

EFFECT OF DIETARY SOURCES AND LEVELS OF SELENIUM SUPPLEMENTS ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, TISSUES SELENIUM DEPOSITION, BLOOD BIOCHEMICAL PARAMETERS, ANTIOXIDANT ACTIVITY AND IMMUNE RESPONSES OF BROILER CHICKS

Abou – Ashour, A. M. H.; Zanaty, G. A.; Abou El-Naga, Manal K.;
Yassin, A. S. and Hussein, Eman A.

Department of Poultry and Fish production, Faculty of Agriculture, Menoufia University,
Shibin El – Kom, Egypt.

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ABSTRACT: An experiment was designed to investigate the effects of dietary selenium on performance, carcass traits, blood biochemicals, tissues selenium deposition, antioxidant activity and immunoglobulin of broiler chicks. Total of 210 day old broiler chicks were divided into seven dietary treatment groups with three replicates each. Control group (T₁) was fed with basal diet contain the recommended level of selenium of Arbor-Acres broiler chicks cataloge, as a source of inorganic selenium. Experimental groups; T₂, T₃ and T₄ were given basal diet free of selenium, but supplemented with 0.1, 0.2 and 0.3 g selenium yeast/ kg diet, T₅, T₆ and T₇ were fed basal diet free of Se and supplemented with 0.01, 0.02 and 0.03 g nano-selenium/ kg diet, respectively. Results showed that chicks fed diet supplemented with 0.03g nano-selenium/ kg diet (T₇) had significantly ($P \leq 0.05$) the highest values of daily weight and improved feed conversion ratio compared to the other treatments which also recorded the least feed intake. Se-yeast or nano-selenium showed higher some carcass traits, liver meat of breast and thigh Se contents and high density lipoprotein, while low density lipoprotein, concentrations were significantly ($P \leq 0.05$) decreased. Activity of glutathione peroxidase, in serum blood was significantly ($P \leq 0.05$) increased by supplementation of 0.03 g nano-selenium/ kg diet compared to the control group and other treatments. Also, chicks fed diet supplemented with 0.03 g nano-selenium/ kg diet had the highest livability rate (98%) and the best European efficiency rate (443.5%) but it was less economically efficient and relatively economic efficiency may have been due to the high price of nano-selenium at the present time compared to organic selenium. So, the obtained results in the present study encouraging and indicated that 0.3 g selenium yeast/ kg diet (T₄) can be used in broiler chicken diets to get best economic efficiency and higher relative economic efficiency. It could be concluded that addition of organic and nano-selenium in broiler diets positively affects production performance and various parameters of broilers health.

Keywords: Antioxidant activity, broiler chicks, inorganic selenium, nano, organic, performance and tissues selenium deposition.

INTRODUCTION

Producers aim to improve poultry production efficiency and achieve high profitability, but note that during commercial production, chicks may encounter a variety of microbial challenges, disease infections, and oxidative stress, leading to economic and production inefficiencies. Therefore, improving immune function in chicks by improving antioxidant status may help reduce

morbidity and mortality in birds (Ibrahim *et al.*, 2020).

Many scientists proved the necessary of include selenium (Se) in the nutritional program of both human and animals to ensure that processes of biological functions running efficiently (Zhou and Wang, 2011). Selenium (Se) plays several important physiological roles in many organisms. It is an antioxidant and

increase reproductive, immune responses and thyroid hormone metabolism (Liu *et al.*, 2017).

The biological role of selenium in birds is primarily related to glutathione peroxidase activity, including in antioxidant defense mechanism (Mikulkova *et al.*, 2019). It is an essential micronutrient required for normal growth and maintenance in poultry. Selenium supplementation in diet also increases immune status and immune system's ability to respond to disease problems (Shojadoost *et al.*, 2019). The amount of selenium in grain used in poultry feed stuffs is only 0.12 to 0.2 mg/ kg, with values at the lower end of this range more commonly (Suttle, 2010). The intake of these grains may result in a selenium deficiency, with certainly impaired bird efficiency, health problems of both. Thus, a selenium source must be added to poultry diet (Bakhshalinejad *et al.*, 2019).

Premix (minerals and vitamins) as sources of inorganic selenium used in poultry diet to meet the Se requirement (Perci *et al.*, 2009). Inorganic selenium is poor in absorption, less efficient in transferring to meat and to supply and maintain selenium reserve in the body (Markovic *et al.*, 2018). Dietary supplementation of organic selenium such as selenium enriched yeast in poultry diets was legally allowed (FAD, 2000). Usually, the organic forms of Se have higher bioavailability and antioxidant properties than inorganic forms (Wang *et al.*, 2011). In addition, organic forms are less toxic and more environmental friendly than inorganic forms (Yoon *et al.*, 2007) and widely used as feed additive now a days. Organic forms of selenium supplementation had positive effect on performance, antioxidant and immune responses in broiler chicken reared in tropical summer (Rao *et al.*, 2016). There are some evidences on positive effects of organic selenium on rear performance and productivity of broiler breeders as the organic Se at the rate of 0.5 ppm was found to be an excellent source of Se as it improved the meat quality through enhanced Se retention, higher glutathione peroxidase (GPx) activity, decreased lipid peroxidation rate and also, improved the meat water holding capacity (Rajashree *et al.*, 2014).

Recently, there are some minerals and vitamins produced by nanotechnology technique (Rezvanfar *et al.*, 2013). Those products have especial properties leading to better efficiency like smaller particle size lead to increased surface area and high catalytic efficiency which affect absorption and efficiency in the body (Xia, 2012). Nano-selenium considered as a novel form of Se, exhibiting high absorption ability surface activity, catalytic efficiency and low toxicity (Zhang *et al.*, 2008). The nano-selenium showed good efficiency in improving chicken overall performance when compared to other sources of selenium (Aljumaily and Tareq, 2021). In this trend Wang *et al.* (2011) evaluated a dose of 0.3mg nano-selenium/ kg and reported better performance and general antioxidant status. So, the present investigation aimed to evaluate the growth performance, carcass traits, blood components, liver and tissues selenium concentration and antioxidant activity in broilers as influenced by supplementation of different sources and levels of Se in broiler chicks diet.

MATERIALS AND METHODS

Ethical Approval

The care and procedure used for broiler chickens of the current trial were permitted by Institutional Animal Care and Use Committee (IACUC), Faculty of Agriculture, University of Menoufia (Ethical approval number: VUSC – 04/2017).

