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Effect of Dietary Organic Selenium Supplementation on Growth Performance, Carcass Characteristics and Antioxidative Status of Growing Rabbits

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ABSTRACT

Total of 45 weaned male New Zealand White (NZW) rabbits about six weeks old with an average initial body weight 618.11±10.01g were randomly allotted to three dietary groups; the first group fed the basal diet without organic Se, the second fed basal diet +0.2 mg Se-yeast, the third fed basal diet +0.2 mg Se-algae. The obtained results showed that supplementation rabbit diets with Se-yeast and Se-algae have no impact on final body weight and average daily body weight gain. Se-algae supplementation tended to increase (P<0.05) average daily feed intake. Rabbits group fed diet supplemented with Se-yeast achieved better (P<0.05) FCR than that group fed Se-algae (5.06 g feed/g gain). Supplementation of Se-algae at 0.2 mg was the highest (P<0.05) in total protein, albumin, and globulin concentration (7.94, 4.16 and 3.78 g/dl). Diets supplemented with Se-yeast or Se-algae significantly reduced plasma creatinine levels compared to the control group. All recorded values of creatinine and urea concentrations were within the normal ranges. Dietary supplementation with 0.2 mg Se-yeast or Se-algae resulted in a significant (P<0.05) decrease in the activity of AST enzyme. Plasma total cholesterol and plasma LDL levels were significantly decreased (P<0.05) with dietary supplementation with Se-yeast or Se-algae. There was a significant (p<0.05) decrease in plasma MDA level in rabbits fed diets supplemented with Se-yeast or Se-algae. While Catalase activity was significantly (P< 0.05) increased. Rabbits fed diet supplemented with Se-algae was the lowest (P<0.05) group in ether extract meat content while dietary supplementation of Se-algae significantly increased (P<0.05) Se content of rabbits meat of hind leg. Conclusively, Se-yeast and Se-algae can be used as selenium sources in growing rabbit diets without causing any adverse effects on growth performance. Besides, their beneficial effects in improving the antioxidative status.

Key words: Anti-oxidative status, Carcass, Growth, Organic selenium, Rabbit

INTRODUCTION

Selenium (Se) supplements are commonly added to animal feedstuffs. Selenium is an important micronutrient in animals as well as human and its deficiency has various negative impacts (Kieliszek and BłaZejak, 2016). Diseases such as white muscle, liver degeneration, exudative diathesis, impaired reproduction, and poor immunity have been associated with selenium deficiency. Se is a constituent of the enzyme Glutathione (GSH) peroxidase which plays a role in the detoxification of peroxides formed during metabolic processes (Mateos et al., 2010). The H_2O_2 is the most toxic molecule to the cells, and it is detoxified by GSH and catalase. Thus, the inhibition of GSH causes the inhibition of the activities of its dependent enzymes (Safhi et al., 2018). It is also important for a number of physiological processes including regulation and function of the immune system through its incorporation into selenoproteins. Also, Se is involved in the regulation of oxidative stress, redox mechanisms, and other crucial cellular processes involved in innate and adaptive immune response (Dalgaard et al., 2018). Body weight gain, feed conversion efficiency and antioxidant capacity of growing rabbits were improved when offered supplementary dietary Se at a level of 0.24 mg Se/kg Dry Matter (DM) (Zhang et al., 2011). While, Syvyk et al., (2018) mentioned the best dose of selenium for rabbits is 0.2 mg/kg of DM. This dose of Se seemed to be optimal for young rabbits for fattening.

Feedstuffs are routinely supplemented with various Se sources, but organic forms of Se like as selenized yeast, selenomethionine and selenium enriched algae are better utilized due to higher bioavailability and less toxic than the inorganic forms as selenites and selenates which can be toxic at increased dietary concentration (Suraï, 2002; Dunshea and Uglietta, 2008; Douch et al., 2009; Hassan et al., 2015). Papadomichelakis et al. (2017) reported that dietary organic Se supplementation at 0.5mg/kg improves meat fatty acids composition and oxidative stability of growing rabbits, whereas at 2.5mg/kg may induce pro-oxidant effects. Se-enriched microalgae may benefit from the presence of specific

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bioactive compounds such as antioxidant, pigments, fatty acids, polysaccharides and immune active substances (Douch et al., 2009; Kouba et al., 2014). Dietary fortification with Spirulina platensis microalga seems promising in improving the oxidative stability of rabbit meat, besides, adding functional ingredients (Dalle Zotte et al., 2011). Chen and Wong (2008) stated that Se with phycocyanin (Spirulina platensis) is a promising organic Se and antioxidant agent. Selenium enriched spirulina supplementation improved growth performance and anti-oxidative status of growing rabbits under hot conditions (Hassan et al., 2015). Yeast enriched with Se has recently become commercially available, and research suggests that it may be an efficacious source for the production of Se enriched animal products (Shini et al., 2015).

