Mansoura University
Faculty of Agriculture
Poultry Production Department

STUDIES ON USING SOME ANTIOXIDANTS FOR IMPROVING THE REPRODUCTIVE PERFORMANCE IN TURKEYS

By

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Avowal of Subject Newness

I am the researcher/ **Michael Adel Labeeb Gorgy** registered for degree in Ph.D. of science in Agricultural (**Poultry Production**) department, admitted that the subject under study in new and not transported from any other places or sides. Which title (**Studies On Using Some Antioxidants For Improving The Reproductive Performance In Turkeys**).

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عنوان الرسالة

دراسات على استخدام بعض مضادات الأكسدة لتحسين الكفاءة التناسلية فى الرومى

ملخص الرسالة لا يزيد عن صفحة

تم اجراء التجربة فى محطة بحوث الانتاج الحيوانى بمحله موسى، كفرالشيخ التابعة لمعهد بحوث الانتاج الحيوانى، مركز البحوث الزراعية، وزارة الزراعة ، مصر. وهذه التجربة تهدف الى دراسة تأثير بعض مضادات الاكسدة لتحسين الاداء الانتاجي والتناسلى فى الرومى.

تم اجراء تجربتين، فى التجربة الاولى تم استخدام عدد ٨٤ طائر (انثى) من سلالة الرومى البرونز، عمر ٣٢ اسبوع واستخدام عدد ١٠ ديك من سلالة الرومى البرونز فى نفس العمر. وزعت اناث الرومى بطريقة عشوائية الى ٧ معاملات تجريبية، واحتوت كل معاملة على ثلاثة مكررات متساوية، تم تسكين الاناث بطريقة فردية فى بطاريات. فى التجربة الثانية تم استخدام عدد ٦٣ ديك من سلالة الرومى البرونز عمر ٣٢ اسبوع واستخدام عدد ٧٠ طائر (انثى) من سلالة الرومى البرونز فى نفس العمر. وزعت الديوك بطريقة عشوائية الى ٨ معاملات تجريبية ، احتوت كل معاملة على ٣ مكررات متساوية، تم تسكين الديوك أرضيا. استغرقت التجربة ١٢ اسبوع من عمر ٣٢- ٤٤اسبوع. غذيت الطيور بعليقة اساسية (كنترول) مكونة من ذرة صفراء وكسب فول الصويا مضاف اليها الاضافات الغذائية.

ويمكن تلخيص اهم النتائج كالتالى :

- لم يتأثر الوزن النهائى للجسم وكذلك معدل الزيادة فى وزن الجسم لكل من ديوك واناث الرومى وايضا معدل التحويل الغذائى للديوك معنويا بالمعاملات الغذائية خلال فترة التجربة من عمر ٣٢-٤٤ اسبوع.
- لوحظ انخفاض معنوى فى معدل استهلاك العلف للاناث والديوك عند إضافة الزنك أو السلينيوم فى كل من الصورة الغيرعضوية، العضوية اوالنانو مقارنة بالكنترول خلال فترة التجربة من عمر ٣٢-٤٤ اسبوع.
- سجلت زيادة معنوية فى معدل انتاج البيض ووزن البيض الناتج من الاناث التى تغذت على عليقة مضاف اليها الزنك فى الصورة العضوية او النانو او السلينيوم فى الصورة الغير عضوية، العضوية او النانو مقارنة بالكنترول.
- اضافة الزنك او السلينيوم فى الصورة الغيرعضوية، العضوية أوالنانو تحسن معنويا معدل التحويل الغذائى للاناث مقارنة بالكنترول.
- لم يتأثر الوزن النسبى للمكونات الداخلية للبيضة، دليل القشرة، دليل الصفار أو درجة لون الصفار بالمعاملات الغذائية.
- تحسنت جودة البياض المقاس من خلال وحدات هاو وسمك قشرة البيضة معنويا لاناث الرومى التى تغذت على عليقة مضاف اليها السلينيوم فى الصورة العضوية أو النانو مقارنة بالكنترول.

الخلاصة:

يستنتج من النتائج المتحصل عليها إن إضافة الزنك فى كل من الصورة العضوية أو النانو (١٠٠ او٤٠ مجم/كجم عليقة على التوالى) أو إضافة السلينيوم فى كل من الصورة العضوية أو النانو (٠.٣ او٠.١٥ مجم/كجم عليقة على التوالى) يمكن أن يحدث تأثيرات إيجابية على الاداء الانتاجي والتناسلى للرومى.

رؤوس الموضوعات ذات الصلة (لا يزيد عن ١٠):

College: Agriculture	**Department:** **Poultry Production**	**Cal No.:**
Author: Michael Adel Labeeb Gorgy	**Degree:** Ph.D.	**Date:** / /2017

Dissertation Title

STUDIES ON USING SOME ANTIOXIDANTS FOR IMPROVING THE REPRODUCTIVE PERFORMANCE IN TURKEYS

Dissertation Abstract (One page A4)☐

The present study was carried out at Mehalet Mousa Animal Production Research Station, Kafr El-Sheikh, belonging to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. This experiment aimed to study using some antioxidants for improving the productive and reproductive performance in turkeys.

Two experiments were carried out. In experiment 1, 84 Bronze female turkeys, 32 weeks of age were used. The turkey hens were randomly distributed into 7 experimental groups; each consisted of three equal replications. The turkey hens were individually housed in battery cages. In experiment 2, 63 Bronze male turkeys (toms), 32 weeks of age were used. The toms were randomly distributed into 7 experimental groups; each consisted of three equal replications. Toms of each experimental group were kept in three floor pens. The experimental period lasted 12 weeks (from 32 to 44 weeks of age). The birds were fed a yellow corn-soybean meal basal diet supplemented with the tested feed additives.

Results obtained could be summarized as follows:

- Final body weight and body weight gain of turkey hens and toms and feed conversion rate were not affected by dietary treatments during the whole experimental period from 32-44 weeks of age**.**
- Feed intake was significantly decreased ($P\leq0.05$) by inorganic, organic or nano forms of zinc or selenium supplementation of turkey hens and toms as compared to those of the controls during the entire experimental period.
- Significantly increases were observed in hen-day egg production rate and egg weight of hens fed the diet supplemented with organic and nano forms of zinc or with inorganic, organic and nano forms of selenium as compared to that of the controls.
- Inorganic, organic and nano forms of zinc or selenium supplementation of turkey hens diets significantly improved ($P\leq0.05$) their feed conversion ratio as compared to that of the controls.

CONCLUSION

It can be concluded that dietary supplementation with organic or nano forms of znic (100 or 40 mg/kg diet, respectively) or organic or nano forms of selenium (0.3 or 0.15 mg/kg diet, respectively) can induce beneficial effects on productive and reproductive performance of turkeys.

Key Words: (not more than Ten)

CONTENTS

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviated notation	Full name of word/phrase
ATP	Adenosine triphosphate
DNA	Deoxyribonucleic acid
Exp.	Experiment
FAO	Food and Agriculture Organization of the united nation
g	gram(s)
GSH-PX	Glutathione peroxides
Kcal	Kilocalorie (s)
Kg	Kilogram(s)
Mg	Milligram
ml	Milliliter(s)
mm	Millimeter (s)
Nano-Se	Nano-selenium
NDV	Newcastle disease virus
NRC	National Research Council
NS	Not significant
ppm	Parts per million
RNA	Ribonucleic acid
Se	Selenium
SEM	Standard error of the means
SM	Selenomethionine
SOD	Superoxide dismutase
SS	Sodium selenite
SY	Se-enriched yeast
wk	Week(s)
Zn	Zinc
Zn-Met	Zinc-methionine
ZnO	Zinc Oxide
ZONPs	Zinc Oxide Nanoparticles
nm	Nanometer (s)
min	Minute (s)
Se NPs	Selenium nano particles
rpm	Revolutions per minute

1. INTRODUCTION

Poultry industry is an important economical business in the agriculture field, providing meat and eggs that increase the nutritional quality of human food. It has become an attractive business due to its rapid outcomes **(Basak *et al.* 2002)**. Poultry has undergone rapid changes during the past decades due to modern intensive production methods, new breeds, improved bio-security and preventive health measures.

Nowadays in Egypt, there is a necessity of increasing animal production to fulfill the insisting demand of animal protein. It is noticed that the price of animal protein progressively increased during the last few years. So, the increase in animal protein production can be performed via maximizing the productivity of poultry. Turkeys are considered as one of the principal poultry kept for meat production in many countries.

One of the problems challenging poultry production is the generation of free radicals and lipid peroxidation that can contribute to the development of different diseases in humans as well as animals, with a decrease in the live performance and product quality in poultry. Free radicals are typically atoms containing one or more unpaired electrons. Most biologically-relevant free radicals are derived from oxygen and nitrogen, the so-called reactive oxygen species and reactive nitrogen species. Both elements are essential for life of organisms but in certain circumstances they are converted into free radicals which are highly unstable and their reactive capacity makes them capable of damaging biologically relevant molecules such as deoxyribonucleic acid (DNA), proteins, lipids or carbohydrates

(Surai, 2002). The formation of free radicals is a patho-biochemical mechanism involved in the initiation or progression of various diseases **(Hogg, 1998)**. In livestock production, free radical generation and lipid peroxidation are responsible for the development of various diseases and decreasing the animal productivity, and product quality **(McDowell, 2000).**

Once free radical production exceeds the capacity of antioxidant systems to neutralize it, lipid peroxidation causes damage to unsaturated lipids in cell membranes, amino acids in proteins, and nucleotides in DNA. Thus, these degenerative reactions result in membrane and cell integrity disruption in biological cells and adversely affect the integrity of their membranes. This inevitably results in decreased productive and reproductive performance of living organisms.

The processes of oxidation and reduction are necessary in the biochemistry of the animal body. This gain or removal of an electron keeps many of the life processes working. As respiration occurs in animals, which is defined as the process from which cells derive energy in the form of adenosine tri-phosphate (ATP) from the reactions of hydrogen and oxygen, they often produce various peroxides. These peroxides, including hydrogen peroxide, can be harmful to the body as they can lead to generation of free radicals, which can damage or destroy cells **(Arthur, 2000)**.

In fact, in the body of an organism all antioxidants are working in concert as a team, the so-called “antioxidant system” which is responsible for prevention of the damaging effects of free radicals and toxic products of their metabolism. In this team, every member has its own role to do and these antioxidants are located in various parts of the cell in such a way to provide a maximal efficiency of antioxidant protection.

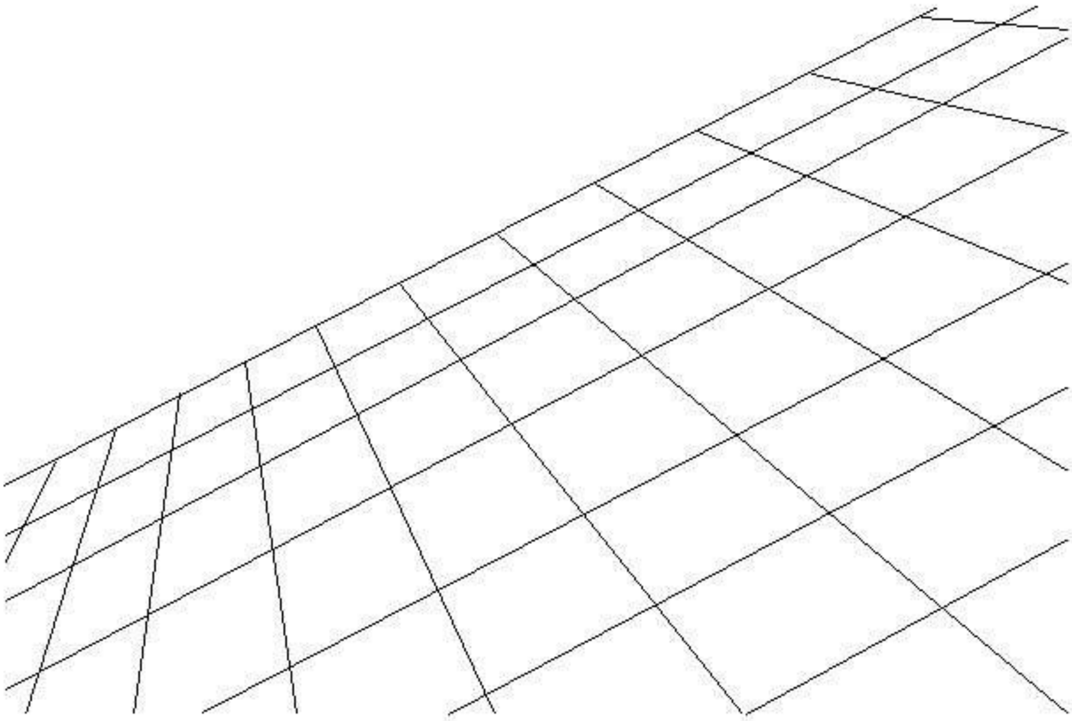
The protective antioxidant compounds are located in cellular organelles, intracellular compartments or in the extracellular space, enabling maximum cellular protection to occur. The antioxidant system of the living cell includes three major levels of defense. The first level is based on the activity of superoxide dismutase (SOD), glutathione peroxidase (GPx) and catalase which, together with metal-binding proteins, are responsible for prevention of free radical formation and keep this process under control. The second level of antioxidant defense is based on chain-breaking antioxidants (zinc, selenium and etc.) which are responsible for restriction of chain formation and propagation. The third level of defense is based on the activity of specific enzymes responsible for repairing or removal of damaged molecules from the cell.

The trace mineral zinc (Zn) is a key element in poultry development (**Pandav and Puranik 2015)** and involved in many physiological, metabolic and digestive processes in the body as it acts as a cofactor of more than 300 enzymes **(Rink and Gabriel, 2000)** which are essential for the metabolism of protein and carbohydrate ,growth and reproduction. In poultry, zinc is essential for reproductive system development **(Park *et al.* 2004)**. It is also responsible for activation of the antioxidant status (**Prasad and Kucuk, 2002)** and immune system of the bird **(Rink and Gabriel, 2000)**

Selenium (Se) is an essential mineral in poultry feeding for the maintenance of optimal health and meat quality (**Choct *et al.* 2004)** because it is involved in the antioxidant system of the body through the regulation of the antioxidant defense mechanism in all living tissues by controlling the body's glutathione pool and its major Se-containing antioxidant enzyme, glutathione peroxidase.

This experiment aimed to study using some antioxidants for improving the productive and reproductive performance in turkeys.

REVIEW OF LITERATURE



2. REVIEW OF LITERATURE

Role of trace elements in poultry nutrition:

Trace mineral nutrition in poultry production is a complicated subject due to the large number of minerals and dietary inclusion levels as well as substantial interactions between the minerals. Macrominerals are required in quantities great enough to be expressed as a percentage of poultry diets such as sodium, potassium, magnesium, chloride, calcium and phosphorus. Microminerals are those required in small amounts of diet such as copper, manganese, iron, manganese, iodine, zinc and selenium.