Experimental birds and their management

A total of number 210 unsexed Arbor-Acres chicks, one day old and weighted (42.59g) were randomly distributed on seven equal treatments; every treatment contains three replicates with 30 chicks each. During the period of this experiment chicks were housed in groups in pens with litter (wheat straw) from 1 day old up to 35 days of age. All birds were kept under the same managerial and environmental conditions with A 23 h of light and 1 h of darkness lighting schedule was maintained for the duration of the experiment. The initial temperature was 33°C at the first day of age and decreased approximately

2°C / week until reach to 24°C, which was maintained at this temperature until the end of the experimental period. Vaccination was performed according to breeder standard for all experimental treatments and feed was offered *ad-libitum* in mash form and fresh water also.

Experimental diets:

All birds were fed a starter diets (1 - 21 days of age) and grower diet from 22 days of age until marketing (35 days of age) as shown (Table 1). Two corn-soybean based basal diets were formulated to be fed during starter and grower diets in this experimental period. The broiler diets were formulated to meet or exceed the nutritional requirements according to National Research Council's nutrient (NRC, 1994) and used to formulate the basal diet (the control group, Table 1). The basal corn – soybean meal

starter diet contained approximately, 22.98% CP and 3108 ME Kcal/ kg diet and 20.00% CP and 3103 ME Kcal/ kg in grower diet and both were offered in mash form.

Addition of premix of mixed mineral and vitamins as normal premix to meet maintenance of broiler chickens (basal diet; the control group, T₁). While, others diets were supplemented with different sources and levels of dietary selenium from treatments two to seven (T₂ - T₇). Selenium sources used in the experimente (inorganic Se; normal premix) and organic Se as selenium enriched yeast (Se-Y) were purchased from Multimix Bruli-ER with out choline (MV/Q C-F-13) Ideco- 6 October, Gizza city in Egypt country. Also nano- selenium was purchased from nano Tech., Egypt country.

Table 1. Composition and calculated analysis of the basal diets fed during starting (1 - 21) and growing periods (22 - 35) days of age.

Ingredients	Starter diet (1 - 21 d)	grower diet (22 - 35 d)
Ground yellow corn (8.5%).	47.20	56.70
Soybean meal (44%).	41.30	34.50
Corn gluten (60 %)	1.32	-
Vegetable oil.	6.35	4.97
Limestone.	1.35	1.35
Di-calcium phosphate.	1.88	1.88
Vitamins and mineral mixture,(premix) ¹ .	0.30	0.30
Salt (Sodium chloride).	0.30	0.30
Total	100	100
<u>Calculated analysis²:</u>		
Crude protein, CP %.	22.98	20.00
Metabolizable energy, ME, Kcal/ kg diet.	3108	3103
C/ P ratio.	135	155
Calcium, C %.	1.02	1.00
Available phosphorous, %.	0.48	0.46
Lysine, %.	1.31	1.13
Methionine, %.	0.37	0.32

¹Vitamin and Mineral mixture at 0.30% of the diet supplies the following per kilogram of the diet: Vitamin A, 12,000 IU; vitamin D₃, 3,000 IU; vitamin E, 40 mg; vitamin K₃, 3 mg; vitamin B₁, 2 mg; vitamin B₂, 6 mg; vitamin B₆, 5 mg; vitamin B₁₂, 0.02 mg; niacin, 45 mg; biotin, 0.075 mg; folic acid, 2 mg; pantothenic acid, 12 mg; manganese, 100 mg; zinc, 60 mg; iron, 30 mg; copper, 10 mg; iodine, 1 mg; selenium, 0.1 mg and cobalt, 0.1mg.

²Calculate according to NRC (1994).

Chicks received seven dietary treatments throughout the studied experimental period as follows: T₁: basal diet, the control group meets the recommended level of selenium of Arbor-Acres broiler chicks catalogue, T₂: basal diet free of selenium, perimix without selenium + selenium yeast (Se-Y) at a level of 0.1g/ kg diet, T₃: basal diet free of Se + 0.2g Se-Y/ kg diet, T₄: basal diet free of Se + 0.3g Se-Y/ kg diet, T₅: basal diet free of Se + 0.01 g nano-selenium/ kg die, T₆: basal diet free of Se + 0.02 g nano-selenium/ kg diet and T₇: basal diet free of Se + 0.03 g nano-selenium/ kg diet.

3. Studied traits:

3.1. Performance traits:

Body weight gain in grams were estimated during the intervals periods (0 - 3) and (3 - 5) then the overall period (0 - 5 weeks) as subtracting the initial live weight from the final one. Feed intake (FI, g) was recorded weekly for each replicate by subtracting the residual from the offered feed according to the following equation:

$$FI = \frac{\text{Feed intake (g) / week / pen}}{\text{Number of / pen}}$$

The calculations were done during the intervals (0 - 3) weeks of age and the total feed intake (TFI, g) g for each chicks during whole experimental periods was also, calculated.

Feed conversion ratio (FCR) values were obtained by divided the amount of feed intake/ chicks by the corresponding weight gain by the following formula:

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Amount of feed intake(g) / bird}}{\text{Body weight gain(g) / bird}}$$

Mortality (MO, %) was recorded during the experimental periods and calculated by subtracting the number of live birds at the end of the experiment from the total number of birds at the beginning of the experiment as follow:

$$MO, (\%) = \frac{\text{no. of birds at the beginning of a given period} - \text{no. of birds at the end of the same period}}{\text{no. of birds at the beginning of a given period}} \times 100$$

Livability (Liv %) was recorded during the experimental periods and calculated by the total number of birds at the end of the experiment /

No. of birds at the begning of the experiment as follow:

$$(\text{Liv, \%}) = \frac{\text{no. of birds at the end of the experiment period}}{\text{no. of birds at the beginning of the experiment}} \times 100$$

European efficiency index (EEI) was also, calculated cited by Soltan and Kusainova (2012), Where:

$$EEI = \frac{\text{Mean BW, Kg} \times \text{Livability}}{\text{Marketing age, days} \times \text{FCR}} \times 100$$

3.2. Slaughter traits and some immune organs:

At the end of the experiment (35 days of age), 3 birds from each treatment around the average live body weight were randomly chosen, fasted for about 12 hours, weighed and slaughtered to complete bleeding, followed by plucking the feathers. Empty carcass without giblets and some giblets (liver, heart and gizzard) weights were calculated relative to pre-slaughtering weight and dressing % was calculated as following:

$$\text{Dressing \%} = \frac{\text{Empty carcass weight, g}}{\text{Pre-slaughtering weight, g}} \times 100$$

