142	0.0047
HDL (mg/dl)	29.32^{c}	32.12^{bc}	39.53^{ab}	43.34^{a}	2.877	0.0169
LDL (mg/dl)	55.72^{a}	47.48^{ab}	40.64^{bc}	35.15^{c}	2.820	0.0014
VLDL (mg/dl)	26.86^{a}	22.18^{b}	20.24^{b}	20.73^{b}	1.090	0.0040
Triglycerides (mg/dl)	136.31^{a}	118.46^{b}	118.73^{b}	115.63^{b}	3.992	0.0122

a,b,c Within the same rows, means have similar letter(s) are not significant different at 0.05. SEM = standard error of mean. TP: total protein, Albumin: Alb; Globulin: Glob, aspartate aminotransferase: AST, alanine aminotransferase: ALT, T.Cholesterol: total cholesterol, HDL: high-density lipoprotein cholesterol, LDL: low-density lipoprotein cholesterol and VLDL: low-density lipoprotein cholesterol.

Table (7): Effect of organic selenium (Alkosel) on antioxidant indices of growing rabbits

Items	Groups				SEM	p-value
	Control	T1	T2	T3		
TAC (mmol/L)	0.81^{c}	1.16^{b}	1.37^{b}	1.78^{a}	0.111	0.0004
SOD (U/L)	21.40^{c}	22.31^{bc}	25.73^{ab}	26.84^{a}	1.336	0.0380
CAT (U/L)	135.47^{b}	141.15^{b}	148.22^{ab}	159.67^{a}	4.833	0.0222
GSH-px (U/L)	0.40^{c}	0.51^{bc}	0.71^{ab}	0.76^{a}	0.071	0.0131
MDA (mmol/L)	5.38^{a}	4.66^{b}	4.30^{b}	3.57^{c}	0.213	0.0005

a,b,c Within the same rows, means have similar letter(s) are not significant different at 0.05. SEM = standard error of mean. TAC: total antioxidant capacity SOD: superoxide dismutase, CAT: catalase, GSH-Px: glutathione peroxidase and MDA: malondialdehyde.

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الملخص العربي

تقييم السلينيوم العضوي علي الأداء الانتاجي وصفات الذبيحة والخصائص الكيميائية الحيوية للدم وحالة مضادات الأكسده للأرانب الناميه تحت ظروف المناخ الحار

ابو القاسم ابو بكر عبد الوهاب طنطاوي – مها احمد عبد اللطيف –
عبد الحميد صلاح عبد الحميد محمد

أجريت هذه التجربة لدراسة تأثير السيلينيوم العضوي (OR-Se) المعتمد على السيلينوميثيونين (Alkosel) على الاداء الانتاجي ، صفات الذبيحة ، مؤشرات الدم وحالة مضادات الأكسدة للأرانب النامية خلال فصل الصيف. في الفترة التجريبية التي كانت مدتها 8 أسابيع ، تم توزيع عدد 48 من الأرانب البيضاء النيوزيلندية بشكل عشوائي إلي 4 مجموعات. وتشكلت التجربة من 4 مجموعات وهي الكنترول (تغذت علي عليقة اساسية) و T1، T2 و T3 وتم تغذيتهم علي عليقة أساسية مضافا اليها 0,4 ، 0,8 و 1,2 ملليجرام من السيلينيوم العضوي / كجم علف، على الترتيب. أظهرت النتائج أن الأرانب المعرضة للاجهاد الحراري في المجموعات المعاملة بالسيلينيوم أدت الي تحسن معنوي في مؤشرات النمو (فيما عدا الغذاء المأكول) ونسبة الذبيحة ودهن البطن. بالإضافة إلى ذلك سجلت المجموعات المعاملة (T2، T3) المستويات الأعلى ($p<0.05$) في عدد خلايا الدم الحمراء وقيم الهيموجلوبين والهيماتوكريت. سجلت هذه المجموعات ايضا زيادة معنوية في البروتين الكلي والجلوبيولين في الدم وإنخفاض ملحوظ في الكوليسترول الكلي والدهون الثلاثية. وبالتتابع المجموعات المعاملة بالسيلينيوم العضوي حسنت بشكل معنوي مضادات الأكسدة مقارنة مع مجموعة الكنترول. تتلخص نتائج هذه الدراسة إلي أن إضافة السيلينيوم العضوي للأرانب النامية في الأوقات الحارة يمكن أن يخفف الآثار الضارة للإجهاد الحراري عن طريق تحسن في مضادات الأكسدة التي تنعكس على الأداء الإنتاجي و مقاييس الذبيحة وخصائص الدم.