Trace minerals, include Cu, Mn, Fe, Zn, I and Se are essential for growth and production of turkeys and involved in many physiological, digestive, and biosynthetic processes within the body. These minerals are constituents of hundreds of proteins involved in intermediary metabolism, hormone secretion pathways and immune defense systems of birds. Nowadays, livestock is generally fed highly concentrated diets that are formulated to provide an excess of nutrients to maximize performance **(Leeson, 2003)**.

The term "organic mineral" refers to a variety of compounds including metal-amino acid complexes, metal amino chelates, metal proteinates, metal-polysaccharide complexes, metal-yeast complexes, and metal-organic acid complexes **(Patton, 1990).** Organic minerals can be classified into two categories: natural and synthetic. Natural mineral complexes are formed during normal digestion, absorption, and metabolism in a living system. Synthetic mineral complexes, however, are used to enhance mineral utilization efficiency. During digestion, a variety of natural mineral complexes are formed which either enhance or diminish the usefulness of the ingested minerals.

An organic mineral is simply a combination of a metal ion with an organic legand such as proteins, amino acids, yeast, polysaccharides, or organic acids. Specifically, the metal ion is bound to the organic legand through multiple attachments with the metal ion occupying a central position in the structure **(Nelson, 1988)**. He started also that during organic minerals formation, the metal ion and organic legand act as mutual electron donors (legand) and electron acceptors (metal cations) forming a heterocyclic ring structure. In general, the metal ion is attached to electro negative areas (two or more) on a legand (**Nelson, 1988)**.

Majority of trace minerals in commercial poultry diets are commonly supplemented in the form of inorganic salts, such as sulfates, oxides and carbonates, to provide levels of minerals that prevent clinical deficiencies and allow the birds to reach their genetic growth potential. Organic complexed mineral is a type of mineral linked to protein/peptide/amino acids that has a higher bioavailability than inorganic salts (**Swiatkiewicz *et al.* 2014)**.

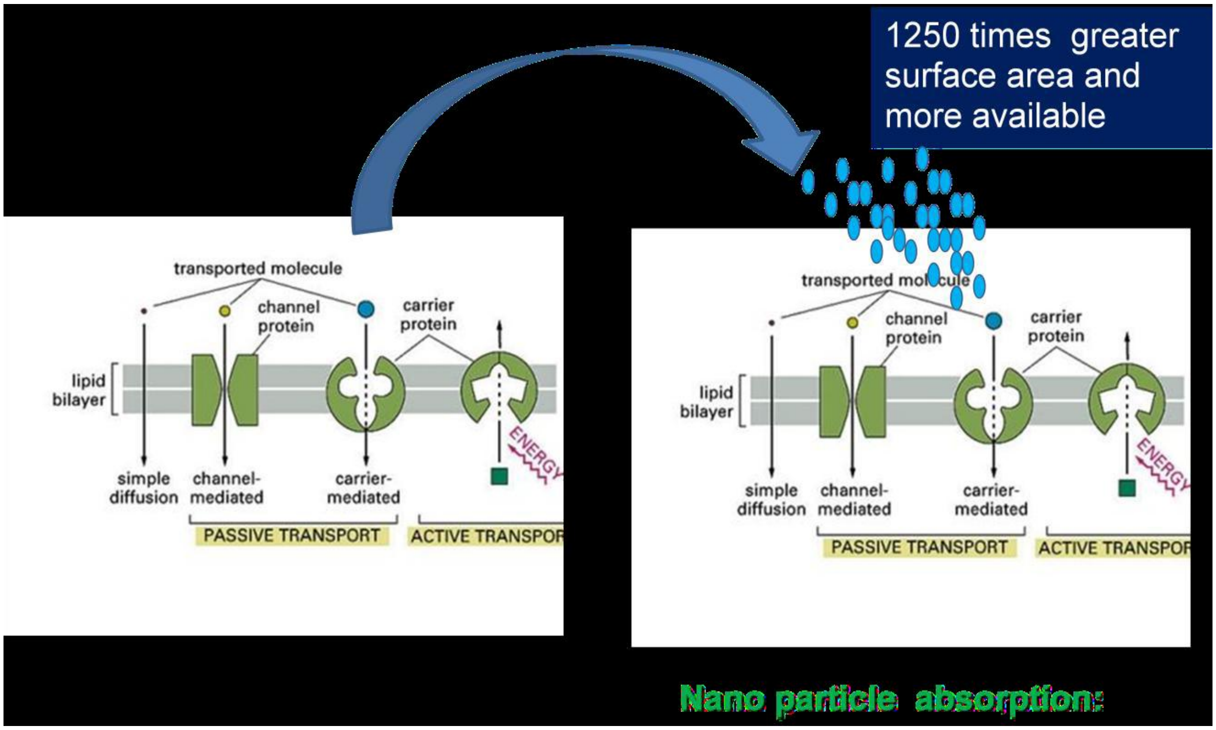
Role of Nanotechnology in agriculture and bioscience:

Nanotechnology is one of the branches of science that can be referred to as an innovative technology which deals with different elements to create materials and change structure, and to improve the quality and texture of foodstuffs at the molecular level (**Mahmoud, 2012).** Nanotechnology holds promise for medication and nutrition because materials at the nanometer dimension exhibit novel properties different from those of both the isolated atom and bulk material **(Albrecht *et al.*, 2006).**

Nanotechnology has emerged at the forefront of research and technology development (**Lam *et al.*, 2006).** The term nano is derived from Greek word meaning “little old man or dwarf” and is usually combined with a noun to form words such as nanometer, nanorobot and nanotechnology. In the recent years, the application of nanotechnology in human and veterinary medicine has shown a great progress. Also, nanotechnology has revolutionized the commercial application of nanoparticles in the fields of medicine, engineering, manufacturing, and information and environmental technology (**Rasmussen *et al.*, 2010)**.

Recently, the used of nanotechnology and related products has rapidly progresed in different scientific areas. In fact, this branch of science has fundamental effects on all aspects of life, and environment. Nanoscale of materials like nanosilver (as antimicrobial), nano-selenium and zinc oxide nanoparticles has an increasing attention because nano-formulated particles exhibit a distinguishing quality such as a size, shape, large surface area, high surface activity, high catalytic efficiency, and strong adsorbing ability (**Wijnhoven *et al.*, 2009)**.

In recently years, researchers have used certain nano-particles as feed additives in broiler nutrition to achieve positive effects in poultry production, some examples of these nano-particles are nanosilver, nanoselenium and zinc oxide (**Sawosz *et al.*, 2007).**



The source is Rajendran (2013).

2.1. Zinc:

2.1.1. Use of zinc in poultry diets:

For many years zinc (Zn) as an essential nutrient has been recognized. Recently, researchers have understood the full impact of this nutrient on poultry and human health. They have identified over 300 zinc-dependent enzymes in all the major biochemical pathways in the body **(Rink and Gabriel, 2000; Case and Carlson 2002).**

A lot of feed additives are included of poultry diets to improve their growth and productive performance. Zinc as an essential trace mineral has significant functions in the organism, probably because it is a co-factor of more than 300 enzymes. So, the presence of adequate dietary zinc is important for normal development, maintenance and function of the immune system in poultry (**Sahin *et al.*, 2005)**.

One of the most significant roles of zinc is related to its antioxidant function and its participation in the antioxidant defense system of the body **(Powell, 2000)**. Zinc deficiency provokes oxidative damage through the effect of free radical action and alters the status of antioxidant enzymes and substances (**Salgueiro *et al.*, 2000).**

Zinc is also essential for the normal functioning of a variety of hormones such as glucagon, insulin, growth hormone and the sex hormones. Normal Zn status is necessary for the immune function in broiler chickens (**Cui *et al.*, 2004)**, since, zinc is important for proper functioning of hetrophils, mononuclear phagocytes and T lymphocytes.

Zinc is an essential micromineral that is commonly added as a supplement to all formulated poultry diets. Currently, there are two feed-grade zinc sources commercially used by the poultry feed industry: zinc oxide (ZnO: 72% Zn) and zinc sulfate monohydrate ($ZnSO_4 \cdot H_2O$: 36% Zn). Of the supplemental zinc given, 80-90% is ZnO, which is less bioavailable for poultry than reagent-grade or feed-grade Zn sulfate **(Sandoval *et al.*, 1997; Edwards and Baker, 1999)**. However, the sulfates were reported to be highly water soluble, allowing reactive metal ions to promote free-radical formation, which can to the degradation of vitamins and eventually to the decomposition of dietary lipids, and thus, reducing the nutritive value of the diet (**Batal, 2001**).

However, zinc-methionine is a specific organo-amino acid complex of zinc which differs from inorganic zinc proteinates and zinc polysaccharide complexes **(Association of American Feed Control Officials, 1990)**. In this respect, **Kidd *et al.*, (1996)** reported that zinc-methionine, which is an organic complex, may be more available than inorganic sources of zinc (zinc sulphate and zinc oxide) and/or it may be absorbed intact and alter zinc pools and zinc mettaloenzymes.

Zinc has numerous biological roles in DNA synthesis, cell division and multiplication **(Rubin and Koide, 1973)**. It is also involved extensively in nucleic acid and protein metabolism **(Forbes, 1984; Hambidge *et al.*, 1986)**, in the cell mediated immune response (**Bertuzzi *et al.*, 1998)** and performance of broiler chicks (**Sadoval *et al.*, 1999)**.

Organic complexes of zinc have been proposed to be more available source of zinc for laying hens **(Aliarabi *et al.*, 2007)**. Zn-methionine had more bioavailability than inorganic zinc sources such as ZnO or $ZnSO_4{:}H_2O$ **(Rahman *et al.*, 2002).**

Richards *et al.*, (2015) demonstrated that bioavailability of chelated Zn is greatly higher compared with that of Zn sulfate. They also concluded that feeding the diets containing chelated Zn is advantageous to those having inorganic Zn, especially when the diets are rich in Ca and P.

Concerning Zn requirements of laying hens, NRC (1994) recommended between 29-44 mg Zn/kg for Leghorn-type layers, which appeared to be based on the results that considered the laying performance as the only criterion. Higher dietary Zn concentration was found to be beneficial, especially when added in the form of zinc-amino acid complx (**Hudson *et al.*, 2004)**.

Ahmadi *et al.* (2014) found that the levels of zinc oxide nanoparticles from 60 to 90 mg/kg diet improved antioxidant state and positively affected the activity of serum enzymes in broiler chickens.

Zinc oxide nanoparticles are used for industrial and cosmetics purposes. Zinc is an integral component of a wide range of mettaloenzymes and acts as a cofactor for RNA and DNA polymerases **(Hambidg, *et al.*, 1986)**. It is of particular importance in rapidly-dividing cells, including those of the epidermis (**Nishi, 1996; Watson, 1998).** Zinc is also essential for the biosynthesis of fatty acids and participates in both the inflammatory and immune systems **(Watson, 1998).**

2.1.2. Effect of zinc on live body weight and body weight gain:

Pimentel *et al.* (1991) showed that low zinc intake impaired body weight of Ancona chicks. **Kidd *et al.* (1994)** reported that Zn-Met supplementation increased body weight gain in young turkeys.

Osman and Ragab (2007) indicated that supplementation of 0.5g zinc-methionine/kg diet had the highest value of live body weight and weight gain of Hubbard broiler chicks from 3 to 7 weeks of age.

2.1.3. Effect of zinc on feed consumption and feed conversion ratio:

Ferket *et al.* (1992) showed that the dietary addition of Zn-Met of turkey toms had improved feed conversion. **Kaya *et al.* (2001)** showed that laying hens that were fed different levels of zinc 0, 20, 50, 100 and 200 mg/kg diet exhibited no significant improvement in feed conversion. **Kucuk *et al.* (2003)** indicated that supplemental dietary zinc (30 mg /kg diet) as zinc sulphate to the basal diet improved feed conversion of broiler chicks.

Dietary zinc supplementation increases feed intake and feed efficiency in quails from 10-42 days of age (**Sahin *et al.*, 2005**). **Osman and Ragab (2007)** found that supplemental zinc-methionine at the level 0.3 g/kg diet of chicks significantly reduced feed intake during the period from 21 to 49 days of age. They also reported that chicks fed the diet supplemented with 0.3g zinc-methionine/kg diet had the best feed conversion during the period from 36 to 42 days of age.

Also, **Namra *et al.* (2008)** showed that dietary addition of zinc methionine as organic source significantly reduced feed intake and significantly improved feed conversion ratio of Japanese quail compared with the control group. **Namra *et al.* (2009)** showed that the dietary addition of 50 mg Zn (from the zinc-methionine)/kg diet of laying Japanese quail significantly reduced feed intake and achieved the best feed conversion ratio compared with the control group.

Refaie (2009) reported that broilers fed diets supplemented with an organic source of zinc (zinc-methionine) displayed significantly higher feed intake and had better feed conversion ratio than those fed diets supplemented with zinc oxide.

Idowu *et al.* (2011) indicated that supplemental with adding inorganic Zn sources of 140 mg/kg diet led to a significant decrease in feed consumption of laying hens compared with the control group.

Ahmadi *et al.* (2013) showed that dietary addition of zinc oxide nanoparticles at levels of 60 and 90 mg /kg diet resulted in a significant increase in feed intake from 1 to 21 days of age. They also observed a significant improvement in feed conversion ratio of birds due to dietary addition of zinc oxide nanoparticles as compared to the control group.

Bahakaim *et al.* (2014) showed that supplemental organic zinc as Zn methionine (100 mg) of laying hens' diet gave the best feed conversion of Golden Montazah laying hens at 24 weeks of age and insignificantly increased feed intake as compared to those fed inorganic zinc (zinc sulphate).

On the other hand, **Pimentel *et al.* (1991)** observed that supplemental zinc had no significant affect on feed intake or feed conversion ratio of broiler chickens.

Ludeen (2001) also did not find any effect of organic or inorganic trace minerals (Zn and Mn) on feed intake or feed conversion ratio of 40 to 60 week-old laying hens. **Sechinato *et al.* (2006)** found no improvement of supplemental organic trace minerals compared with the inorganic form on feed conversion of Babcock layers.

Sunder *et al.* (2008) observed that supplemental zinc did not show any significant effect on feed intake or feed efficiency of broiler chickens. **Abdallah *et al.* (2014)** reported that supplemental dietary organic Zn had no significant effect on feed intake and feed conversion of Gimmizah chickens compared with those supplemented with inorganic Zn from 24-40 weeks old.