Also, immune organs such as bursa of fabricius, thymus (all lobes from left side of the neck) and spleen were cut and weighted separately to determine the immune organs weight/ body weight by using the following formula (Giaborne and Closser, 1990):

$$\text{Immune organ, \%} = \frac{\text{Immune organ weight (g)}}{\text{Pre-slaughtering weight (g)}} \times 100$$

3.3. Tissue selenium concentrations of broiler chickens:

At 35 days, carcasses were dissected to obtain samples from the muscles of breast, thighs (pectoralismajor) and tissue of liver to determine its selenium content. The liver, breast and thigh muscles were frozen at -20°C for further meet quality and Se concentration analysis. The concentrations of Se in liver, thigh and breast muscles samples were determined according to the method described by Tinggi (1999) by hydride generation atomic absorption spectrophotometer (AA6501, Shimadzyld.,

Japan).

3.4. Serum blood parameter, antioxidant activity and immunological status of broiler chicks:

Blood samples were collected at 35 days of age from the slaughtered chickens during their exsanguination. Blood samples were collected in dry clean centrifuge tube without anti coagulant for serum separation and immediatary centrifuged at 3000 rpm (rotation per minute) for 15 minutes. The clear serum samples were carefully drown and transferred to epindorf tubes and stored at -20°C in the deep freezer until the time of chemical determinations.

Serum high-densitylipoprotein (HDL, mg/dL) and low-densitylipoprotein (LDL, mg/dL) were determined according to methods described by Knight *et al.* (1972), Roschlau *et al.* (1974), Assmann (1979) and Stein and Myers (1995). Glutathione peroxidase activity (GPx) was measured colorumetrically, in erthrocytes as stated by procedures of Rotruck *et al.* (1973). The serum immunoglobulin (IgA, IgG and IgM) were established employing commercial kits (chicken IgA, IgM and IgG ELISA in antitation kits), Total serum Ig concentration was calculated by the sum of the respective serum IgA, IgM and IgG concentrations (Mountzouris *et al.*, 2010).

3.5. Economical efficiency:

The economical efficiency was calculated from the input-output analysis (Heady and Jensen, 1954), assuming that other head costs were constant under experimental condition, as follows:

$$\text{Economical efficiency} = \frac{\text{Price of kg weight gain} - \text{feed cost/ kg gain}}{\text{Feed cost / kg gain}}$$

3.6. Statistical analysis:

Data were statistically analyzed by the completely randomized design using SPSS (2011) program and the differences among means were determined using Duncans multiple range test (Duncan, 1955). Percentages were transformed to the corresponding arcsine values

before performing statistical analysis (Snedecor and Cochran, 1982). The following statical model was applied:

$$Y_{ij} = \mu + \alpha_i + E_{ij}$$

Where; Y_{ij} = Observed traits, μ = Overall mean, α_i = Effect of treatment ($i= 1, 2, 3, 4, 5, 6$ and 7), E_{ij} = Experimental random error.

RESULTS AND DISCUSSION

Effect of dietary selenium sources and levels on performance of broiler chicks:

Body weights were of broiler chicks as affects by different dietary Se sources (inorganic, organic and non Se) and levels (0, 0.1, 0.2, 0.3, 0.01, 0.02 and 0.03, respectively) are presented in Table 2. At 3 weeks of age, body weight gain (g/ chick/ d) was significantly ($P \leq 0.05$) increased with different levels of nano-Se supplementation. In general, with the progress in age and feeding dietary treatments, at 5 weeks of age; chicks fed the addition of different sources and levels (organic Se and nano-Se) had significantly increased BWG from T_2, T_3, T_4, T_5, T_6 and T_7 . The heaviest BWG had shown in group fed 0.03g nano-Se/ kg die being.63.62 g/chick/d g in comparison with 54.18 the control group (T_1) and other treatments, (56.46, 58.48, 60.15, 59.78 and 61.90) g , for T_2, T_3, T_4, T_5 and T_6 , respectively).

The improvements in BWG in treated groups may confirm the important role of Se as a structural component of 5-deiodinase, which is a key enzyme participating in the thyroxine (T_4) conversion to the active triiodothyronine (T_3), which may influence the body energy and protein uptake, and thus may regulate chick growth (Jianhua *et al.*, 2000). This may also be due to the fact that selenium deficiency leads to nutritional muscular dystrophy and the selenium supplementation prevents such a negative effect. A similar trend was also reported by Rozbicka-Wieczorek *et al.* (2012) who found beneficial effects of selenium-enriched yeast addition into feed on body weight of broiler chickens Likewise, Zia *et al.* (2017) reported increased body weight for broilers supplemented with organic source of selenium compared to

inorganic source. Ibrahim *et al.* (2020) declared an improvement in body weight and body weight gain due to the selenium nano particles dietary supplementation on broiler chicks diets.

In contradictory to the results obtained in the present study Gangadoo *et al.* (2018) and Shourrap *et al.* (2018) observed no significant changes in BW of chicken due to dietary supplementation of organic selenium and nano-selenium compared to inorganic selenium.

The effects of dietary organic or nano-selenium by different levels on feed intake (FI, g/ chick/ day) of starting (0 - 3) and growing (0 - 5) chicks during experimental periods presented in Table 2. All experimental chicks from T₂ – T₄ had lower feed intake compared to the control group (T₁) but not significant, while chicks receiving different levels of nano selenium had significantly lower feed intake (96.71, 96.87 and 92.08 g in comparison with the other groups. Similarly, Saleh (2014) who showed that feed intake was lowering by the addition of Se NPS in broiler diets.

Results in the current experiment was disagreement with the results of Dalia *et al.* (2017)

who observed no significant difference in FI of chicken due to Se supplementation.

Data revealed that FCR was significantly improved by the supplementation during the experimental period (0 - 5 weeks of age). Chicks consuming the basal control diet (T₁) had FCR 1.95 during 0 – 5 wks of age, but FCR was improved gradually with the supplementation of Se–yeast upto 0.3 g Se–Y/ kg diet) and nano – Se up to 0.03g/ kg diet. The best value of FCR was 1.37 for chicks fed diet supplemented with 0.03g nano - selenium/ kg diet (T₇) at 5 weeks of age. The improvement in FCR may be a result from the higher utilization of SeNPS associated with the unique properties of nano form selenium, such as greater surface activity, higher solubility, mobility, high cellular uptake and excellent bioavailability (Zhang *et al.*, 2008). In agreement with the present results, Zhou and Wang (2011) showed that SeNPs supplementation up to 0.5 mg/ kg broiler diet effectively improved FCR. The improvement in feed conversion ratio (FCR) was reported in earlier experiments by supplementing organic selenium and nano-selenium to basal diet at 0.05, 0.15 and 0.25 mg/ kg level (Wang *et al.*, 2016) and at 0.3 mg nano-selenium/ kg diet (Zia *et al.*, 2017).