The objective of this study was to evaluate the effects of dietary supplementation of organic Se forms such as Se-yeast and Se-algae on growth performance, carcass characteristics, blood biochemical parameters and antioxidant status of growing rabbits.

MATERIALS AND METHODS

Experimental region

The present study was carried out in rabbit research unit at Sakha research station located in Alexsanderia governorate, Egypt, belongs to Animal Production Research Institute (APRI), Agricultural Research Center (ARC).

Ethical approval

This experiment was conducted after obtaining the ethical approval of the Animal Production Research Institute (APRI), Egypt.

Experimental design and application

Forty-five (six weeks of age) New Zealand white male rabbits were divided randomly into three homogeneous groups (n=15 each) with 618.11±10.01 g average live body weight. Each group has five replicates of which three rabbits. The treated groups were, control (basal diet without any supplementation), the second one was supplemented by selenium enriched yeast (Se-yeast) at 0.2 mg/kg diet and the third group was supplemented with selenium enriched algae Spirulina (Se-algae) at 0.2 mg (Figure, 1). Se enriched yeast (Se-yeast) is produced by growing strain of yeast (*Saccharomyces cervisiae*) in a Se-enriched media, (Sel-Plex®, was obtained from Alltech Inc, Nicholasville, KY, USA). Selenium enriched algae is produced by growing strain of Spirulina platensis (*Arthrospira platensis*), algae containing 1 mg Se/g algae. This algae strain was obtained from agricultural microbiology department, National Research Centre (NRC), Giza, Egypt.

Throughout the experimental period, body weight was determined every four weeks (at 6, 10 and 14 weeks of age) and average body weight gain was calculated. During the whole experimental period, the feed intake was determined precisely and is given as grams per rabbit per week. From each cage, feed residuals were collected daily, weighed and taken into consideration for the calculation of feed intake and feed conversion ratio (FCR) was calculated as a ratio of gram of feed per gram of gain.

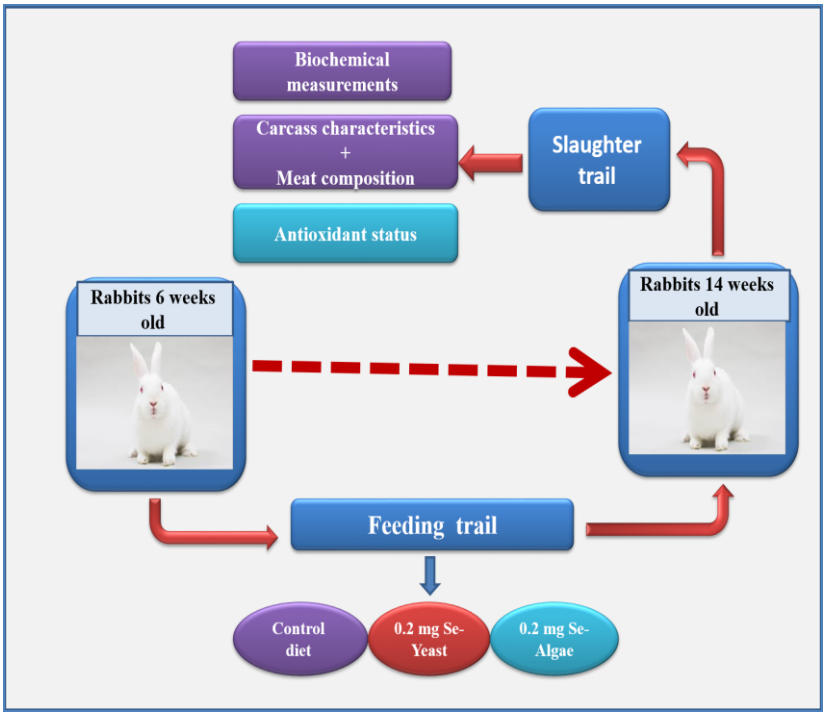

Figure 1. Experimental design and feeding trail of New Zealand white rabbit (6-14 weeks old) under Egyptian conditions