2.1.4. Effect of zinc on egg production traits:

The addition of Zn-methionine has improved performance of laying hens **(Flinchum, 1990)** and turkey **(Waibel *et al.*, 1974)** and indicated that supplemental dietary Zn-Met resulted in overall beneficial responses in turkey growth and egg production. **Sahin *et al.* (2002)** found that dietary supplementation of Zn sulfate increased egg weight and egg production of laying hens.

Stanley *et al.* (2012) reported that dietary supplementation with organic zinc (20 ppm/kg diet) significantly increased rate of egg production of 78-wk-old White Leghorn laying hens. **Bahakaim *et al*. (2014)** showed that dietary supplementation organic zinc as zinc- methionine significantly increased egg production of laying hens. **Abdallah *et al.* (2014)** reported that 24-wk-old hens fed diets supplemented with organic zinc at different levels produced heavier eggs compared with those fed the inorganic-supplemented diet of Gimmizah laying hens.

However, **Namra *et al.* (2009)** showed that supplemental dietary zinc (50 mg/kg diet) had no significant effect on egg production or egg weight of Japanese quail hens.

2.1.5. Effect of zinc on egg quality:

Sahin *et al.* (2002) reported that addition of inorganic Zn to laying hens increased egg shell thickness, egg specific gravity and Haugh units. **Klecker *et al.***

(2002) reported that 20 or 40% supplemental inorganic Zn improved egg shell weight, egg shell strength and egg shell thickness of laying hens compared with the control ones.

Mabe *et al.* (2003) observed an improvement in breaking strength and fracture toughness of eggs due to added dietary zinc (60 mg/kg) in old laying hens but percentage egg shell, shell weight per unit surface area and egg shell stiffness were not affected. **Aliarabi *et al.* (2007)** showed that weights of egg components and shell thickness were not significantly influenced by supplementation of organic zinc of the diets but values of albumen height and Haugh units were higher in the groups received organic zinc than those of hens fed diet without supplemental organic zinc.

Stanley *et al.* (2012) indicated that supplemental dietary organic Zinc (20 mg/kg of diet) significantly reduced weights of egg, albumen, and egg shell weights in 78-wk-old weeks old White Leghorn laying hens compared with their control laying hens. **Abdallah *et al.* (2014)** indicated that supplemental dietary organic minerals (Zn or Se) had significantly higher egg shell thickness and yolk solids weight percentage of 24-wk-old laying hens compared with those fed diets supplemented with inorganic trace minerals.

Bahakaim *et al.* (2014) found that dietary supplementation with zinc did significantly affect egg components of egg quality traits but organic zinc caused an increase in shell thickness compared with those fed the inorganic source of zinc.

Idowu *et al.* (2011) found that egg quality parameters were not significantly influenced by Zn sources except Haugh units values which were significantly higher with organic zinc than zinc carbonate of laying hens.

Kita *et al.* (1997) reported that the supplemental dietary Zn-Met (500mg/kg diet) did not affect egg shell quality in layers hens under hot climate environment.

2.1.6. Effect of zinc on semen quality:

Moce *et al.* (2000) showed that dietary zinc supplementation (100 ppm) increased total sperm production of rabbit bucks as compared to the control group.

Abdallah *et al.* (2014) observed that dietary organic minerals (Zn or Se) supplementation had significantly increased sperm concentration, live sperm percentage and sperm motility of Gimmizah cockerels compared with inorganic sources of these minerals.

2.1.7. Effect of zinc on egg fertility and hatchability:

Hassan *et al.* (2003) reported that dietary addition of Zn plus methionine improved egg fertility and hatchability percentages as compared to the control group. **Abdel Galil and Abdel Samad (2004)** showed that dietary supplementation with Zn (100 mg/kg diet) improved egg fertility rate and hatchability percentage in Dokki-4 and Bandara laying hens compared with their control group.

Namra *et al.* (2009) showed that added Zn-methionine (50 mg/kg diet) improved egg fertility of laying Japanese quail. **Amen and Al-Daraji (2011a)** found that dietary supplementation with Zn (50-100 mg zinc/kg diet) led to significant improvements in fertility and hatchability of eggs and a significant decrease in embryonic mortality compared with the controls.

Kidd *et al.* (1993) reported that dietary addition of zinc as ZnO or Zn-methionine (72 to 123 mg Zn/kg diet) Zn oxide or Zn-methionine had no significant effect on egg fertility or hatchability of young broiler breeders.

2.1.8. Effect of zinc on some blood constituents:

Levengood *et al.* (2000) showed that concentrations of blood serum calcium, glucose and total protein were decreased while levels of phosphorus and uric acid increased in Mallards ducks fed diet supplemented with zinc compared with those of the control group. **Hassan *et al.* (2003)** found that dietary supplementation with Zn plus methionine caused significant increases in serum levels of total protein and albumin but decreased cholesterol while globulin was not affected as compared to the control group of Mandarah laying hens.

Parák and Straková (2011) reported that dietary supplementation of organic or inorganic zinc (100 mg/kg) significantly decreased levels of total cholesterol in blood plasma as compared to inorganic zinc and the control group of breeding cocks. **Idowu *et al.* (2011)** found that serum glucose and creatinine concentrations were not affected by supplementation of Zn sources.

Amen and Al-Daraji (2011b) reported that supplemental dietary zinc (50, 75 or 100 mg Zn/kg of diet) significantly increased blood plasma level of testosterone in broiler breeders chickens compared with those of the control group. **Bahakaim *et***

***al.* (2014)** indicated that supplemental dietary zinc-methionine significantly increased plasma levels of zinc total protein, albumin, and globulin and improved albumin / globulin ratio in 36-wk-old Golden Montazah laying hens.

Sahoo *et al.* (2014) observed significant decreases in serum cholesterol of birds fed diets supplemented with 15 ppm organic zinc or 0.06 ppm nano zinc compared with the control group, however, other blood parameters was not altered.

2.1.9. Effect of zinc on poultry immunity:

Kidd *et al.* (1994a) suggested that supplemental dietary organic zinc may improve immunity in birds**. Kidd *et al.* (1996)** pointed out that addition of zinc-methionine to the diet of poultry may improve their immune system and augment the disease resistance. Additionally, zinc-methionine supplementation has beneficial effects on macrophage function and humoral immunity of young turkeys **(Kidd *et al.*, 1992)**. Successively, zinc-methionine enhances the activity of both circulatory and resident components of the mononuclear phagocytic system which considered important for disease resistance **(Kidd *et al.*, 1994)**.

In addition, zinc-methionine supplementation of diets fed to broiler breeders has been shown to increase cellular immunity of their progeny **(Kidd *et al.* 1992)**. It has been reported also that chicks hatched from breeder hens fed Zn-supplemented diets had improved cellular and humoral immunity **(Kidd *et al.*, 1993).**

Amen and Al-Daraji (2011b) reported that dietary supplementation with zinc to diet (50, 75 and 100 mg Zn/kg) significantly increased blood plasma concentrations of estrogen and progesterone hormones at 54 and 66 weeks of age as compared to the control group. Similarly, dietary supplementation with zinc (50, 75 and 100 mg Zn/kg) significantly increased blood plasma concentration of testosterone hormone as compared to the control group.

2.1.10. Effect of zinc on carcass traits:

Namra *et al*. (2008) found that dietary supplementation of different sources of dietary Zn had no significant effect on most of the carcass traits of Japanese quails chicks.

Osman and Ragab (2007) found no significant effect of dietary supplementation with zinc-methionine on the carcass traits of Hubbard broiler chicks.

2.2. Selenium

2.2.1. Use of selenium in poultry feed:

Selenium (Se) is a dietary essential trace mineral for poultry **(NRC, 1994)**. It was discovered in 1817 by Jons Jakob Berzelius **(Sunde, 1997)**. Selenium is an essential dietary nutrient for laying hens. The selenium requirement for laying hens ranges from 0.05 to 0.08 ppm depending on daily feed intake **(NRC, 1994)**. However, Se content of feed grains widely varies from region to region, and thus it is common practice in the poultry industry to supplement laying hen diets **(NRC, 1994)**.

Selenium is regarded as an essential trace element that exerts many functions in several biological processes in animals and birds. Selenium is required for maintenance of growth fertility health, and other physiological functions **(Levander, 1986)**. It has been well-known to play vitally important roles for reproduction and immune function, and as on antioxidant. Supplementation of Se to diets is a common practice in poultry industry as well as for other animal species **(Pavlovic *et al.*, 2009)**.

Sources of selenium can be divided into four groups according to their efficiency, as reviewed by **Suchy *et al.*, (2014):**

The first is elementary selenium and certain compounds that are practically inactive due to poor absorption **(Levander, 1986)**.

The second group is inorganic selenium compounds: Inorganic Se (sodium selenite) is not too biologically active. It accelerates oxidization processes in organism and may cause health problems. Most inorganic selenium is excreted from the body, but higher doses are toxic. Traditionally, Se has been added to poultry diets via inorganic sources, such as sodium selenite. One of the most common inorganic Se supplements that are used in poultry nutrition is sodium selenite. In 2000, the FDA approved the use of an organic source of Se in poultry diets **(FDA, 2000)**.

The third group is organic selenium compounds: Organic selenium compounds perform a key role in biological processes. They are more active than inorganic salts. They are a component of proteins and include selenomethionine (Se-Met) and selenocysteine. Se-Met exists in two isomer forms, D and L, and was identified in plant proteins **(Schrauzer, 2000)**. Only the L-form occurs naturally, D-form may only be prepared synthetically. This form represents about 50% of the total Se content in vegetarian food and higher organisms are unable to synthesize it **(Schrauzer, 2000)**. There are many sources of organic selenium such as selenocysteine, selenomethionine, Se-enriched yeast, and Selenium Chlorella as supplemental sources of Se.

Se-Met is quickly absorbed with the consequence of higher blood levels in comparison to inorganic Se **(Suchy *et al.*, 2014)**. They also stated that Bioavailability of Se depends on its chemical form. Organically-bound Se is mostly used in the form of Se-enriched yeast or other preparations. Se-enriched yeast contains Se in the form of Se-Met. This form is also present in most plants and cereals.

Most of Se in the inorganic form is excreted via urine while its organic form is excreted via fasces **(Hitchcock *et al.*, 1978).** Se in its organic form shows higher bioavailability 75.7% than Se bound in the inorganic form 49.9% **(Mahan *et al.*, 1999)**. This is manifested by higher levels of organic Se in all tissues and organs. **Attia *et al.* (2010)** stated that addition of organic and inorganic Se improved the productive and reproductive performance of Gimmizah breeding hens.

Inorganic minerals are traditionally added to feed, but because of the antagonism that exists between salts and other components of the digest a their bioavailability is often compromised, leading to lesser absorption of specific minerals. The organic form of minerals implies that they are bound principally to an organic substrate **(Radcliffe *et al.,* 2007)**.

The fourth group is nano-selenium. Products of nanotechnology have begun to be applied in the area of nutritional supplements and they are largely available and usable now. A good example of these products is nano-elements, including nano-selenium (nano-Se), with noted significant increases in their chemical reactivity. Effects of nano-Se on yield, meat quality, immune functions, oxidization resistance, and Se levels in tissues of broilers have been reported by **Cai *et al.* (2012).**

Wang and Fu (2012) reported that the transport efficiencies of selenomethionine and nano-Se were higher than that of sodium selenite. They also observed that the highest uptake efficiency was in cells treated with nano-Se and significant difference was also observed between the cells incubated with sodium selenite and selenomethionine **(Wang and Fu, 2012).**

Glutathione peroxidase (GSH-Px) has anti oxidative action and contributes to the oxidative defense by catalyzing the reduction of hydrogen peroxide and lipid peroxides to less harmful hydroxides **(Arthur, 2000)**. The activity level of this enzyme in the liver or plasma is indicative of the selenium supply to the organism; its antioxidant protection levels are affected by dietary Se status **(Wang, 2009).**

Furthermore, **Rotruck *et al.* (1973)** showed that Se was essential for the proper function of the glutathione peroxidase enzyme. In an early study, **Mills (1957)** described the activity of glutathione peroxidase and it was hypothesized that its function was to protect red blood cells from oxidative hemolysis. Selenium has six naturally occurring stable isotopes with the ^{78}Se and ^{80}Se forms accounting for over 73% of the total isotopes **(Sunde, 1997)**.

Since then, Se has been identified to be an integral part of over 30 distinct selenoproteins, including the enzyme, glutathione peroxidase. The glutathione peroxidases are a group of antioxidant enzymes that are essential for protection of the cells of the body from peroxidative and free-radical damage**.** These enzymes are unique because Se is required in the form of selenocysteine. The activity of glutathione peroxidase depends on dietary Se intake, **(Arthur**, **2000).**

Selenium also is necessary in the diets of poultry to protect them from exudative diathesis and pancreatic fibrosis, which are two common conditions in poultry caused by Se deficiency **(Cantor, 1975)**. Despite the establishment of a dietary need for Se, it is still considered to be the most toxic dietary essential trace mineral. **(FDA, 2000)**. But, its toxicity to animals is variable based on the amount and chemical forms of Se ingested, duration and continuity of Se intake, diet composition and animal species **(Levander, 1986)**. Selenium can be found in all cells and tissues of the body, but the concentration of Se will depend on its chemical form in the diet and amount of Se provided by the diet **(Levander, 1986)**. He showed that the metabolism of Se is dependent on its chemical form and the amount ingested and on the presence or absence of interacting dietary factors.

In this regard, **Combs G.F. and S.B. Combs (1986)** indicated that inorganic sources of Se, such as sodium selenite or selenates, are passively absorbed, while organic sources, such as selenium yeast or selenomethionine, are actively absorbed via amino acid transport mechanisms. Organic Se is metabolized in a different manner to inorganic Se **(Sunde, 1997)**.

2.2.2. Effect of selenium on live body weight and body weight gain:

Choct *et al.* (2004) showed that supplemental dietary organic selenium had had no effect on body weight gain of broiler chickens. **Payne and Southern (2005)** found that the body weight gain of broilers was not affected by addition of Se source (sodium selenite vs-Se-enriches yeast) or level of supplementation (0 or 0.30 mg/kg diet).

Zhou and Wang (2011) indicated that dietary supplementation with 0.3 mg nano-Se/kg diet improved final body weight, daily body weight gain as compared the control groups of Guangxi Yellow chickens after go days of feeding. **Cai *et al.* (2012)** showed that dietary supplementation with nano-Se had no body weight gain of chickens.

Zduńczyk *et al.* (2013) indicated that supplemental dietary Se at (0.15 and 0.30 mg/kg diet) from 18 to 30 weeks old had no significant effect on the body weights of Lohman Brown hens at 30 weeks of age.

Rama Rao *et al.* (2013) observed no effect of supplemental dietary organic Se d on body weight gain of broiler chickens. **Radwan *et al.* (2015)** found that body weight change of Silver Montazah laying hens was not significantly influenced by added dietary levels of sources of Se (sodium selenite or nano-Se).