Table 2: Performance traits of broiler chicks as affected by different dietary selenium sources and levels during experimental period (Means ± S.E.).

Dietary treatments ¹	Body weight gain (g/ chick/ d)		Feed intake (g/ chick/ d)		Feed conversion ratio (g feed/ g gain)	
	0 - 3 weeks	0 - 5 weeks	0 - 3 weeks	0 - 5 weeks	0 - 3 weeks	0 - 5 weeks
	T ₁	39.97 ^e ± 1.25	54.18 ^e ± 4.39	55.39 ^a ± 0.66	105.86 ^a ± 1.29	1.40 ^a ± 0.12
T ₂	41.79 ^d ± 1.92	56.46 ^d ± 3.73	55.00 ^a ± 0.59	103.24 ^a ± 1.33	1.35 ^{ab} ± 0.13	1.83 ^b ± 0.18
T ₃	42.54 ^{dc} ± 1.03	58.48 ^c ± 4.92	53.69 ^b ± 0.62	100.81 ^a ± 1.56	1.30 ^b ± 0.19	1.72 ^c ± 0.11
T ₄	43.90 ^{bc} ± 1.11	60.15 ^b ± 5.77	53.62 ^b ± 0.49	101.57 ^a ± 1.62	1.26 ^c ± 0.14	1.59 ^c ± 0.18
T ₅	43.55 ^c ± 1.29	59.78 ^c ± 2.19	51.51 ^c ± 0.62	96.71 ^b ± 1.00	1.20 ^d ± 0.14	1.51 ^d ± 0.18
T ₆	44.79 ^b ± 1.97	61.90 ^{ab} ± 6.30	52.34 ^{bc} ± 0.59	96.87 ^b ± 0.85	1.20 ^d ± 0.11	1.48 ^d ± 0.19
T ₇	45.18 ^a ± 1.93	63.62 ^a ± 8.02	50.30 ^d ± 0.59	92.08 ^c ± 0.82	1.13 ^e ± 0.12	1.37 ^e ± 0.16
Sig.	*	*	*	*	*	*

¹T₁: basal diet with normal premix (selenium sources, inorganic selenium), T₂: basal diet free of selenium + 0.1 g se-yeast/ kg diet, T₃: basal diet free of selenium + 0.2 g se-yeast/ kg diet, T₄: basal diet free of selenium + 0.3 g se-yeast/ kg diet, T₅: basal diet free of selenium + 0.01 g nano-selenium/ kg diet, T₆: basal diet free of selenium + 0.02 g nano-selenium/ kg diet, and T₇: basal diet free of selenium + 0.03 g nano-selenium/ kg diet.

² means ± S.E. of 3 replicates/ treatment.

³a,b,c.....etc: Means within the same column with different superscripts are significantly different (P ≤ 0.05).

On the other hands, Cai *et al.* (2012) revealed no significant difference on FCR in broilers as influenced by nano - selenium supplementation at 0.0, 0.3, 0.5, 1.0, or 2.0 mg/ kg diet. Li *et al.* (2018) supplemented 0.3 mg Se/ kg diet as organic selenium and nano-selenium in chicken feed and observed no significant difference in FCR.

Effect of dietary selenium sources and levels on carcass characteristics and some immune organs of broiler chicks:

The effect of selenium levels and sources supplementation on carcass characteristics of Arbor - Acres broiler chicks at 5 weeks of age are presented in Table 3. Statistical analysis of data revealed that pre-slaughtering weight was significantly higher for the different sources and levels of selenium supplementation than the control group. The highest value of pre-slaughter weight was for 0.02 and 0.03 g nano-selenium (2109.29 and 2188.66 g) about 11.30 and 15.50% over the control group (T_1 , 1895.33 g) followed by se-yeast (0.1, 0.2 and 0.3 g/ kg diet) being values 1959.76, 2009.00 and 20689, respectively. At 5 weeks of age, there were significant different between dietary treatments on dressing percentage compared to the control group (T_1). The highest percent of dressing (79.25%) was observed in group 7 that have 0.03g nano-Se/ kg diet. The lower values of abdominal fat were recorded for the supplementation treatments (Se-yeast and nano-Se) compared to the control group (T_1). Different levels of nano-selenium supplementation significantly affected the carcass traits as giblets percentage (liver and heart), but gizzard percentage did not significantly different between all dietary treatments. Moreover, increasing liver and heart percent by using Se-yeast and nano-Se may be related to positive effects via physically grinding and increasing bile secretion on nutrient digestion with increasing amounts of absorbed amino acids Mahmoud *et al.* (2016) increasing dietary nano-selenium supplementation significantly increased the giblets percent upto 0.03g nano-selenium/ kg diet, being 6.18% compared to the control group;

T_1 , 5.22%. Data also, represents the effect of different levels of dietary selenium (selenium yeast and nano-selenium) on immune organs (spleen, bursa and thymus) in Table 3. Immune organs were significantly improved with different levels and sources of dietary selenium compared to the control group (T_1). The increase in immune percent may be attributed to the production of specific or non-specific antibodies against different antigens, since lymphoid sinophil and heterophil are responsible for achieving the defense mechanism and immune response introduced into body (El-Feki, 1987). These results agree with Shourrap *et al.* (2018) who indicated that carcass yield (dressing, %) was increased with dietary selenium enriched yeast and nano- selenium supplementations of broiler diets.

In contrast, Jamnongtoti *et al.* (2018) showed that all dietary Se sources supplementation had no significant affect on some carcass traits and lymphoid organ weights. Also, Ibrahim *et al.* (2020) indicated that there was no significant effect of diets with Se NPS addition on carcass traits (carcass, heart, gizzard, liver, spleen, thymus, and bursa of fabicius) as percentage of BW of chicks.