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Experimental diets and housing

The experimental diets were pelleted and formulated to meet recommended nutrient requirements of growing rabbits according to Lebas (2013). Ingredient and chemical composition of the basal diet is presented in table 1. The control diet, thus containing only the endogenous Se contained in the ingredients of the diet (0.08mg Se/kg diet). Rabbits were housed individually in stainless steel cages (35 ×35 ×60 cm^3) provided with feeders and automatic nipple drinkers. Diet and water were offered *ad libitum*. All rabbits were kept under the same management, hygienic and environmental conditions.

Table 1. Feed ingredients and chemical analysis of the basal diet on the dry matter basis for New Zealand white rabbit (6-14 weeks old) during January 2018

Feed Ingredient	(%)	Chemical analysis (% dry matter basis)	(%)
Soybean meal (44% CP[a])	19.60	Dry matter (DM)	89.87
Barley	17.10	Organic matter (OM)	90.70
Yellow corn	7.00	Crude protein (CP)	17.86
Wheat bran	25.08	Crude fiber (CF)	13.33
Clover hay	24.50	Ether extract (EE)	2.350
Molasses	3.00	Nitrogen free extract (NFE)	58.44
Limestone	1.08	Ash	8.020
Di- calcium phosphate	1.71	Methionine[b]	0.670
DL-Methionine	0.08	Methionine+cysteine[c]	0.760
Sodium chloride	0.35	Lysine[d]	0.980
Vit.-Min. premix[b]	0.30	Calcium[e]	1.290
Anti-coccidiosis	0.10	Available Phosphours[f]	0.510
Anti-Fungi	0.10	Digestible energy (Kcal/Kg DM) [g]	2708.14
Total	100	Selenium (mg/kg DM) [h]	0.08

[a] CP: Crude Protein, [b]Vit.-Min. premix: Mineral and vitamin mixture supplied per kg of diet: Vitamin A 10000 IU, Vitamin D3; 1800 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 mgm I; 1 mg, Mn; 60 mg, Cu; 5.5 mg, Zn; 75 mg, Fe; 40 mg, Co; 0.3 mg, Robenidine; 52.8 mg, (b,c,d,e,f,h) Calculated on the basis of the ingredients composition. (g) Digestible energy (DE) was calculated according to Lebas (2013).

Carcass traits

At the end of the experimental period (14 weeks old), five rabbits from each treatment were randomly kept off feed for 12h, weighed and slaughtered for carcass characteristics and meat analysis. Carcass characteristics were measured according to Blasco and Ouhayoun et al. (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 Blasco and Ouhayoun et al. (1996).

Biochemical measurements and antioxidant parameters

Blood samples (5ml from each rabbit) were collected during slaughtering to determine blood plasma components. Plasma was separated by centrifugation at 3000 rpm for 10 min and stored at −20°C until analyzed. Plasma total protein, albumin, total cholesterol, Low Density Lipoprotein (LDL-cholesterol), creatinine, urea, Aspartate Transaminases (AST), Alanin Transaminases (ALT), Malondialdehyde (MDA) and Catalase (CAT) were colorimetrically determined using commercial kits (purchased from Bio-Diagnostic, Cairo, Egypt, according to the manufacturers' instructions). The concentration of globulin (g/dl) was calculated by subtracting albumin values from total protein values, thereby we calculated Albumin/ Globulin ratio (A/G ratio).

Chemical analysis

Chemical analyses of the experimental diets, hind leg meat was carried out according to AOAC (2000) for Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF) and ash. Total selenium of meat determination according to Shaltout et al. (2013), the analytical procedure was performed using an inductively coupled plasma mass spectrometry (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 ($P< 0.05$) (Duncan 1955). All results were analyzed using the statistical model was: $Yij= \mu+ Ti+ eij$, Where: Yij= the observation of ij; μ = Overall mean; Ti= Effects of i (treatments) and eij= Experimental random error.