2.2.3. Effect of selenium on feed consumption and feed conversion ratio:

Wang and Xu (2008) found that feed efficiency was improved by supplementation organic Se at 0.20 mg/kg diet in broilers. **Attia *et al.* (2010)** found that dietary supplementation of Se improved feed conversion ratio compared with hens fed the control diet. **Zhou and Wang (2011)** indicated that feed conversion was improved by addition of 0.3 mg nano-Se/kg diets of Guangxi Yellow chickens.

Radwan *et al.* (2015) showed that dietary supplementation of nano-Se to layer diets improved feed conversion ratio compared with addition of sodium selenite. They also observed that dietary supplementation of sodium selenite or nano-Se or their levels had no significant effect on feed intake of Silver Montazah laying hens, from 32-45 weeks of age.

On the other hand, **Payne and Southern (2005)** found that feed efficiency of broilers was not affected by addition of Se source or level (0 or 0.30 mg/kg).

Sechinato *et al.* (2006) observed that feed conversion of Babcock laying hens was not influenced by addition of organic or inorganic Se as compared to the control group. **Cai *et al.* (2012)** indicated that neither feed intake nor feed conversion of broilers was no affected by dietary supplementation of nano-Se. **Rama Rao *et al.* (2013)** indicated that feed efficiency was not affected by organic Se addition to broiler diets.

2.2.4. Effect of selenium on egg production traits:

Renema (2004) found that the addition of organic selenium source to the diet of layers improved egg production and egg weight as compared to inorganic Se and non supplemented treatments during the late lay period (49-58 weeks old).

Stanley *et al.* (2004) showed that hens fed diet supplemented with organic Se significantly increased hen-day egg production and egg weight compared with the control group.

Leeson *et al.* (2008) observed that addition of 0.3 mg Se/kg diet improved hen-day egg production percentage of broiler breeder hens (Ross 308) compared with those fed diet supplemented with 0.1 mg/kg of selenium. **Hanafy *et al.* (2009)** found that Bandarah hens fed diets supplemented with organic Se produced significantly heavier eggs than those produced by the control ones form of Bandarah hens from 44 to 60 weeks of age. They also found that egg production percentage was significantly increased for hens fed organic Se supplementation compared with those in control group.

Gjorgovska *et al.* (2012) found that supplemental dietary organic selenium in layer diets increased egg production percentage. **Radwan *et al.* (2015)** showed that nano-Se supplementation in layer diets from 32 to 45 weeks old significantly increased egg production percentage compared with inorganic Se (sodium selenite) of Silver Montazah laying hens.

On the other hand, **Chantiratikul *et al.* (2008)** found that egg production and egg weight of aged Brown laying hens were not affected by source and level of dietary supplementation with Se. **Zduńczyk *et al.* (2013)** found that supplemental Se (0.15 and 0.30 mg/kg diet) had no significant effect on egg production of Lohman Brown hens from 18-28 weeks of age.

Cruz and Fernandez (2011) observed no differences in egg production percentage and egg weight of Japanese quail hens fed diets supplemented with organic Se. **Radwan *et al.* (2015)** showed that neither Se source (sodium selenite or nano-Se) nor level had an effect on egg weight of Silver Montazah laying hens from 32 to 45 weeks old.

Attia *et al.* (2010) indicated that the addition of Se significantly increased egg weight compared with hens fed the control diet, while egg production percentage was not affected by Se source or level. **Payne *et al.* (2005)** showed that percentage hen-day production was not affected by added by sources or levels of Se to the diet of hens. **Chantiratikul *et al.* (2008)** indicated that added dietary sources and levels of Se had no effect on egg production, egg weight or feed conversion rate of laying hens.

Pavlovic *et al.* (2009) observed no effects of adding sodium selenite or Se-enriched yeast to layer diet until the 8^{th} weeks of feeding, whereas from the ninth wk, addition of Se-enriched yeast to the hens diet led to higher egg production rate than that of hens given diet supplemented with sodium selenite.

. 2.2.5. Effect of selenium on egg quality:

Chantiratikul *et al.* (2008) found that Haugh units and egg shell thickness were not changed by source and level of Se addition of aged Brown laying hens. **Hanafy *et al.* (2009)** reported that some egg quality parameters (Haugh unit, egg yolk index and shell thickness) were significantly increased with supplemental dietary organic Se (Sel-Plex^{TM}) than control group of Bandarah laying hens.

Gajcevic *et al.* (2009) found that dietary supplementation of organic selenium increase Haugh units values compared with eggs produced of hens fed the control diet. **Cruz and Fernandez (2011)** observed no significant differences in Haugh unit, yolk index, albumen index, egg shell thickness of Japanese quails in response to feeding diets supplemented with organic Se from 60 to 172 days of age.

Radwan *et al.* (2015) reported that external and internal egg quality parameters of Silver Montazah laying hens were not affected by Se source (nano-Se or sodium selenite), except yolk index which significantly increased by feeding nano-Se-supplemented diet compared with those fed the diet supplemented with sodium selenite. The high level of Se addition (0.4 ppm) positively affected yolk index compared with the low level (0.1 ppm).

Attia *et al.* (2010) found that dietary supplementation of organic or inorganic selenium had no significant effect on most traits of egg quality of Gimmizah breeding hens. **Gjorgovska *et al.* (2012)** showed that dietary supplementation with Se (organic or inorganic) to 80-week-old) molted hens produced significant increases in egg weight, egg white weight and egg shell weight but yolk weight was not affected. **Paton *et al.* (2000)** indicated that feeding organic-selenium compounds to Babcock laying hens improves shell strength.

2.2.6. Effect of selenium on semen quality:

Edens (2002) found that dietary supplementation of organic Se can improve semen quality of cocks by decreasing the abnormalities of spermatozoa damage and reducing the production of defective sperm, thereby having a positive effect on the fertilizing potential of the male.

Spring (2006) reviewed significant improvements in spermatozoa concentration and activity of male guinea fowl when fed diets were supplemented with Se yeast compared with sodium selenite. **Renema (2006)** showed that broiler breeders fed the diets supplemented with 0.2 mg organic Se/kg diet increased semen concentration. **Davtyan *et al.* (2006)** showed that the number of spermatozoa was also increased significantly by addition of organic Se (Sel-Plex).

Edens and Sefton (2009) found that the sperm quality, as evidenced by spermatozoa morphology, was greater and sperm concentration per ejaculate was significantly increased when diets of roosters were supplemented with organic Se (Sel-Plex[B]) or sodium selenite compared with those fed on non-supplemented diets.

Hanafy *et al*. (2009) showed that semen ejaculate volume, advanced motility percentage, live sperm percentage and sperm concentration were significantly increased by dietary addition of organic Se for Bandarah cocks from 40 to 60 weeks of age.

Słowińska *et al.* (2011) found that dietary Se supplementation enhanced the sperm concentration and total number of sperm compared with the control toms but had no effect on the anti oxidative properties of turkey seminal plasma. They also reported that the highest percentage of motile spermatozoa was recorded for semen of toms the organic Se.

Surai (2002) noted that Se-dependent from of glutathione peroxidase comprised between 77.7 % (chicken) and 87.4 % (guinea fowl) of total enzymatic activity. He also reviewed that dietary Se supplementation to male birds is needed to maintain sperm membrane integrity during in vitro sperm manipulation.

On the other hand, **Dimitrov *et al.* (2007)** found that dietary supplementation with organic Se led to better semen integrity associated with an improve fertilizing ability of spermatozoa.

2.2.7. Effect of selenium on egg fertility and hatchability:

Agate *et al.* (2000) observed that dietary organic Se supplementation of laying hen diets improved the environment of the sperm storage tubules in the hen's oviduct, allowing sperm to live longer. **Hanafy *et al.* (2009)** indicated that supplemental dietary organic Se of laying hens increased the egg fertility and hatchability of fertile eggs.

Abdallah *et al.* (2014) found that addition of 50% organic Se to the diet of Gimmizah chickens significantly increased egg fertility and hatchability compared with those fed the inorganic Se and the control group.

2.2.8. Effect of selenium on some blood constituents:

Brown and Jessup (1999) observed that cholesterol concentration decreased with increasing addition of antioxidants in the diet. **Poirirer *et al.* (2002)** found that blood plasma levels of cholesterol and low density lipoprotein cholesterol plus very low density lipoprotein cholesterol were significantly decreased when Se was added in the diet of hamsters. **Abaza (2002)** found that the plasma levels of cholesterol and total lipids were significantly increased by Se supplementation of the hens diet.

Attia *et al.* (2010) observed that blood plasma level of cholesterol was significantly decreased when laying hens were fed on diets supplemented with inorganic or organic selenium compared with the control group.

El-Sheikh *et al.* (2010) showed that supplemental dietary organic selenium at 0.2 and 0.3 ppm significantly increased the blood level of hemoglobin and triiodothyronine. **Selim *et al.* (2015)** found that antibody titers of broiler chicks against Newcastle disease virus, malondialdehyde, activity of liver enzymes and plasma proteins were not affected by dietary supplementation with Se sources or levels. They also observed a significant increase in plasma level of T_3 hormone due to increasing dietary Se level from 0.15 to 0.30 ppm.

Hegazy and Adachi (2000) indicated that dietary supplementation with Se of chickens increased antibody immune response of chicks. **Saad *et al.* (2013)** observed no differences in antibody titers against NDV and Infectious bursal disease virus of organic and inorganic selenium to broiler chick diet.

Mohapatra *et al.* (2014) reported significant increases in hematological parameters of chickens in response to dietary supplementation of nano-Se as compared to those received inorganic Se (sodium selenite) or the control group. They also reported that dietary nano-Se supplementation increased both humoral and cellular immunity as evidenced by antibody titers against sheep red blood cells and coetaneous basophilic hypersensitivity response compared with sodium selenite and the control group.

Payne and Southern (2005) reported that plasma glutathione peroxidase activity was not affected by addition of Se source or concentration. **Leeson *et al.* (2008)** found that plasma glutathione peroxidase activity was greater in hens fed inorganic Se (sodium selenite) compared with addition of organic Se (B-traxim Se or Se yeast) in broiler breeder hens (Ross 308). **Chantiratikul *et al.* (2008)** showed that plasma GSH-Px activity was not affected by Se sources of laying hens. **Gajcevic *et al.* (2009)** indicated that blood GSH- Px activity in hens was significantly higher due to addition of 0.4 ppm Sel-Plex® than those given 0.2 ppm of organic Se.

Zhou and Wang (2011) reported that supplemental dietary nano-Se significantly increased the activity of GSH-Px in blood serum of growing chickens. **Yang *et al.* (2012)** reported that activity of serum GSH-Px of broilers fed organic selenium (Se-enriched yeast) diet was higher than that of the control chicks fed inorganic Se diet.

Cai *et al.* (2012) found that glutathione peroxidase activity was significantly increased when broiler chicks were fed diets supplemented with 0.3, 0.5, 1.0, and 2.0 mg nano-selenium/kg diet compared with the control group. **Rama Rao *et al.* (2013)** showed that activity of glutathione peroxidase and glutathione reductase in plasma of broiler chickens increased linearly with dietary addition of Se. They also observed that Newcastle disease antibody titers were not affected by Se supplementation to broiler diets.

Jing *et al.* (2015) reported that plasma activity of GSH-Px and superoxide dismutase significantly increased by added Se compared with those of laying hens fed the control diet. **Radwan *et al.* (2015)** found that supplemental dietary nano-Se significantly decreased blood plasma levels of cholesterol and total lipids compared with those of hens fed the control diet. They also reported that glutathione peroxidase (GSH-Px) activity significantly increased in blood by supplementing Nano-Se in the diets compared with the than inorganic Se (sodium selenite) of Silver Montazah laying hens.

2.2.9. Effect of selenium on carcass traits:

Ševčikova *et al.* (2006) found that no significant effect dietary supplementation of organic Se on carcass traits of broiler chickens. **Hanafy *et al.* (2009)** indicated that relative weights of ovary, testes, thymus and spleen were significantly increased by dietary addition of organic Se to Bandarah chickens from 40 to 60 weeks of age.

Edens and Sefton (2009) showed that the dietary addition of inorganic Se and organic Se selenium caused a significant increase in relative weight of testes in 26-wk old Cobb-500 with no significant differences in relative testes weights between sodium selenite and sel-Plex® fed roosters. **Rama Rao *et al.* (2013)** found that relative weights of liver and lymphoid organs (bursa, spleen and thymus) were not affected by addition of organic Se to broiler diets.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study was carried out at Mehalet Mousa Animal Production Research Station, Kafr El-Sheikh, belonging to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. This experiment started in November 2015 and was terminated in February 2016.

3.1. <u>Birds and management:</u>

Two experiments were carried out to study the use of some antioxidants for improving the productive and reproductive performance in turkeys. In experiment 1, 84 Bronze female turkeys, 32 weeks of age plus 10 Bronze male turkeys (toms) of the same of age were used. The hens were randomly distributed into 7 experimental groups; each consisted of three equal replications. The hens were individually housed in battery cages (65 × 50 cm) fitted with individual feeders and automatic nipple drinkers while, the toms were maintained in floor pens. In experimental 2, 63 Bronze male turkeys (toms), 32 weeks of age plus 70 Bronze female turkeys of the same of age were used. The toms were randomly distributed into 7 experimental groups; each consisted of three equal replications. Toms of each experimental group were maintained in three floor pens, each measuring 5 m length and 4 m width while, the hens were individually housed in battery cages. The experimental period lasted 12 weeks (from 32 to 44 weeks of age).

The semen collected from toms in experiment 2 that were fed diets supplemented with feed additives (three forms of zinc or selenium) was artificially inseminated to control turkey hens (70 hens) fed the diet (without supplementation of zinc or selenium forms). While semen of the control toms in experiment 1 was artificially inseminated to turkey hens fed the diet with feed additives (zinc or selenium forms) in experiment 1, to evaluate the effects of these feed additives on the fertility and hatchability of turkey hens and toms.

Birds were fed *ad libitum* and fresh water was available all the time, during the experimental period. A daily Photoperiod of 16 hours was applied during the experimental period. The experiment was terminated at 44 weeks of age.

3.2. Experimental diets:

The birds were fed yellow corn-soybean meal based-diet, supplemented with two natural antioxidants, (zinc or selenium) in three forms (organic, inorganic and nano forms).Only toms in experiment 1 were fed on the basal diet (control).

The experimental groups in both experiments were fed one of the following diets:

1-The first group was fed a basal diet (control group) without added zinc or selenium.

2-The second group was fed the basal diet + inorganic zinc (zinc oxide) 100 mg/kg diet.