Effect of dietary selenium sources and levels on selenium concentration in some muscles and tissues of broiler chicks:

Selenium contents of some muscles and tissues as breast, thigh and liver of broiler chicks affected by dietary selenium sources and levels shown in Table 4 Selenium concentration in breast muscle of broilers was significantly ($P \leq 0.05$) increased by increasing dietary both Se enriched yeast or Se nano particular (NPS). The highest Se value in breast muscle was 6.02 mg/ g in group fed diet supplemented with 0.03 mg nano-Se and the lower value was recorded for the control group (T_1 , 1.49 mg/ g). The addition of Se-yeast levels were increased the concentration of Se in breast being (3.72 , 3.63 , 3.96 mg/ g) for groups fed basal diet free of Se supplementation with 0.1, 0.2 and 0.3 g Se-yeast/ kg diet and were 4.65 and 4.79 in groups fed

Table 3: Carcass characteristics and immune organs at 5 weeks of age of broiler chicks as affected by different dietary selenium sources and levels during experimental period (Means ± S.E.)

Dietary treatments ¹	Carcass traits			Giblets traits					Immune organs		
	Pre-slaughtering weight, g	Dressing, %	Abdominal fat, %	Liver, %	Heart, %	Gizzard, %	Giblets, %	Spleen, %	Bursa, %	Thyms, %	
T ₁	1895.33 ^c ±21.93	74.11 ^d ±1.11	1.57 ^a ±0.03	2.03 ^d ±0.01	0.40 ^c ±0.03	2.77±0.12	5.22 ^c ±0.12	0.33±0.01	0.126 ^c ±0.01	0.331 ^{e,2,3} ±0.01	
T ₂	1959.76 ^d ±18.92	74.98 ^c ±1.98	1.36 ^{ab} ±0.03	2.66 ^b ±0.01	0.54 ^a ±0.02	2.79±0.13	5.36 ^b ±0.14	0.42±0.02	0.143 ^b ±0.01	0.347 ^c ±0.01	
T ₃	2009.00 ^c ±23.02	76.00 ^{ab} ±2.02	1.29 ^b ±0.05	2.19 ^c ±0.03	0.50 ^a ±0.05	2.75±0.12	5.44 ^a ±0.16	0.50±0.01	0.158 ^a ±0.01	0.339 ^d ±0.02	
T ₄	2068.26 ^b ±19.33	78.77 ^a ±1.23	1.31 ^b ±0.03	2.76 ^{ab} ±0.05	0.48 ^b ±0.03	2.80±0.12	6.04 ^{ab} ±0.09	0.43±0.03	0.141 ^b ±0.01	0.348 ^c ±0.02	
T ₅	2059.29 ^b ±23.66	76.83 ^{ab} ±0.98	1.26 ^b ±0.03	2.78 ^{ab} ±0.03	0.53 ^a ±0.01	2.75±.13	6.06 ^a ±0.11	0.49±0.01	0.156 ^a ±0.01	0.367 ^b ±0.01	
T ₆	2109.29 ^a ±24.09	76.90 ^{ab} ±1.19	1.29 ^b ±0.03	2.82 ^a ±0.02	0.49 ^b ±0.04	2.78±0.11	6.09 ^a ±0.12	0.48±0.02	0.162 ^a ±0.01	0.346 ^c ±0.02	
T ₇	2188.66 ^a ±30.11	79.25 ^{ab} ±1.36	1.12 ^c ±0.02	2.83 ^a ±0.05	0.53 ^a ±0.02	2.82±0.10	6.18 ^a ±0.16	0.52±0.01	0.167 ^a ±0.02	0.379 ^a ±0.02	
Sig.	*	*	*	*	*	NS	*	NS	*	*	

¹T₁: basal diet with normal premix (selenium sources, in organic selenium), T₂: basal diet free of selenium +0.1 g se-yeast/kg diet, T₃: basal diet free of selenium +0.2 g se-yeast/kg diet, T₄: basal diet free of selenium +0.3 g se-yeast/kg diet, T₅: basal diet free of selenium +0.01 g nano-selenium/kg diet, T₆: basal diet free of selenium +0.02 g nano-selenium/kg diet, and T₇: basal diet free of selenium +0.03 g nano-selenium/kg diet.

²means ± S.E. of 3 replicates/treatment.

³a, b, c, etc: Means within the same column with different superscripts are significantly different (P ≤ 0.05).

Table 4: Selenium concentrations in liver and tissues of broiler chicks as affected by different dietary selenium sources and levels during experimental period (Means \pm S.E.).

Dietary treatments ¹	Items		
	Breast muscles (mg/ g)	Thigh muscles (mg/ g)	Liver (mg/ g)
T ₁	1.49 ^e \pm 0.03	1.70 ^f \pm 0.08	4.03 ^{f2,3} \pm 0.09
T ₂	3.72 ^{dc} \pm 0.02	3.39 ^e \pm 0.03	4.27 ^e \pm 0.10
T ₃	3.63 ^d \pm 0.011	3.37 ^e \pm 0.12	4.67 ^d \pm 0.13
T ₄	3.96 ^c \pm 0.03	4.17 ^c \pm 0.09	4.91 ^c \pm 0.12
T ₅	4.65 ^b \pm 0.05	3.78 ^d \pm 0.11	5.11 ^b \pm 0.10
T ₆	4.79 ^{ab} \pm 0.011	4.59 ^b \pm 0.17	5.35 ^{ab} \pm 0.12
T ₇	6.02 ^a \pm 0.03	5.37 ^a \pm 0.06	5.89 ^a \pm 0.15
Sig.	*	*	*

¹T₁: basal diet with normal premix (selenium sources, inorganic selenium), T₂: basal diet free of selenium + 0.1 g se-yeast/ kg diet, T₃: basal diet free of selenium + 0.2 g se-yeast/ kg diet, T₄: basal diet free of selenium + 0.3 g se-yeast/ kg diet, T₅: basal diet free of selenium + 0.01 g nano-selenium/ kg diet, T₆: basal diet free of selenium + 0.02 g nano-selenium/ kg diet, and T₇: basal diet free of selenium + 0.03 g nano-selenium/ kg diet

²means \pm S.E. of 3 replicates/ treatment.

³a,b,c.....etc: Means within the same column with different superscripts are significantly different ($P \leq 0.05$).

0.01 and 0.02g SNP, respectively. The response of Se deposition in tissues was consistent with the concept that organic Se tends to be deposited more than inorganic Se does in slow turnover tissues, such as breast and thigh muscles (Schrauzer, 2003).