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RESULTS

Growth performance

The effect of dietary of Se-yeast and Se-algae on growth performance of growing rabbits is presented as shown in table 2. The obtained results showed that supplying rabbits diets with Se-yeast and Se-algae had no significant effect on the average of both final body weight and daily body weight gain during the different experimental periods compared to the control group. However, rabbits group fed diet supplemented with Se-algae was the highest group in final body weight (1918.66g) followed by rabbits group fed diet supplemented with Se-yeast (1888.66g) while, the lowest one was with that rabbits group fed the control diet (1880.66g). On the other hand, Se-algae supplementation tended to increase ($P<0.05$) average daily feed intake during the first, second and the whole periods compared to the rabbits group fed the control diet and the rabbits fed diet supplemented with Se-yeast, while, the supplementation of Se-yeast recorded the lowest ($P<0.05$) average daily feed intake during all the experimental periods.

The results also revealed that FCR values were not significantly ($P>0.05$) influenced by dietary treatment during the first period. It is worthy to notice that rabbits group fed diet supplemented with Se-yeast achieved better ($P<0.05$) FCR (4.33 g feed/g gain) than that group fed Se-algae (5.06 g feed/g gain) while the control group recorded better FCR than Se-algae group during both the second and the whole periods.

Carcass characteristics

Effects of Se-yeast and Se-algae supplementation on carcass characteristics are summarized in table 3. The results indicated that dietary supplementation of Se-yeast and Se-algae did not significantly ($P>0.05$) affect the pre-slaughter weight, carcass weight, heart, and dressing percentages. However, there were significant differences ($P<0.05$) between rabbits group fed diets supplemented with Se-yeast and rabbits group fed diet supplemented with Se-algae in liver%, edible giblet%, and spleen%. While, there were significant ($P<0.05$) differences between the control group and rabbits group fed Se-algae diet in liver% and edible giblets. Moreover, Se-yeast supplementation increased ($P<0.05$) spleen% compared to the control group. The obtained results also showed that feeding rabbits on the tested experimental diets including the control had no effect on cecum weight, length and intestine length.

Chemical composition of meat

Data concerning the effects of Se-yeast and Se-algae on the chemical compositions of rabbit meat are shown in table 4. It could be noticed that supplementation of dietary Se-yeast and Se-algae significantly decreased ($P<0.05$) DM and EE content compared to the control group. Rabbits fed diet supplemented with Se-algae was the lowest ($P<0.05$) group in EE content. On the other hand, it could be observed that there was a significant ($P<0.05$) increase in CP and ash meat content with supplementing Se-yeast and Se-algae compared to the control group. Regarding Se content, the dietary supplementation of Se-algae significantly increased ($P<0.05$) Se content of rabbit's meat of hind leg compared to the other tested rabbits' groups.

Plasma constituents and antioxidative status

Data of plasma biochemical constituents are shown in table 5. Dietary supplementation of Se-yeast and Se-algae significantly ($P<0.05$) increased plasma total protein concentration. It is worthy to note that rabbits group fed diets supplemented with Se-algae at 0.2 mg was the highest ($P<0.05$) group in total protein, albumin and globulin concentration (7.94, 4.16 and 3.78 g/dl, respectively). While no significant ($P>0.05$) differences in albumin and globulin levels were observed between the rabbits group fed Se-yeast diet and rabbits group fed the control diet. The albumin/ globulin (A/G ratio) was not affected significantly ($P>0.05$) by the dietary treatments.

To assess the condition of the kidneys, the following parameters were taken into account creatinine and urea. Feeding diets supplemented with 0.2 mg Se-yeast or Se-algae significantly ($P<0.05$) reduced plasma creatinine levels when compared to the control group. As well as there were significant ($P<0.05$) differences in urea concentrations between the control group and rabbits fed diets supplemented with Se-yeast and Se-algae. Dietary supplementation with 0.2 mg Se-yeast or Se-algae resulted in a significant ($P<0.05$) decrease in the activity of AST enzyme while, the activity of ALT was not affected significantly ($P<0.05$) by the supplemental feeding of Se-yeast but it was lower ($P<0.05$) for the rabbits group given Se-algae diet compared to the rabbits fed the control diet.

Plasma total cholesterol and plasma LDL levels were significantly decreased ($P<0.05$) with dietary supplementation with Se-yeast or Se-algae. Regarding blood antioxidative status as shown in table 5. A significant ($P<0.05$) decrease of plasma MDA level was observed in rabbits fed diets supplemented with Se-yeast or Se-algae. An opposite effect was noticed in CAT activity whereas the values were significantly ($P< 0.05$) increased.