3- The third group was fed the basal diet + organic zinc (zincmethionine) 100 mg/kg diet.

4-The fourth group was fed the basal diet + nano zinc (zinc oxide nanoparticles) 40 mg/kg diet.

5- The fifth group was fed the basal diet + inorganic selenium (sodium selenite) 0.3 mg/kg diet.

6- The sixth group was fed the basal diet + organic selenium (selenomethionine) 0.3 mg/kg diet.

7- The seventh group was fed the basal diet + nano selenium (selenium nano-particles) 0.15 mg/kg diet.

Characterization of selenium nano particles:

Synthesis and characterization of the synthesized SeNPs was done at Nanotechnology and Advanced Materials Central Lab, Agricultural Research Center, Giza, Egypt.

Table 1: Composition and calculated analysis of the basal diet used in experiments 1 and 2

Ingredients	**%**
Yellow corn	70.00
Soybean meal (44% CP)	11.50
Fish meal (65% CP)	10.00
Dicalcium phosphate	2.00
Limestone	6.00
Salt (NaCl)	0.30

L-Lysine. HCl	0.15
DL-Methionine	0.05
Total	100
Calculated analysis(As-fed basis; NRC, 1994)	
Crude protein %	17.72
Metabolizable Energy (kcal/kg diet)	2920

***** Supplied per kg of diet: Vit. A, 12000 IU; Vit. D_3, 2200 IU; Vit. E, 10 mg; Vit K_3, 2 mg; Vit. B_1, 1 mg; Vit. B_2, 5 mg; B_6, 1.5 mg; B_{12}, 10 mg; Nicotinic acid, 30 mg; Folic acid, 1mg, Pantothenic acid, 10 mg; Biotin, 50 mg; Choline, 250 mg; Copper, 10 mg; Iron, 30 mg; Manganese, 60 mg; Iodine, 0.3 mg and Cobalt, 0.1 mg.

3.3.Characteristics Investigated :

3.3.1. Body weight:

Birds were individually weighed at 32, 36, 40 and 44 weeks of age within each treatment.

3.3.2. Feed intake:

Feed intakes of the experimental groups of turkey birds were measured at weekly intervals according to the following equation:

Feed intake/bird = weekly feed consumed per treatment weekly/number of birds alive during the same period.

3.3.3. Body Weight gain:

Body weight gain was calculated according to the following equation:

Body weight gain = W_2 - W_1

Where:

W_1 = body weight at the beginning of the period.

W_2 = body weight at the end of the same period.

3.3.4- Feed conversion ratio:

Feed conversion ratios were calculated using the following formula:

Feed conversion ratio of toms = weekly feed intake (in grams) / body weight gain (g) for the same week or period.

Feed conversion ratio of hens = weekly feed intake (in grams)/total egg mass for the same week or period.

3.3.5. Egg production rate:

Hen-day egg production rate was calculated every day using the following equation:

$$= \frac{\text{number of eggs produced every day}}{\text{number of hens alive in that day}} \times 100$$

3.3.6. Egg number:

Number of eggs laid during the investigated age intervals from 32 to 44 weeks of age were recorded for each experimental group.

3.3.7. Egg weight:

Egg weight was measured to the nearest 0.01 gram for all experimental groups during the laying period.

3.3.8. Egg quality traits:

Egg quality measurements were done on freshly laid eggs. Ten eggs per treatment were taken at random and used for egg quality evaluation.. Egg quality measurements were carried out at the peak of egg production when the birds were 38 weeks of age. In addition, absolute and relative weights of egg components were also estimated. Yolk was carefully separated from albumen. Weights of egg yolk, albumen and egg shell were determined to the nearest 0.01 gram. Relative weights of egg components were also determined.

3.3.8.1. Albumen weight:

Albumen weight was calculated using the following equation:

Albumen weight = egg weight – (yolk weight + egg shell weight).

3.3.8.2. Albumen percent:

Albumen percent was calculated for experimental groups according to the following equation:

$$\text{Albumen percent} = \frac{\text{Albumen weight}}{\text{Egg weight}} \times 100$$

3.3.8.3. Yolk weight:

Yolk weight was determined to the nearest 0.01 gram.

3.3.8.4. Yolk percent:

Yolk percent was calculated using the following equation:

$$\text{Yolk percent} = \frac{\text{Yolk weight}}{\text{Egg weight}} \times 100$$

3.3.8.5. Yolk index:

It was calculated using the following equation:

$$\text{Yolk index} = \frac{\text{Yolk height (mm)}}{\text{Yolk diameter (mm)}} \times 100$$

3.3.8.6. Haugh units:

This was measured according to the next formula presented by **Eisen *et al*. (1962):** Haugh units = 100 × log (H- 1.7 W $^{0.37}$ + 7.57).

Where:

H= the height of thick albumen (mm).

W= the egg weight (g).

3.3.8.7. Egg shape index:

The two axis of the egg were measured using a steel venire caliper, then the egg shape index was computed as follows:

$$\text{Egg shape index} = \frac{\text{Egg width (mm)}}{\text{Egg length (mm)}} \times 100$$

3.3.8.8. Egg shell traits:

1- Egg shell weight with membranes to the nearest 0.01 gram.

2- Egg shell percent, it was determined as following:

$$\text{Egg shell percent} = \frac{\text{Egg shell weight}}{\text{Egg weight}} \times 10$$

3.3.8.9. Egg shell thickness:

Each egg shell was rinsed with tab water and shell membranes were manually removed. Shell thickness was measured using a micrometer to the nearest micron. Estimates were done at three portions, large end, small end and the equator of each egg. The average of the three readings was calculated.

3.3.8.10. Yolk color score: Yolk color score was determined by using a Roche yolk color fan.

3.3.9. Fertility and hatchability of eggs:

Fertility and hatchability (four hatches) of eggs were made every 3 weeks of the experimental period. The eggs were incubated in Petersime incubators. Incubators, hatcheries and eggs were fumigated for 30 min. directly before setting eggs using 20 g potassium permanganate and 40 ml of formalin per m^3.

Eggs were collected from 7days after the beginning of egg collection and were stored in a room at 18.5 ^{o}C (dry bulb) and 70% relative humidity. Egg were incubated at 99.5° F and 60% relative humidity during the first 25 days of incubation period. Eggs were turned automatically through an angle of 90° every hour until the 25th day of incubation period. Ventilation channels were opened and closed automatically according to temperature fluctuations. Incubated eggs from each incubator were transferred to a single hatchery at the 25th day of incubation period. The relative humidity was risen in each hatchery until reached 75 to 80 %**,** while temperature was decreased to 99° F until hatching process was completed at day 28 of incubation period..

Incubated eggs were individually candled using a hand candling ultraviolet lamp at 18 and 25 days of incubation period to determine the infertile eggs and embryonic mortality.

Fertility was calculated as the number of fertile eggs relative to total number of eggs set; while egg hatchability was calculated as the number of healthy hatched chicks relative to total number of settable eggs and or to number of fertile eggs.

3.3.10. Blood constituents:

In both experiments, blood samples were collected from 44-week-old turkey toms and hens (3 specimens per treatment) by venipuncture of the wing vein. Immediately after collection, blood sample was transferred into two test tubes a heparinized tube and non-heparinized one.

Heparinized whole blood samples were used for the determination of hemoglobin concentration according to **Campbell (1995)** and haematocrit value, as described by **Hunsaker (1969)**.

The separated sera from non-heparinized blood samples were used for the estimation of levels of glucose **(Trinder, 1969)**, total protein **(Henry *et al.*, 1974),** albumin **(Doumas *et al.*, 1971),** cholesterol (**Watson, 1960)** and total lipids Frings ***et al.*, 1972)**, using commercial kits. The concentration of serum globulin was calculated by the difference between serum total protein and serum albumin.

Turkeys were vaccinated against Newcastle disease virus (NDV) by inactivated Newcastle vaccine at 30 weeks of age. Serum samples from toms and layers at 44 weeks of age were used for determination of Newcastle disease virus antibodies titer, as described by **(Liu *et al.*, 1999)**. Activity of serum glutathione peroxidase (GSHPX) was also estimated using available commercial Kits.

For measuring concentrations of testosterone and estrogen hormones in blood plasma of males and females, three blood samples from male birds and 3 from females were taken in heparinized test tubes by using heart puncture procedure **(Al-Daraji *et al.*, 2008).** Blood plasma was separated by centrifugation at 3000 rpm for 15 min. Blood plasma samples were frozen at -25°C till analysis.

Testosterone determination: The quantitative determination of total testosterone concentration in plasma was done by Micro plate Enzyme Immunoassay using ELISA device and commercial kits (Monobin Inc., USA)

Estrogen determination: Enzyme immunoassay was used for the quantitative determination of Estradiol (E2) concentration in blood plasma. This steroid hormone has a molecular weight of 272.4. It is the most potent natural estrogen, produced mainly by the ovary and in smaller amounts by the adrenal cortex and the male testes **(Tsang *et al.*, 1980).**

3.3.11. Semen quality:

The method of semen collection was performed by massaging the bird abdomen as described by **Al-Daraji (2007).** The time of semen collection was in the morning between 8.00 and 9.00 a.m. at the peak of egg production of the experiment (38 weeks of birds age) to evaluate some parameters of semen quality. Semen was collected from toms and artificially inseminated to hens .The insemination was made as soon as possible after semen collection. The artificial insemination was done once a week. All hens were inseminated intra-vaginally. Raw semen was diluted in the rate of 1:1 with 0.9 NaCl. The insemination was performed by inserting 0.1 ml of the diluted semen with one millimeter tuberculin syringe into the vagina of each hen. Ejaculate volume (ml) was measured using 2 ml calibrated pipette. Sperm motility was estimated just after semen collection by microscopical examination. The percentages of abnormal and dead spermatozoa were determined in number of 2300 sperms. Sperm concentration was determined using a hemocytometer.

3.3.12. Carcass traits:

At the ends of experimental period (44 weeks old), 3 birds (males or females) from each treatment were randomly selected and slaughtered for carcass evaluation. Carcass yield and some internal organs were expressed as percentage of live body weight. The oviduct length was also estimated.

3.4. Statistical analysis:

Data were statistically analyzed by one-way analysis of variance by using the General Linear Model procedures **(SAS, 2003)**. Significant differences among means of treatments were detected by Duncan multiple range test **(Duncan, 1955)**. The following model was used to study the effect of inorganic, organic and nano forms of zinc or selenium on parameters investigated as follows:

$Y_{ij} = \mu + T_i + e_{ij}$

Where,

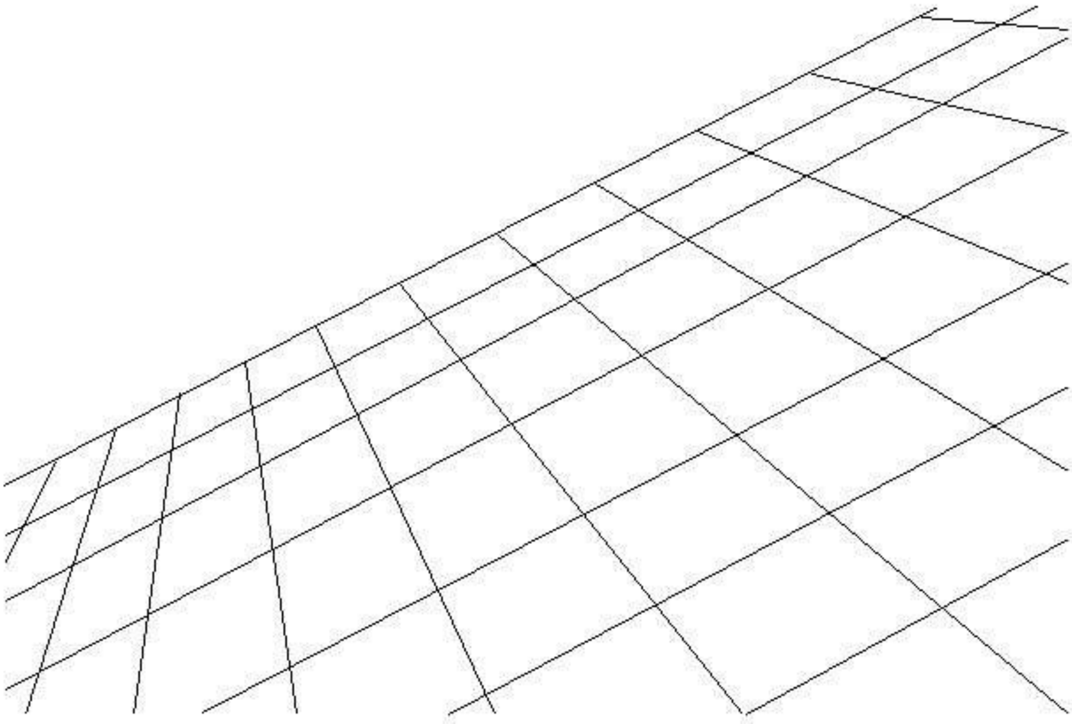
Y_{ij} = an observation

μ = overall mean

T_i = treatments (i = 1, 2 … and 7)

e_{ij} = residual "random error".

RESULTS AND DISCUSSION



4. RESULTS AND DISCUSSION

4.1. Effects of dietary inorganic, organic and nano forms of zinc or selenium on productive performance of turkey hens and toms:

4.1.1. Live body weight and body weight gain of turkey hens:

Data presented in Tables 2 and 3, show the effects of different dietary treatments on live body weight and body weight gain of turkey hens. (Experiment 1).

The initial body weight of hens at 32 weeks old in Experiment 1 was approximately similar with a little bit difference indicating the well randomization way for distributing birds within the experimental treatments.

Results presented in Table 2 indicated that final body weight of turkey hens at 44 weeks of age was not affected by dietary treatments. At 36 weeks of age hens fed the diet supplemented with inorganic Zn which gave significantly ($P \leq 0.05$) lower body weight of hens as compared to that of the controls and other different dietary treatments.

The present results are in partial agreement with the findings of **Zduńczyk *et al.* (2013)** supplemental dietary Se at (0.15 and 0.30 mg/kg diet) had no significant effect on the body weights of 28-week-old, Lohman Brown hens.