Our results indicated that Se concentration in breast and thigh muscles by SY and NSP sources were higher than in selenium salinate (SS) and agreed with other researchers (Zhou and Wang, 2011 and Hu *et al.*, 2012). It is likely that organic sources of Se, such as SY, can be absorbed by active transport and nonspecifically incorporated into proteins in place of methionine (Met.), and is preferentially absorbed and utilized by the body over inorganic Se (Schrauzer, 2003).

In addition, seleno methionine (SM) can be utilized for the synthesis of proteins without the body distinguishing. Thus, organic sources of Se (SM and SY) might be easily utilized in the tissue than SS (Suzuki, 2005). Bio fortification of meat with utilization of nanotechnology is one of the recently developed ways to improve meat quality and their retention rate is considered to be a criterion for mineral utilization in animals (Liao *et al.*, 2010). Different absorption and metabolic pathways can be attributed to the

different retention rate of various sources of Se (Zang *et al.* 2008). Boiago *et al.* (2014) observed highest Se concentration in muscles of broiler fed diets enriched with organic Se. Similar observation was started by Markovic *et al.* (2018) who reported that receiving Se yeast at levels of 0.6 and 0.9 mg/ kg increased meat Se contents in breast and thigh compared to the control group. The same trend was noticed at Se concentration in thigh muscle that was affected by the dietary selenium sources and levels ($P \leq 0.05$). nano-selenium supplementation at level of 0.03 g/ kg diet resulted in higher Se concentration in the thigh muscle in comparison with the other treatments ($P \leq 0.05$) and Se-yeast supplementation at the level of 0.3 g SY/ kg diet. Simaliry Bakhshalinejad *et al.* (2019) reported that nano-selenium and SY supplementation at the level of 0.3 mg/ kg resulted in higher Se concentration in thigh and breast muscles compared to other treatments. Regarding to selenium sources, Mahan and Parrett Nishikimi (1996) reported that muscle tissue had retained much lower concentration of inorganic Se, which was less efficiently absorbed and excreted at higher rate than organic Se because of their different metabolism pathway.

Whereas, selenium concentration of the liver was significantly increased by NSP supplementation at level of 0.03 g/ kg diet T₇, (5.89 mg/ g) in comparison with chicks fed the control (T₁) and other treatments, T₂, T₃, T₄, T₅ and T₆, (4.27,4.67,4.91,5.11 and 5.35 mg/ g), respectively at 5 weeks of age. Similar to our result, reported that Se concentration in the liver (Zhou and Wang, 2011) was dependent on the supplemental level of Se and increased linearly with an increase in dietary Se concentration (Echevarria *et al.*, 1988).

Meanwhile, Bakhshalinejad *et al.* (2019) noticed that nano-selenium and selenium-yeast did not have any effect on Se concentration in the liver of broiler chicks.

Effect of dietary selenium sources and levels on some serum blood parameters:

The results of serum total cholesterol (TC), HDL, LDL concentration and GPx activity showed in Table 5. Serum levels of total cholesterol (TC) and low density lipoprotein

(LDL) were decreased by nano-selenium supplementation at level of 0.03 g Se NPS/ kg diet compared to the control group, the high density lipoprotein (HDL) was increased being 66.79 mg/dL (T₇) compared to 31.62; in T₁ group. These results are partially consistent with the results of Saleh (2014) who found significant decrease in plasma TC levels in broiler chickens fed Se NPS addition, while plasma HDL content was increased. Also, El-Said (2015) found that there was a significant increase of HDL with the addition of nano-Se (40 mg) compared to 20mg NPS. Radwan *et al.* (2015) observed a significant decrease in plasma total cholesterol (TC) and increase in HDL as a result of Se NPS. Also, Ibrahim *et al.* (2020) reported that addition of 10mg Se NPS/ kg diet supplementation was significantly decreased of serum total cholesterol and high density lipoprotein cholesterol, while glutathione peroxidase activity was increased by nano-selenium. Yang *et al.* (2012) reported no significant difference in serum TC and HDL levels in chicks fed diet supplemented with selenium.

Table 5: Serum blood total cholesterol, high density lipoprotein, low density lipoprotein and glutathione peroxidase activities content of broiler chicks as affected by different dietary selenium sources and levels during experimental period (Means ± S.E.).

Dietary treatments ¹	Items ²			
	TC (mg/g)	HDL (mg/dL)	LDL (mg/dL)	GPx activity (mg/dL)
T ₁	159.00 ^a ± 0.620	31.62 ^e ± 0.626	56.11 ^a ± 0.342	0.94 ^{f3,4} ± 0.01
T ₂	142.06 ^b ± 0.569	47.16 ^d ± 0.593	50.29 ^b ± 0.372	1.19 ^e ± 0.01
T ₃	144.17 ^b ± 0.629	50.73 ^c ± 0.532	36.26 ^d ± 0.372	1.98 ^d ± 0.03
T ₄	136.29 ^{bc} ± 0.623	53.00 ^b ± 0.629	44.08 ^c ± 0.576	2.16 ^c ± 0.01
T ₅	133.11 ^c ± 0.539	53.19 ^b ± 0.629	37.00 ^d ± 0.539	2.56 ^{bc} ± 0.02
T ₆	127.66 ^d ± 0.522	58.16 ^{ab} ± 0.530	34.29 ^e ± 0.356	2.91 ^b ± 0.02
T ₇	116.00 ^e ± 0.512	66.79 ^a ± 0.570	31.17 ^f ± 0.499	3.88 ^a ± 0.03
Sig.	*	*	*	*

¹T₁: basal diet with normal premix (selenium sources, inorganic selenium), T₂: basal diet free of selenium + 0.1 g se-yeast/ kg diet, T₃: basal diet free of selenium + 0.2 g se-yeast/ kg diet, T₄: basal diet free of selenium + 0.3 g se-yeast/ kg diet, T₅: basal diet free of selenium + 0.01 g nano-selenium/ kg diet, T₆: basal diet free of selenium + 0.02 g nano-selenium/ kg diet, and T₇: basal diet free of selenium + 0.03 g nano-selenium/ kg diet.

²TC= Total cholesterol, HDL= high density lipoprotein, LDL= low density lipoprotein and GPx= glutathione peroxidase activities.

³ means \pm S.E. of 3 replicates/ treatment.

⁴a, b, c...etc: Means within the same column with different superscripts are significantly different ($P \leq 0.05$).