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Table 2. Effect of dietary supplementation of Se-yeast and Se-algae on growth performance of New Zealand white rabbit (6-14 weeks old) during February 2018 in Egypt

Item \ Experimental diets	Control	Se-yeast	Se-algae	±SEM	P value
Average body weight (g/rabbits)					
Initial body weight (g)	618.33	617.66	618.33	17.75	0.999
Final body weight (g)	1880.66	1888.66	1918.66	36.36	0.739
Average daily weight gain (g/day/rabbit)					
Weeks 6-10	27.33	25.97	27.59	0.99	0.475
Weeks 10-14	17.75	19.42	18.84	0.93	0.439
Weeks 6-14	22.54	22.69	23.22	0.59	0.702
Average daily feed intake (g/day/rabbit)					
Weeks 6-10	77.25^{b}	74.55^{c}	83.06^{a}	0.65	0.0001
Weeks 10-14	82.47^{b}	79.43^{b}	94.16^{a}	1.41	0.0001
Weeks 6-14	79.85^{b}	76.99^{c}	88.62^{a}	0.92	0.0001
Feed Conversion Ratio (g feed/g gain)					
Weeks 6-10	2.89	2.92	3.07	0.12	0.520
Weeks 10-14	4.78^{ab}	4.33^{b}	5.06^{a}	0.24	0.106
Weeks 6-14	3.58^{ab}	3.42^{b}	3.84^{a}	0.10	0.016

Se-yeast 0.2 mg selenium yeast/kg diet; Se-algae, 0.2 mg selenium algae/kg diet;SEM: Strandard Error Mean, ^{a,b,c} Means values with the same letter within the same row did not differ significantly (P>0.05)

Table 3. Effect of dietary supplementation of Se-yeast and Se-algae on carcass characteristics of New Zealand White (NZW) rabbits

Item \ Experimental diets	Control	Se-yeast	Se-algae	±SEM	P value
Pre-slaughter weight (g)	2033.3	2031.7	2061.7	28.67	0.720
Carcass weight (g)	1056.67	1056.67	1101.67	27.43	0.456
Dressing (%)	51.96	52.01	53.42	0.97	0.521
Liver (%)	3.08^{a}	3.08^{a}	2.08^{b}	0.23	0.034
Heart (%)	0.39	0.31	0.35	0.03	0.373
Kidney (%)	0.70^{ab}	0.80^{a}	0.60^{b}	0.039	0.036
Spleen (%)	0.80^{b}	1.23^{a}	0.63^{b}	0.07	0.004
Edible giblet%[1]	4.18^{a}	4.19^{a}	3.03^{b}	0.22	0.015
Total edible parts%[2]	56.15	56.21	56.45	1.03	0.975
Cecum weight (g)	88.23	85.67	84.33	9.11	0.959
Cecum length (cm)	31.67	31.33	31.00	0.92	0.880
Intestine length (cm)	286.00	283.67	291.00	13.61	0.927

Notes: Se-yeast, 0.2 mg selenium yeast/kg diet; Se-algae, 0.2 mg selenium algae/kg diet. SEM: Strandard Error Mean. a,b Means values with the same letter within the same row did not differ significantly (P>0.05). (1) Edible Giblets %= (liver+ kidney + heart) / Pre-slaughter weight (g)*100 (2) Total edible parts %= (carcass wt. + edible giblets wt.) / Pre-slaughter weight (g)*100

Table 4. Effect of dietary Se-yeast and Se-algae supplementation on the chemical composition of New Zealand white rabbit's meat (6-14 weeks old) during April 2018 in Egypt

Experimental diets \ Item	Control	Se-yeast	Se-algae	±SEM	P value
Moisture	71.57^{c}	72.68^{b}	73.17^{a}	0.103	0.0001
DM	27.38^{a}	27.35^{b}	27.02^{c}	0.102	0.0001
CP	22.09^{c}	22.55^{b}	22.91^{a}	0.086	0.0017
EE	3.73^{a}	3.56^{a}	3.16^{b}	0.048	0.0004
Ash	1.20^{c}	1.24^{b}	1.31^{a}	0.004	0.0001
Se (µg/g) content of hind leg	0.091^{b}	0.098^{b}	0.12^{a}	0.003	0.0018

Se-yeast, 0.2 mg selenium yeast/kg diet; Se-algae, 0.2 mg selenium algae/kg diet; SEM: Strandard Error Mean, ^{a,b,c} Means values with the same letter within the same row did not differ significantly (P>0.05)

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