Table (2): **Effects of dietary inorganic, organic and nano forms of zinc or selenium on live body weight (g) of turkey hens (Exp. 1)**

Dietary treatments	Body weight (g)			
	32 Weeks old	36 Weeks old	40 Weeks old	44 Weeks old
Control (Basal diet)	**4302.96**	**4407.00** ^{a}	**4507.80** ^{abc}	**4612.37** ^{ab}
Basal diet + Inorganic Zn	**4265.43**	**4372.12** ^{b}	**4480.19** ^{c}	**4594.89** ^{b}
Basal diet + Organic Zn	**4306.91**	**4401.63** ^{a}	**4500.05** ^{bc}	**4606.97** ^{b}
Basal diet + Nano Zn	**4290.42**	**4401.74** ^{a}	**4505.68** ^{abc}	**4616.68** ^{ab}
Basal diet + Inorganic Se	**4330.40**	**4427.59** ^{a}	**4529.05** ^{ab}	**4636.37** ^{ab}
Basal diet + Organic Se	**4290.93**	**4401.50** ^{a}	**4521.06** ^{abc}	**4624.99** ^{ab}
Basal diet + Nano Se	**4321.39**	**4430.27** ^{a}	**4548.72** ^{a}	**4656.85** ^{a}
SEM	**11.03**	**8.96**	**14.60**	**15.29**
Significance	**NS**	*	*	*

a-c: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

Table (3): **Effects of dietary inorganic, organic and nano forms of zinc or selenium on body weight gain (g) of turkey hens (Exp. 1)**

Dietary treatments	Body weight gain (g)			
	32-36 Weeks old	36-40 Weeks old	40-44 Weeks old	32-44 Weeks old
Control (Basal diet)	104.03	100.80	104.56	309.40
Basal diet + Inorganic Zn	106.69	108.06	114.70	329.46
Basal diet + Organic Zn	94.72	98.42	106.92	300.07
Basal diet + Nano Zn	111.33	103.94	111.00	326.27
Basal diet + Inorganic Se	97.20	101.46	107.31	305.97
Basal diet + Organic Se	110.57	119.55	103.93	334.06
Basal diet + Nano Se	108.88	118.45	108.13	335.47
SEM	8.39	9.06	6.91	14.72
Significance	NS	NS	NS	NS

NS: Not significant   SEM: Standard error of the means

In disagreement with the present results, **Zhou and Wang (2011)** indicated that dietary supplementation with nano-Se improved final body weight of growing Guangxi Yellow chickens as compared with the control group. Similarly, **Osman and Ragab (2007)** found that dietary supplementation of zinc-methionine at the level of 0.5g/kg diet led to the highest value of live body weight of Hubbard broiler chicks at 49 days of age.

Results presented in Table 3, indicated that there was no significant effect of different dietary treatments on body weight gain (g) of turkey hens from 32 to 44 weeks old (Experiment 1). The results indicated that the heaviest body weight gain of hens during the experimental period (32 to 44 weeks old) was recorded for hens fed nano-Se, followed by those of hens fed organic Se as compared to their control counterparts.

The present results agree with those of **Radwan *et al.* (2015),** who found that body weight change of Silver Montazah laying hens was not significantly influenced by levels or sources of added dietary Se from 32 to 45 weeks of age. Conversely, **Zhou and Wang (2011)** indicated that dietary supplementation with nano-Se improved body weight gain of Guangxi Yellow chickens as compared with the control group from 1-90 days of age.

4.1.2. Live body weight and body weight gain of turkey toms:

Data presented in Tables 4 and 5, show the effects of different dietary treatments on live body weight and body weight gain of toms from 32 to 44 weeks old. (Experiment 2).

Table (4): **Effects of dietary inorganic, organic and nano forms of zinc or selenium on body weight (g) of turkey toms from 32 to 44 weeks old (Exp. 2)**

Dietary treatments	Body weight (g)			
	32 Weeks old	36 Weeks old	40 Weeks old	44 Weeks old
Control (Basal diet)	**9362.50**	**9424.17**	**9492.50**	**9555.00**
Basal diet + Inorganic Zn	**9290.83**	**9352.50**	**9421.67**	**9481.67**
Basal diet + Organic Zn	**9316.67**	**9382.50**	**9454.17**	**9516.67**
Basal diet + Nano Zn	**9303.33**	**9367.50**	**9438.33**	**9501.67**
Basal diet + Inorganic Se	**9335.00**	**9400.83**	**9470.83**	**9530.83**
Basal diet + Organic Se	**9299.17**	**9365.00**	**9434.17**	**9495.00**
Basal diet + Nano Se	**9322.50**	**9386.67**	**9455.00**	**9517.50**
SEM	**26.84**	**26.18**	**27.85**	**28.36**
Significance	**NS**	**NS**	**NS**	**NS**

NS: Not significant SEM: Standard error of the means

Table (5): **Effects of dietary inorganic, organic and nano forms of zinc or selenium on body weight gain (g) of turkey toms from 32 to 44 weeks old (Exp. 2)**

Dietary treatments	Body weight gain (g)			
	32-36 Weeks old	36-40 Weeks old	40-44 Weeks old	32-44 Weeks old
Control (Basal diet)	61.66	68.33	62.50	192.50
Basal diet + Inorganic Zn	61.66	69.17	60.00	190.83
Basal diet + Organic Zn	65.83	71.67	62.50	200.00
Basal diet + Nano Zn	64.16	70.83	63.33	198.33
Basal diet + Inorganic Se	65.83	70.00	60.00	195.83
Basal diet + Organic Se	65.83	69.17	60.83	195.83
Basal diet + Nano Se	64.16	72.50	62.50	195.00
SEM	5.00	7.45	2.68	9.80
Significance	NS	NS	NS	NS

NS: Not significant SEM: Standard error of the means

The initial body weight of toms was approximately similar with a little bit difference indicating the well randomization way for distributing birds within the experimental treatments.

Results presented in Tables 4 and 5 indicated that there was no significant effect of different dietary treatments on average body weights on body weight gain of toms at all egg intervals and the whole experimental period from 32-44 weeks of age. As presented in Table 5, the heaviest body weight change of toms during the experimental period (32 to 44 weeks old) was recorded for toms fed the diet supplemented with organic Zn followed by those of toms fed nano Zn as compared to their control counterparts.

The present results agree with those of **Rama Rao *et al.* (2013)** who observed no effect of supplemental dietary organic Se on body weight gain of broiler chickens. Similarly results were obtained by **Choct *et al.* (2004)**, who found that supplemental dietary organic selenium had had no effect on the final body weight of broiler chickens.

The present results also agree with those of **Cai *et al.* (2012),** who showed that dietary supplementation with nano-Se had no effect on body weight and body weight gain of broiler chickens. Similarly, **Payne and Southern (2005)** found that the body weight gain of broilers was not affected by addition of Se source or level of supplementation (0 or 0.30 mg/kg diet).

On the other hand, the current results disagree with those of **Zhou and Wang (2011)**, who indicated that dietary supplementation with nano-Se improved final body weight and daily body weight gain of Guangxi Yellow chickens from 1-90 days old as compared with the control group. **Kidd *et al.* (1994)** reported that Zn-Met supplementation increased 3-week body weight gain of young turkey.

4.1.3. Feed consumption of turkey hens:

Results presented in Table 6 illustrate the effects of dietary inorganic, organic and nano forms of zinc or selenium on feed consumption of turkey hens (g/hen/day) from 32-44 weeks of age. (Exp. 1)

The results indicated that hens fed the diet supplemented with inorganic, organic and nano forms of zinc or selenium displayed significantly ($P \leq 0.05$) lower feed consumption compared with the control group during all age intervals studied and the whole period from 32 to 44 weeks of age.

These results agree with those of **Namra *et al.* (2009),** who showed that dietary addition of 50 mg/kg Zn from zinc-methionine or $ZnSo_4$ significantly reduced feed intake of Japanese quail hens compared with those fed the control diet. Also, **Idowu *et al.* (2011)** indicated that dietary Zn supplementation (140 mg/kg diet) decreased significantly the feed consumption of laying birds as compared to their control ones.

On the other hand, the current results disagree with the findings of **Abdallah *et al.* (2014)** that supplemental dietary organic Zn had no significant effect on feed intake of Gimmizah laying hens compared with those supplemented with inorganic Zn from 24 to 36 weeks old.

Table (6): Effects of dietary inorganic, organic and nano forms of zinc or selenium on daily feed intake (g) of turkey hens from 32 to 44 weeks old (Exp. 1)

Dietary treatments	Feed intake (g)			
	32 - 36 Weeks old	36 - 40 Weeks old	40 - 44 Weeks old	32 - 44 Weeks old
Control (Basal diet)	111.83 [a]	130.00 [a]	148.00 [a]	129.94 [a]
Basal diet + Inorganic Zn	110.33 [b]	127.13 [b]	145.33 [b]	127.59 [b]
Basal diet + Organic Zn	104.00 [e]	119.16 [d]	135.33 [cd]	119.49 [e]
Basal diet + Nano Zn	104.33 [e]	115.16 [e]	133.50 [d]	117.66 [f]
Basal diet + Inorganic Se	108.40 [c]	126.00 [b]	144.16 [b]	126.18 [c]
Basal diet + Organic Se	106.90 [d]	120.93 [c]	135.66 [c]	121.16 [d]
Basal diet + Nano Se	104.00 [e]	115.50 [e]	134.16 [cd]	117.88 [f]
SEM	0.40	0.50	0.60	0.32
Significance	*	*	*	*

a-f: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

The present results in Table 6 indicated that the least values of feed consumption of turkey hens was achieved by hens fed the diets supplemented with organic and nano forms of zinc or selenium, followed by those of hens fed the diets supplemented with inorganic forms of selenium or zinc compared with the control group during the experimental period from 32-44 weeks of age (Table 6).

The reduced feed intake of turkey hens fed the nano forms of Zn and Se may be related to their effects on absorption process and metabolic pathways. Mineral nanoparticles have been reported to have new characteristics of transport and uptake and exhibit higher absorption efficiencies **(Liao *et al.*, 2010)**.

They suggested that the superior performance of nanoparticles may be attributed to their smaller particle size and larger surface area, increased mucosal permeability and improved intestinal absorption and tissue deposition.

4.1.4. Feed consumption of turkey toms:

Feed consumption data for the experimental groups of turkey toms fed different dietary forms of Se or Zn are presented in Table 7 (Exp. 2).

Results presented in Table 7 indicated that dietary inorganic, organic or nano forms of zinc or selenium of turkey toms caused a significant reduction ($P \leq 0.05$) in feed consumption during the whole experimental period (32 to 44 weeks old) and during the periods 36-44 weeks of age as compared to that of the control group.

Also, toms fed the diets supplemented with organic and nano forms of zinc or with inorganic, organic and nano forms of selenium exhibited significantly

Table (7): Effects of dietary inorganic, organic and nano forms of zinc or selenium on feed intake (g) of turkey toms from 32-44 weeks old (Exp. 2)

Dietary treatments	Feed intake (g)			
	32 - 36 Weeks old	36 - 40 Weeks old	40 - 44 Weeks old	32 - 44 Weeks old
Control (Basal diet)	281.00 [a]	284.16 [a]	287.50 [a]	284.22 [a]
Basal diet + Inorganic Zn	278.33 [ab]	281.00 [b]	283.66 [b]	281.16 [b]
Basal diet + Organic Zn	263.33 [d]	265.33 [d]	266.66 [d]	265.11 [d]
Basal diet + Nano Zn	262.33 [de]	264.66 [de]	266.33 [d]	264.44 [de]
Basal diet + Inorganic Se	277. 16 [bc]	280.50 [b]	282.66 [bc]	280.11 [b]
Basal diet + Organic Se	275.16 [c]	277.33 [c]	280.50 [c]	277.66 [c]
Basal diet + Nano Se	260.50 [e]	262.66 [e]	264.83 [d]	262.66 [e]
SEM	0.77	0.87	0.92	0.80
Significance	*	*	*	*

a-e: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

($P \leq 0.05$) lower feed consumption during the period of 32-36 weeks of age as compared to that of the control group.

The present results in Table 7 indicated that the least values of feed consumption was achieved by turkey toms fed the diets supplemented with nano form of selenium or zinc, followed by those of toms fed the diets supplemented with organic form of zinc or selenium, and then those of toms fed the diets supplemented with inorganic forms of selenium or zinc, respectively compared with the control group during the entire experimental period from 32-44 weeks of age. (Table 7).

The present results disagree with the findings of **Ahmadi *et al.* (2013)** who showed that dietary addition of zinc oxide nanoparticles at levels of 60 and 90 mg/kg led to a significant increase in feed intake of broiler chicks compared with those of the control group.

In harmony with the present results, **Namra *et al.* (2008)** showed that dietary addition of zinc methionine as organic source significantly reduced feed intake of Japanese quails compared with the control group.

Similarly, **Osman and Ragab (2007)** found that broiler chicks fed the diet supplemented with 0.3g Zn methionine/kg diet consumed significantly less feed than the control group.

On the other hand, **Cai *et al.* (2012)** indicated that feed intake of broilers was not affected by dietary supplementation of nano-Se. **Sunder *et al.* (2008)** observed that supplemental dietary zinc did not show any significant effect on feed intake of broiler chicks.

4.1.5. Feed conversion ratio of turkey toms:

The effects of dietary supplementation with inorganic, organic and nano selenium or zinc on feed conversion ratio of turkey toms during the entire experimental period (32-44 weeks old) are presented in Table 8 (Experiment 2).

The present results showed that added dietary inorganic, organic and nano forms of Zn or Se did not significantly affect feed conversion ratio of toms during the whole the experimental period (32-44 weeks of age) and during all age intervals examined (Table 8).

These results agree with those of **Abdallah *et al.* (2014)** who reported that supplemental dietary organic Zn had no significant effect on feed conversion of Gimmizah laying hens compared with those supplemented with inorganic Zn from 24-40 weeks old. Also, Ludeen (2001) did not find any effect of organic or inorganic trace minerals (Zn and Mn) on feed conversion ratio of 40 to 60 week-old layers.

Similarly, **Payne and Southern (2005)** found that feed conversion of broilers was not affected by addition of Se source (inorganic Se or organic Se) or level (0 or 0.30 mg/kg diet). Additionally, **Rama Rao *et al.* (2013)** indicated that feed conversion ratio was not affected by organic Se addition to broiler diets. The present results agree also with those of **Cai *et al.* (2012)**, who indicated that dietary supplementation with nano-Se significantly affect feed conversion ratio of broilers. Conversely, **Ferket *et al.* (1992)** showed that the dietary addition of Zn-Met of turkey toms resulted in improved feed conversion ratio.

Table (8) Effects of dietary inorganic, organic and nano forms of zinc or selenium on feed conversion ratio (g feed/g gain) from 32 to 44 weeks old of turkey toms (Exp. 2)

Dietary treatments	feed conversion ratio (g feed/g gain)			
	32 - 36 Weeks old	36 - 40 Weeks old	40 - 44 Weeks old	32 - 44 Weeks old
Control (Basal diet)	4.66	4.37	4.64	4.47
Basal diet + Inorganic Zn	4.69	4.57	4.87	4.54
Basal diet + Organic Zn	4.18	3.87	4.30	3.99
Basal diet + Nano Zn	4.13	3.90	4.22	4.01
Basal diet + Inorganic Se	4.23	4.29	4.75	4.33
Basal diet + Organic Se	4.96	4.08	4.63	4.35
Basal diet + Nano Se	4.11	3.79	4.27	4.09
SEM	0.55	0.44	0.24	0.24
Significance	NS	NS	NS	NS

NS: Not significant SEM: Standard error of the means

4.2. Egg production rate of turkey hens:

Data presented in Table 9 show the effects of different dietary treatments on egg production rate during the experimental periods from 32-44 weeks of age.