In general; the results of serum antioxidant status of glutathione peroxidase activities (GPx) showed significant increased by addition of different selenium sources and levels (Table 5). GPx levels were increased by addition 0.03 g nano-selenium/ kg diet in comparison with other treatments. The obtained results on serum antioxidant status shed light upon the selenium function as a major component of the antioxidant system which participates in controlling the body glutathione peroxidase. The results clarify the vital roles of Se NPS in protecting cells from reactive oxygen species (Ros) abundance by reducing free radicals and lipid peroxidation products (Pilarczyk *et al.*, 2012). Wang *et al.* (2009) stated that the GPx activity influences the oxidation state of myofibrillar protein and reduce the drip loss by improving the cell membranes integrity. These results agree with Edens (2002) who reported a steady state release of selenium from organic selenium for incorporation into the glutathione peroxidase antioxidant system which resulted in increased GPx activity. Similarly, Yang *et al.* (2012) stated higher serum glutathione peroxidase activity 155.83% in 0.3 mg/ kg organic selenium supplemented at 42 day old broiler chicken than that in 0.3mg/ kg inorganic selenium supplemented group. Ibrahim *et al.* (2020) observed linearly increased the activity of glutathione peroxidase by dietary supplementation of nano-selenium. The significant elevation in the serum activities of glutathione peroxidase (GPx), as well as in the ability to inhibit hydroxyl radical (OH) and total antioxidant capacity (T-AOC) in chickens treated with selenium yeast (Chen *et al.*, 2013).

Effect of dietary selenium sources and levels on immunoglobulins (IgA, IgM and IgG) of broiler chickens:

As shown in Table 6 inorganic, organic and nano-selenium dietary supplementation in this experiment were affects in immunoglobulins (Ig) contents in serum blood of broiler chicks. Nano-selenium supplementation significantly improved some immunoglobulins (Ig) contents ($P \leq 0.05$) for IgM, IgG and IgA, respectively. The IgM content was the highest in chicks supplemented

with 0.03 g nano-Se/ kg diet (T_7), while in the control group IgM content was the lowest. IgG and IgA levels were elevated only in chicks fed 0.3g SY (T_4) and 0.03 g nano-Se supplementation/ kg diet of broiler chicks (T_7). The improvement in serum immunoglobulins levels may be attributed to the important biological role of Se NPS in increasing the concentration of circulating T and B cells, which leads to an increase in leukocyte sub population and cellular phagocytic activity. These results are coordinated with Cai *et al.* (2012) reported a significant quadratic effect of Se NPS supplementation on serum IgM of broiler chicks. Also, Levkut *et al.* (2009) showed a significant elevation in serum IgM concentrations in broiler chicks fed diet containing increased dose of selenium. This could be explained by the role of Se in protection and thus activation of B-lymphocytes cells which is the source of immunoglobulin (Combs *et al.*, 1986). Moreover, Se could increase the interleukin 2 receptors on the surface of lymphocytes (Roy *et al.*, 1992).

Effect of dietary selenium sources and levels on economic efficiency and European efficiency rate of broiler chicks:

Efficiency and European efficiency rate data are shown in Table 7. The highest economic efficiency and relative economic efficiency was found in the 4th treatment containing 0.3 g organic-Se/ kg diet (1.08 and 123, respectively), followed by the 3rd treatment containing 0.2 g organic selenium/ kg diet (1.04 and 118, respectively). While, the lowest economic efficiency and relative economic efficiency in the 7th treatment diet, which contains 0.03 g of nano-selenium/ kg diet (0.75 and 85, respectively) due to the high price of nano-selenium compared to organic selenium. The results also showed that the best European efficiency rate was for the 7th treatment (443.5%) to which 0.03 g nano-selenium/ kg diet was added. It was followed by the 6th and 5th treatments (404.01 and 378.84%, respectively) to which 0.02 and 0.01 g of nano-selenium/ kg diet were added, respectively. This may have been due to the fact that the treatments to which nano-selenium was added were heavier

in body weight, higher in livability rate and better feed conversion ratio compared to other treatments. The lowest European efficiency rate

was 269.90% for the 1st treatment (control).

Table 6: Serum blood immunoglobulins (Ig) contents of broiler chicks as affected by different dietary selenium sources and levels during experimental period (Means ± S.E.).

Dietary treatments ¹	Items			
	IgG	IgM	IgA	Total Ig
T ₁	430.72 ^f ± 7.020	72.19 ^e ± 0.110	117.37 ^d ± 0.498	620.28 ^{g2,3} ± 11.26
T ₂	480.19 ^d ± 4.450	114.26 ^c ± 0.162	150.56 ^b ± 0.310	745.01 ^e ± 26.33
T ₃	456.00 ^e ± 6.291	82.09 ^d ± 0.139	160.43 ^a ± 0.22	698.52 ^f ± 19.26
T ₄	560.27 ^c ± 7.223	116.24 ^b ± 1.160	148.97 ^c ± 0.892	825.48 ^d ± 25.39
T ₅	623.16 ^b ± 7.112	125.03 ^{ab} ± 1.139	159.22 ^a ± 0.980	907.41 ^c ± 22.11
T ₆	673.11 ^{ab} ± 7.333	112.39 ^c ± 0.98	163.29 ^a ± 0.393	948.79 ^b ± 26.10
T ₇	803.26 ^a ± 5.290	127.00 ^a ± 1.101	167.11 ^a ± 0.393	1097.37 ^a ± 19.36
Sig.	*	*	*	*

¹T₁: basal diet with normal premix (selenium sources, inorganic selenium), T₂: basal diet free of selenium + 0.1 g se-yeast /kg diet, T₃: basal diet free of selenium + 0.2 g se-yeast/ kg diet, T₄: basal diet free of selenium + 0.3 g se-yeast/ kg diet, T₅: basal diet free of selenium + 0.01 g nano-selenium/ kg diet, T₆: basal diet free of selenium + 0.02 g nano-selenium/ kg diet, and T₇: basal diet free of selenium + 0.03 g nano-selenium/ kg diet

² means ± S.E. of 3 replicates/ treatment.

³a, b, c.....etc: Means within the same column with different superscripts are significantly different (P ≤ 0.05).

Table 7: Economic efficiency and European efficiency rate of broiler chicks as affected by different dietary selenium sources and levels during experimental period.