The results indicated that dietary supplementation with organic and nano forms of zinc or with inorganic, organic and nano forms of selenium to diets of laying turkey hens significantly ($P \leq 0.05$) increased hen-day egg production rate compared with the control group during the whole experimental period from 32-44 weeks of age. The results showed that the highest mean of hen-day egg production rate ($P \leq 0.05$) was achieved by hens fed the organic Se-supplemented diet, followed by those of hens fed the diets supplemented with nano Se, nano Zn, inorganic Se and organic Zn during the whole experimental period from 32-44 weeks of age, respectively.

The results showed that addition of nano Se, organic Se, nano Zn and inorganic Se to diets of laying turkey hens produced significant improvement in hen-day egg production rate compared with that of the control group from 32-36 weeks of age.

The present results showed that supplementation of organic Se, nano Se and nano Zn to diets of laying turkey hens positively affected hen-day egg production rate compared with that of the control group during age intervals of 36-40 and 40-44 weeks of age (Table 9).

The present results agree with those of **Radwan *et al.* (2015)**, who showed that nano-Se supplementation of layer diets significantly increased egg production percentage of Silver Montazah laying hens compared with inorganic Se (sodium selenite) from 32 to 45 weeks of age. Similarly, **Gjorgovska *et al.* (2012)** found

Table (9) Effects of dietary inorganic, organic and nano forms of zinc or selenium on egg production rate of turkey hens from 32 to 44 weeks old

Dietary treatments	Egg Production (%)			
	32 - 36 Weeks old	36 - 40 Weeks old	40 - 44 Weeks old	32 - 44 Weeks old
Control (Basal diet)	49.15 [d]	64.42 [b]	52.14 [d]	55.24 [f]
Basal diet + Inorganic Zn	49.65 [d]	64.58 [b]	52.77 [d]	55.66 [ef]
Basal diet + Organic Zn	49.88 [cd]	65.00 [b]	53.13 [d]	56.00 [de]
Basal diet + Nano Zn	53.50 [b]	76.77 [a]	56.08 [c]	62.12 [c]
Basal diet + Inorganic Se	50.57 [c]	65.49 [b]	52.91 [d]	56.33 [d]
Basal diet + Organic Se	64.12 [a]	76.80 [a]	69.34 [a]	70.09 [a]
Basal diet + Nano Se	64.71 [a]	76.43 [a]	66.16 [b]	69.10 [b]
SEM	0.25	0.35	0.37	0.17
Significance	*	*	*	*

a-f: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

that supplemental dietary organic selenium (Se yeast) in layer diets increased egg production percentage in aged laying hens. Also, **Hanafy *et al.* (2009)** who found that egg production percentage was significantly increased for Bandarah laying hens fed organic Se-supplemented diet at 56 and 60 weeks of age compared with the control group.

Renema (2004) found that the addition of organic selenium to the diet of layers improved egg production compared to inorganic Se and the control group during the late lay period (49-58 weeks old). **Stanley *et al.* (2004)** showed that hens fed diet supplemented with organic Se achieved significantly higher hen-day egg production compared with the control group. Similarly, **Bahakaim *et al*. (2014)**, who showed that supplementation organic zinc as zinc methionine of laying hens diet significantly increased egg production of Golden Montazah laying hens compared with those fed inorganic Zn from 24 to 36 weeks old.

Flinchum, (1990), who found that dietary supplementation of Zn-methionine improved performance of laying hens. Also, **Stanley *et al.* (2012)**, reported that dietary supplementation with organic zinc (20 ppm plus 0.3 mg Se/kg diet) significantly increased rate of egg production of White Leghorn laying hens from 78 to 83 weeks of age.

On the other hand, the present results disagree with those of **Chantiratikul *et al.* (2008)**, who found that egg production of Brown laying hens was not affected by Se sources and levels from 71 to 77 weeks of age. Similar results were obtained by **Cruz and Fernandez (2011)**, who observed no differences in egg production percentage due to added dietary Se, in Japanese quails from 60 -172 days of age.

Attia *et al.* (2010) indicated that egg production percentage of Gimmizah laying hens was not affected by Se source.

The observed improvement in egg production of turkey hens in this study may be attributed to Se supplementation. Se is an important auxiliary factor for the key enzyme of 5-deiodinase. The iodothyronine deiodinase enzymes convert the hormone thyroxin (T4) to its active form triiodothyronine (T3). Triiodothyronine is a main hormone that regulates growth by controlling the body's energy and protein anabolism **(Surai, 2000)**. In addition, selenium is an integral part of GSH-Px, which eliminates some of free radicals from metabolic activity. The increase in free radicals has been correlated with reductions in productive performance **(Underwood and Suttle, 1999).**

4.3. Egg weight of turkey hens:

Data presented in Table 10 show the effect of the different dietary treatments on egg weight of turkey hens during the whole experimental period (from 32-44 weeks of age). The results showed that hens fed the diets supplemented with inorganic, organic or nano Se or with organic or nano Zn produced significantly heavier eggs ($P \leq 0.05$) compared with those of the control group during the entire experimental period from 32-44 weeks of age (Table 10).

The present results are in accordance with the findings of **Renema (2004)**, who found that the addition of organic selenium to the diet of layers improved egg weight compared to non-supplemented group during the late lay period (49-58 weeks old). Also, **Stanley *et al.* (2004)** showed that hens fed diet supplemented

Table (10) Effects of dietary inorganic, organic and nano forms of zinc or selenium on egg weight of turkey hens from 32 to 44 weeks old

Dietary treatments	Egg weight (g)			
	32 - 36 Weeks old	36 - 40 Weeks old	40 - 44 Weeks old	32 - 44 Weeks old
Control (Basal diet)	72.29 [b]	74.19 [cd]	76.24 [d]	74.24 [d]
Basal diet + Inorganic Zn	73.32 [b]	73.14 [d]	76.39 [d]	74.28 [d]
Basal diet + Organic Zn	73.22 [b]	75.10 [bc]	77.23 [c]	75.18 [c]
Basal diet + Nano Zn	72.92 [b]	76.17 [b]	77.29 [c]	75.46 [c]
Basal diet + Inorganic Se	79.41 [a]	82.85 [a]	83.37 [a]	81.88 [a]
Basal diet + Organic Se	77.99 [a]	81.58 [a]	82.52 [b]	80.70 [b]
Basal diet + Nano Se	78.95 [a]	81.97 [a]	83.17 [ab]	81.36 [ab]
SEM	0.50	0.48	0.23	0.25
Significance	*	*	*	*

a-d: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).

*: significant at $P \leq 0.05$ SEM: Standard error of the means

with organic Se displayed significantly higher egg weight compared with the control group. Similarly, **Attia *et al.* (2010)** indicated that the addition of Se significantly increased egg weight compared with hens fed the control diet.

On the other hand, the present results disagree with those of **Radwan *et al.* (2015)**, who showed that different levels of Se (sodium selenite or nano-Se) had no effect on egg weight of Silver Montazah laying hens from 32 to 45 weeks old. In addition, **Chantiratikul *et al.* (2008)** found that egg weight was not affected by Se sources of Brown laying hens from 71 to 77 weeks of age. **Sahin *et al.* (2002)** found that supplementation of inorganic Zn increased egg weight of laying hens.

These results disagree with those of **Abdallah *et al.* (2014)**, who reported that hens fed diets supplemented with organic zinc produced egg of similar weights to those fed inorganic diet of Gimmizah layers from 24 to 40 weeks of age.

4.4. Feed conversion ratio of turkey hens:

The effects of dietary inorganic, organic and nano forms of zinc or selenium on feed conversion ratio (g feed/g egg) of turkey hens during the whole experimental period from 32-44 weeks of age are presented in Table 11 (Experiment 1). The present results showed that dietary supplementation of inorganic, organic and nano forms of zinc or selenium to turkey hens significantly improved feed conversion ratio ($P \leq 0.05$) compared with the control group during the whole the experimental period (from 32-44 weeks of age). The same response was observed for all age intervals examined but feed conversion ratio of turkey hens fed inorganic Zn-

Table (11) Effects of dietary inorganic, organic and nano forms of zinc or selenium on feed conversion ratio (g feed / g egg) of turkey hens from 32 to 44 weeks old (Exp. 1)

Dietary treatments	Feed conversion ratio (g feed / g egg)			
	32 - 36 Weeks old	36 - 40 Weeks old	40 - 44 Weeks old	32 - 44 Weeks old
Control (Basal diet)	3.14 [a]	2.71 [a]	3.71 [a]	3.16 [a]
Basal diet + Inorganic Zn	3.02 [b]	2.68 [a]	3.60 [b]	3.08 [b]
Basal diet + Organic Zn	2.84 [c]	2.43 [b]	3.29 [c]	2.83 [c]
Basal diet + Nano Zn	2.67 [d]	1.96 [d]	3.07 [d]	2.50 [e]
Basal diet + Inorganic Se	2.69 [d]	2.32 [c]	3.26 [c]	2.73 [d]
Basal diet + Organic Se	2.13 [e]	1.92 [d]	2.36 [e]	2.13 [f]
Basal diet + Nano Se	2.03 [f]	1.83 [e]	2.43 [e]	2.09 [f]
SEM	0.024	0.022	0.025	0.015
Significance	*	*	*	*

a-f: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

supplemented diet during the period of 36-40 weeks old was not significantly different from that of the control group (Table 11).

As presented in Table 11, the best means of feed conversion ratio for the whole experimental period were attained by hens fed the diets supplemented with nano and organic selenium respectively, compared with that of the control hens.

These results agree with those of **Namra *et al.* (2009)**, who showed that the dietary addition of 50 mg zinc-methionine/kg diet of Japanese quail hens resulted in the best feed conversion ratio compared with the control diet. **Osman and Ragab (2007)** found that supplemental zinc-methionine at the level 0.3g Zn Meth./kg diet of broiler chicks led to the best feed conversion ratio during the period from 36 to 42 days of age.

Similarly, **Bahakaim *et al.* (2014)** showed that supplemental dietary organic zinc as Zn methionine (100 mg/kg diet) of Golden Montazah laying hens diet caused the best feed conversion from 24 to 36 weeks old. **Kucuk *et al.* (2003)** indicated that supplemental dietary zinc (30 mg /kg diet) as zinc sulphate to the basal diet improved feed conversion of broiler chicks.

The present results agree also with those of **Zhou and Wang (2011)**, who indicated that feed conversion of Guangxi Yellow chickens was improved by added dietary nano-Sefrom one-90 days old. In harmony also with the present study **Radwan *et al.* (2015** showed that dietary supplementation of nano-Se to layer diets improved feed conversion ratio of Silver Montazah laying hens from 32 to 45 weeks of age.

Similar results were also obtained by **Attia *et al.* (2010)**, who found that dietary supplementation of Se improved feed conversion ratio of Gimmizah laying hens compared with hens fed the control diet. In addition, **Wang (2009)** found that feed conversion of broilers was improved by supplementation of nano or inorganic Se to their diets.

The observed improvement feed conversion ratio by organic Se in this experiment, is in agreement with the result of **Choct *et al.* (2004).** The reason such a positive effect of Se may be related to that organic selenium could uptake via the enterocyles into blood by active transport. The Selenomethionine from selenised yeast has been proven to be well absorbed and was incorporated into body proteins in place of methionine. The extent of selenomethionine incorporation into proteins depends on the dosage and methionine status **(Butler *et al.*, 1989**).

4.5. Egg quality and egg components of turkey hens:

Data on the effects of dietary inorganic, organic and nano form of zinc or selenium on egg components and certain parameters of egg quality of 38-week-old turkey hens are shown in Table 12. The present results showed that there were no significant differences among dietary treatments with respect to relative weights of egg albumen, egg yolk, egg shell, egg shape index, egg yolk index or yolk color score (Table 12).

The current results indicated that turkey hens fed diets supplemented with organic and nano Se produced eggs with better albumen quality as measured by Haugh

Table (12) Effects of dietary inorganic, organic and nano forms of zinc or selenium on egg components and egg quality of 38 weeks old turkey hens

Dietary treatments	Egg components (%)			Egg quality parameters				
	Egg albumen %	Egg yolk %	Egg shell %	Egg shape index %	Egg yolk index %	Haugh units	Shell thickness (mm)	Yolk Color score
Control (Basal diet)	52.69	30.92	16.37	74.04	53.09	89.62 [c]	0.377 [b]	7.50
Basal diet + Inorganic Zn	52.54	30.85	16.58	73.69	52.55	90.40 [c]	0.383 [b]	7.60
Basal diet + Organic Zn	52.89	30.18	16.91	76.66	53.82	91.11 [abc]	0.385 [b]	7.30
Basal diet + Nano Zn	53.18	30.25	16.54	77.15	52.95	91.02 [abc]	0.389 [b]	7.40
Basal diet + Inorganic Se	53.38	30.14	16.45	74.76	52.82	92.92 [abc]	0.377 [b]	7.40
Basal diet + Organic Se	52.25	29.42	18.30	78.34	52.94	96.49 [a]	0.419 [a]	7.50
Basal diet + Nano Se	52.05	30.16	17.75	78.02	52.23	95.58 [ab]	0.419 [a]	7.40
SEM	0.94	1.16	1.76	1.46	1.27	1.74	0.007	0.24
Significance	NS	NS	NS	NS	NS	*	*	NS

a-c: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
NS: Not significant *: significant at $P \leq 0.05$ SEM: Standard error of the means

units. No significant differences were observed in Haugh units among the other experimental groups of turkey hens. Supplementation of organic and nano Se to the diets of turkey hens led to a significant increase in ($P \leq 0.05$) egg shell thickness as compared to that of the control turkey hens. No significant differences were observed in egg shell thickness among the other experimental groups of turkey hens.

The current results agree with those of **Abdallah *et al.* (2014)**, who indicated that supplemental dietary organic Se positively affected egg shell thickness of Gimmizah laying hens as compared with those given the inorganic form of Se from 24 to 40 weeks old.

Idowu *et al.* (2011), who found that egg quality parameters were not significantly influenced by Zn sources but Haugh unit values of laying hens fed Zn-proteinate, were significantly better than those fed $ZnCo_3$. The present results agree also with those of **Hanafy *et al.* (2009)**, who reported that egg quality parameters (Haugh unit, yolk index and shell thickness) Bandarah laying hens were significantly increased with supplemental dietary organic Se than control group from 50 to 60 weeks of age.