Items	Dietary treatments ¹						
	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇
Initial body weight, g.	42.73	42.39	42.81	42.69	42.52	42.69	42.23
Final body weight, Kg.	1.99	2.01	2.04	2.12	2.13	2.18	2.21
Body weight gain, Kg.	1.95	1.97	2.00	2.08	2.09	2.14	2.17
Total revenue ² , L.E.	42.90	43.34	44.00	45.76	45.98	47.08	47.74
Feed intake, kg.	3.71	3.61	3.53	3.55	3.38	3.39	3.22
Price of one feed, L.E.	6.14	6.01	6.11	6.21	6.76	7.61	8.46
Feed cost, L.E.	22.78	21.69	21.56	22.05	22.85	25.80	27.24
Net revenue ³ , L.E.	20.12	21.65	22.44	23.71	23.13	21.28	20.50
Livability, %.	85	88	92	93	94	96	98
Economical efficiency ⁴ .	0.88	1.00	1.04	1.08	1.01	0.82	0.75
Relative economic efficiency.	100	114	118	123	115	93	85
European productive efficiency ⁵ .	269.90	297.20	332.88	354.90	378.84	404.01	443.50

¹T₁: basal diet with normal premix (selenium sources, inorganic selenium), T₂: basal diet free of selenium + 0.1 g se-yeast/ kg diet, T₃: basal diet free of selenium + 0.2 g se-yeast/ kg diet, T₄: basal diet free of selenium + 0.3 g se-yeast/ kg diet, T₅: basal diet free of selenium + 0.01 g nano-selenium/ kg diet, T₆: basal diet free of selenium + 0.02 g nano-selenium/ kg diet, and T₇: basal diet free of selenium + 0.03 g nano-selenium/ kg diet.

²Total revenue= live body weight × marketing price (22L.E. according to prices in September, 2019), ³Net revenue= total revenue-feed cost.

⁴Economical efficiency= net revenue/ feed cost, ⁵European productive efficiency (EPE),% = (Mean body weight, kg × livability,%)/ (marketing age, days × feed conversion ratio) ×100; cited by soltan and kusainova, 2012.

Conclusion:

The obtained results in the present study encouraging and indicated that 0.3 g selenium yeast/ kg diet (T₄) can be used in broiler chicken diets to get best economic efficiency and higher relative economic efficiency. It could be concluded that addition of nano-selenium in broiler diets positively affects production performance and various parameters of broilers health.

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تأثير إضافة مصادر ومستويات من السيلينيوم على أداء وصفات الذبيحة وتركيز السيلينيوم في الأنسجة وبعض صفات الدم البيوكيميائية ومضادات الأكسدة والاستجابة المناعية لدجاج التسمين

عاطف محمد حسن أبو عاشور – جمال عبد الستار زناتي – منال كمال أبو النجا –

أحمد صابر ياسين – إيمان عاشور محمد حسين

قسم إنتاج الدواجن والأسماك – كلية الزراعة – جامعة المنوفية – مصر.

الملخص العربي

تم إجراء هذه التجربة لدراسة تأثير إضافة مصادر ومستويات مختلفة من السيلينيوم في عليقة كتاكيت التسمين على الأداء، صفات الذبيحة، بعض مكونات الدم، نشاط مضادات الأكسدة، مستويات الإميونوجلوبولين والكفاءة الاقتصادية.

استخدم عدد ٢١٠ كتكوت أربور أكرز غير مجنس عمر يوم - قسمت عشوائياً إلى ٧ مجموعات تجريبية بكل منها ٣٠ كتكوت وزعت على ٣ مكررات (١٠ كتاكيت/ مكررة) - كانت المعاملات التجريبية على النحو التالي: المعاملة الأولى: عليقة المقارنة (الكنترول) كانت عبارة عن العليقة الأساسية التي تحتوى على السيلينيوم المعدنى بالمستوى الموصى به للسلالة، المعاملات الثانية، الثالثة والرابعة تم استبدال السيلينيوم المعدنى فى العليقة الأساسية (الكنترول) بالسيلينيوم العضوى بمستويات ٠.١، ٠.٢ و ٠.٣ جم خميرة غنية بالسيلينيوم/كجم عليقة على التوالى - بينما المعاملات الخامسة، السادسة والسابعة تم استبدال السيلينيوم المعدنى فى العليقة الأساسية (الكنترول) بالنانو سليينيوم بمستويات ٠.٠١، ٠.٠٢ و ٠.٠٣ جم نانو سليينيوم/كجم عليقة على الترتيب كانت الكتاكيت المغذاة علي النانو سليينيوم بمعدل ٠.٠٣ كجم عليقة أثقل معنوياً في وزن الجسم خلال فترات التجربة. كما تحسن معدل التحويل الغذائى معنوياً بإضافة السيلينيوم سواء العضوى أو النانو. ولوحظ أن أقل غذاء مأكول كان لطيور المعاملة السابعة المضاف إليها النانو سليينيوم بمعدل ٠.٠٣ كجم عليقة مقارنة بباقي المعاملات. كما لوحظ تحسن معنوي في صفات الذبيحة وارتفاع تركيز السيلينيوم فى الكبد وأنسجة عضلات الصدر والأفخاذ و مستوى الكوليستيرول العالى الكثافة وانخفاض مستوى الكوليستيرول المنخفض الكثافة في الدم. عند نهاية التجربة لوحظ تحسن نشاط انزيم الجلوتاثيون بيروكسيديز في الدم تحسن بإضافة ٠.٠٣ جم نانوسليينيوم /كجم علف بالمقارنه بالمجموعه الكنترول وباقي المعاملات وبصفة عامة كانت النتائج التي تم الحصول عليها في هذه الدراسة مشجعة وأشارت إلى أن تغذية كتاكيت التسمين على علائق مضاف إليها النانو سليينيوم بمعدل ٠.٠٣ كجم عليقة (المعاملة السابعة) كانت أعلى معدل حيوية (٩٨%) وأفضل معدل كفاءة أوروبى (٤٣.٥%) ولكنها كانت أقل كفاءة اقتصادية وقد يرجع ذلك إلى ارتفاع سعر النانو سليينيوم في الوقت الحالي مقارنة بالسليينيوم العضوي- ولذلك تبين من دراسة الكفاءة الاقتصادية أن إضافة السيلينيوم العضوي (SY) بمعدل ٠.٣ كجم عليقة كتاكيت تسمين (المعاملة الرابعة) أدى إلى الحصول على أفضل كفاءة اقتصادية وكفاءة اقتصادية نسبية. ويمكن استنتاج أيضاً أن إضافة النانو سليينيوم يؤثر إيجاباً على الأداء الإنتاجى والصحة لكتاكيت التسمين.