Paton *et al.* (2000) reported no significant differences in egg breaking strength from hens fed added dietary sodium selenite or selenized yeast in two experiments but observed higher egg breaking strength for hens fed diet supplemented with selenized yeast relative to sodium selenite in athird experiment. **Gajcevic *et al.* (2009)** found that dietary supplementation of organic selenium positively affect albumen quality of eggs as measured by the Haugh units compared with eggs produced of hens fed the control diet.

In line also with the present results, **Aliarabi *et al.* (2007)** observed no significant differences in weights of egg components or egg shell thickness in response to dietary supplementation of organic zinc but Haugh unit index was higher in the groups received organic zinc compared with that of the control hens.

Similarly, **Cruz and Fernandez (2011)** found no significant differences in egg weight, Haugh unit, yolk index, albumen index, egg shell thickness or egg shell weight of Japanese Quails in response to dietary supplementation of Se from 60-172 days old.

Gjorgovska *et al.* (2012) showed that percentage of egg components were not affected by adding Se yeast at 0.08 or 0.16 mg/kg to a basal diet containing 0.30 mg/kg of Se from selenium selenite.

On the other hand, **Bahakaim *et al.* (2014)** reported that egg components, yolk index, albumen index and Haugh unit were not affected by supplemental dietary sources of zinc to Golden Montazah laying hens from 24-36 weeks of age. They also found that shell thickness significantly improved by addition of organic Zn in diet compared with those fed the inorganic Zn-diet. Similar results were obtained by **Attia *et al.* (2010),** who found that dietary supplementation of organic or inorganic selenium had no significant effect on most traits of egg quality. Also, **Chantiratikul *et al.* (2008)** found that Haugh units and egg shell thickness were not changed by added source or level in diets of Brown laying hens from 71 to 77 weeks of age.

In line with the present results, **Rutz *et al.* (2005)** reported an improvement in Haugh units with organic selenium by indirect mode of action of organic selenium which enhanced the function of the selenium-dependent GSH-Px antioxidant system.

4.6. Blood biochemical and hematological parameters of 44- week-old turkey hens:

4.7. Serum immunity index, Glutathione peroxidase activity and estrogen concentration of 44- week-old turkey hens:

Data on the effects of dietary inorganic, organic and nano forms of zinc or selenium on blood biochemical, hematological, immunity index, Glutathione peroxidase activity and estrogen concentration of 44–week–old turkey hens are shown in Tables 13 and 14. The results illustrated in table 13 revealed that no significant differences were observed in serum glucose levels of turkey hens fed inorganic Zn vs. organic Se, but there were no significant differences in serum glucose levels among the other experimental groups.

Serum levels of total protein and concentrations of blood haemoglobin for hens fed diets supplemented with inorganic, organic and nano forms of zinc or selenium were significantly higher ($P \leq 0.05$) than those of the controls.

Serum level of albumin for hens fed the diet supplemented with organic Zn was significantly higher ($P \leq 0.05$) than those of the controls. No significant differences

Table (13) Effects of dietary inorganic, organic and nano forms of zinc or selenium on blood biochemical and hematological parameters of turkey hens at 44 weeks of age (Exp. 1)

Dietary treatments	Glucose (mg/dl)	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Total lipids (g/dl)	Cholesterol (mg/dl)	Hemoglobin (g/dl)	Haematocrit (%)
Control (Basal diet)	354.66 ^{abc}	4.53 ^{d}	2.74 ^{b}	1.78 ^{b}	3.60 ^{a}	295.00 ^{a}	9.28 ^{d}	35.60 ^{b}
Basal diet + Inorganic Zn	348.33 ^{c}	5.26 ^{bc}	3.18 ^{ab}	2.08 ^{b}	2.81 ^{b}	247.33 ^{b}	10.03 ^{c}	34.18 ^{b}
Basal diet + Organic Zn	358.66 ^{abc}	5.71 ^{ab}	3.50 ^{a}	2.21 ^{b}	1.87 ^{d}	185.00 ^{cd}	11.30 ^{b}	34.20 ^{b}
Basal diet + Nano Zn	364.33 ^{ab}	5.88 ^{a}	2.90 ^{ab}	2.98 ^{a}	1.55 ^{e}	177.33 ^{cd}	11.47 ^{b}	34.90 ^{b}
Basal diet + Inorganic Se	352.00 ^{bc}	5.03 ^{c}	2.66 ^{b}	2.37 ^{b}	2.53 ^{c}	239.66 ^{b}	10.13 ^{c}	37.68 ^{a}
Basal diet + Organic Se	366.33 ^{a}	5.48 ^{abc}	3.21 ^{ab}	2.27 ^{b}	1.73 ^{de}	187.66 ^{c}	11.59 ^{ab}	34.69 ^{b}
Basal diet + Nano Se	364.33 ^{ab}	5.85 ^{a}	2.86 ^{ab}	2.98 ^{a}	1.52 ^{e}	176.33 ^{d}	11.85 ^{a}	38.93 ^{a}
SEM	4.17	0.14	0.21	0.18	0.08	3.46	0.11	0.48
Significance	*	*	*	*	*	*	*	*

a-e: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

Table (14) Effects of dietary inorganic, organic and nano forms of zinc or selenium on immunity index, serum glutathione peroxidase activity and plasma estrogen level of turkey hens at 44 weeks of age (Exp. 1)

Dietary treatments	NDV Antibody Titers	GSH Px U/ml	Estrogen pg/ml
Control (Basal diet)	**7.05 ^{c}**	**16.02 ^{f}**	**345.25 ^{c}**
Basal diet + Inorganic Zn	**6.52 ^{c}**	**16.69 ^{f}**	**338.10 ^{c}**
Basal diet + Organic Zn	**9.80 ^{b}**	**22.74 ^{d}**	**369.13 ^{b}**
Basal diet + Nano Zn	**11.11 ^{a}**	**28.65 ^{c}**	**407.37 ^{a}**
Basal diet + Inorganic Se	**7.23 ^{c}**	**19.39 ^{e}**	**351.62 ^{c}**
Basal diet + Organic Se	**9.74 ^{b}**	**37.32 ^{b}**	**371.83 ^{b}**
Basal diet + Nano Se	**11.28 ^{a}**	**39.74 ^{a}**	**421.76 ^{a}**
SEM	**0.33**	**0.70**	**5.57**
Significance	*	*	*

a-f: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means
NDV: Newcastle disease vaccine GSH-Px: Glutathione peroxidase

were observed in serum albumin levels among the remaining experimental groups of turkey hens. Serum globulin concentrations of hens fed the diets supplemented with nano Zn and nano Se were significantly higher ($P \leq 0.05$) than those of the control group, however, other experimental groups of hens exhibited insignificantly different levels of globulin. Dietary addition of inorganic, organic and nano forms of zinc or selenium for turkey hens caused significant reductions ($P \leq 0.05$) in serum levels of total lipids and cholesterol as compared to those of the controls. Dietary supplementation with inorganic and nano Se resulted in significant increases ($P \leq 0.05$) in blood haematocrite values (%) of turkey hens compared with that of the controls, but other experimental groups were comparable to that of the control group.

The results presented in Table 14 showed that dietary organic and nano forms of zinc or selenium of turkey hens caused significant increases ($P \leq 0.05$) in serum antibody titres against Newcastle disease vaccine (NDV) as compared to that of the controls; other experimental groups of hens exhibited insignificantly comparable levels of serum antibody titres against NDV to that of the controls. So, these results indicated that addition of organic and nano form of zinc and selenium as adjuvant to Newcastle vaccine played an important role to improve the level of immunity, as measured by antibodies titers in serum for hens. In addition, there were significant increases ($P \leq 0.05$) in GSH-Px activity due to dietary supplementation with organic and nano forms of Zn or with inorganic, organic and nano forms of Se of turkey hens compared with that of the controls.

The results showed that dietary supplementation with organic and nano forms of zinc or selenium of turkey hens caused significant increases (P≤0.05) in the plasma estrogen concentration as compared to that of the controls; other experimental groups of hens exhibited comparable levels of plasma estrogen to that of the control turkey hens.

The present results agree with those of **Hassan *et al.* (2003)**, who found that addition of Zn plus methionine to the basal diet of Mandarah laying hens significantly increased serum total protein and albumin as compared to the control group. Similarly, **Bahakaim *et al.* (2014)** indicated that supplemental dietary zinc methionine (100 mg/kg diet) to the basal diet of Golden Montazah laying hens from 24-36 weeks of age significantly increased total protein, albumin and globulin, with the inorganic source of Zn. In addition, **El-Sheikh *et al.* (2010)** showed that supplemental dietary organic selenium at 0.2 or 0.3 ppm significantly increased the blood level of hemoglobin and serum concentrations of total protein, globulin and glutathione peroxidase compared with the control group.

These results agree with those reported by **Radwan *et al.* (2015)** found that supplemental dietary nano-Se significantly decreased blood plasma levels of cholesterol and total lipids of silver Montazah laying hens compared with the control group. The present result are also in line with the findings of **Attia *et al.* (2010)** observed that blood plasma levels of cholesterol were significantly decreased when inorganic or organic selenium were added to the diet of laying hens compared with that of hens fed the control diet.

Also, **Sahoo *et al.* (2014)** showed that dietary organic (15 ppm) and nano zinc (0.6 ppm) supplementation to the basal diet of broiler birds significantly decreased serum cholesterol concentration as compared to control group.

The present results also agree with those of **Kidd *et al.* (1996)**, who reviewed that addition of zinc-methionine to the diet of laying hens may improve the immune system and augment disease resistance However, zinc-methionine supplementation has beneficial effects on turkey macrophage function and humeral immunity **(Kidd *et al.* 1996)**.

These results agree with **Amen and Al-Daraji (2011b)**, who reported that dietary supplementation with zinc (50, 75 and 100 mg Zn/kg) significantly increased blood plasma concentrations of estrogen hormone during 54 and 66 weeks of age as compared with the control group. These results agree with the findings of **Radwan *et al.* (2015)** that blood glutathione peroxidase activity significantly increased by supplemental Nano-Se in the diets than inorganic Se (sodium selenite) of Silver Montazah laying hens. Additionally, **Jing *et al.* (2015)** reported that activity of plasma GSH-Px significantly increased in response to dietary addition of organic Se (0.3 mg/kg diet) of brown laying hens compared with those supplemented with sodium selenite.

Also, Wang and Xu (2008) reported that supplemental dietary organic Se (0.2 mg/kg diet) significantly increased plasma GSH-Px activity of broiler chickens compared with the group of chickens. Moreover, **Yang *et al.* (2012)** reported that activity of plasma GSH-Px of broilers fed organic selenium diet was higher than that of the control chicks. Similarly results were obtained by **Cai *et al.* (2012)**, who found that glutathione peroxidase activity was significantly increased when laying hens fed diets supplemented with 0.3, 0.5, 1.0, and 2.0 mg/kg of nano-selenium compared with the control group.

These results might be explained by their metabolic route. Selenomethionine is converted into selenocysteine that can be degraded further in liver to serine and selenide. Sodium selenite is converted initially to selenoglutathione trisulfide and then degraded in liver to from selenide.The selenide is finally used for selenoprotein synthesis, such as GSH-Px **(Schrauzer, 2000)**

The significant amelioration of plasma estrogen concentration in birds fed diets supplemented with zinc may be attributed to the zinc role on the metabolism of proteins, amino acids, nucleonic acids, fat carbohydrates and vitamins as well as the metabolism of the other trace elements but also relates to the activity of prostaglandin, gonad stimulating hormone and it is necessary to the physiological function. Estrogen stimulates both vitellogenesis through its affect on liver and food intake **(Al-Daraji, 2007).**

4.8. Blood biochemical and hematological parameters of 44- week-old turkey toms:

4.9. Serum immunity index, Glutathione peroxidase activity and testosterone concentration of 44- week-old turkey toms:

Table (15) Effects of dietary inorganic, organic and nano forms of zinc or selenium on blood biochemical and hematological parameters of turkey toms at 44 weeks of age (Exp. 2)

Dietary treatments	Glucose (mg/dl)	Total protein (g/dl)	Albumin (g/dl)	Globulin (g/dl)	Total lipids (g/dl)	Cholesterol (mg/dl)	Hemoglobin (g/dl)	Haematocrit (%)
Control (Basal diet)	343.66	4.21^{e}	2.46^{b}	1.75^{d}	1.94^{a}	295.00^{a}	9.21^{c}	33.32^{c}
Basal diet + Inorganic Zn	344.65	5.73^{b}	3.55^{a}	2.18^{bcd}	1.56^{b}	252.33^{b}	9.89^{b}	34.18^{bc}
Basal diet + Organic Zn	346.33	4.76^{cd}	2.48^{b}	2.28^{abc}	0.76^{c}	187.35^{c}	11.53^{a}	34.58^{b}
Basal diet + Nano Zn	349.67	5.85^{ab}	3.14^{a}	2.70^{a}	0.68^{cd}	180.34^{c}	11.54^{a}	35.05^{b}
Basal diet + Inorganic Se	341.66	5.08^{c}	3.11^{a}	1.96^{cd}	1.48^{b}	243.32^{b}	10.08^{b}	38.58^{a}
Basal diet + Organic Se	351.65	4.65^{d}	2.28^{b}	2.36^{abc}	0.74^{cd}	187.66^{c}	11.66^{a}	34.71^{b}
Basal diet + Nano Se	349.67	6.11^{a}	3.62^{a}	2.49^{ab}	0.64^{d}	182.35^{c}	11.91^{a}	38.77^{a}
SEM	5.31	0.11	0.18	0.13	0.03	3.82	0.20	0.31
Significance	NS	*	*	*	*	*	*	*

a-e : Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
NS: Not significant *: significant at $P \leq 0.05$ SEM: Standard error of the means

Table (16) Effects of dietary inorganic, organic and nano forms of zinc or selenium on immunity index, serum glutathione peroxidase activity and plasma Testosterone level of turkey toms at 44 weeks of age (Exp. 2)

Dietary treatments	NDV Antibody Titers	GSH Px U/ml	Testosterone ng/ml
Control (Basal diet)	6.66 ^{d}	17.38 ^{e}	1.93 ^{e}
Basal diet + Inorganic Zn	6.87 ^{d}	16.78 ^{e}	2.20 ^{d}
Basal diet + Organic Zn	9.21 ^{c}	24.36 ^{d}	3.11 ^{bc}
Basal diet + Nano Zn	10.65 ^{ab}	28.35 ^{c}	2.98 ^{c}
Basal diet + Inorganic Se	7.16 ^{d}	16.92 ^{e}	2.23 ^{d}
Basal diet + Organic Se	10.18 ^{b}	37.60 ^{b}	3.26 ^{ab}
Basal diet + Nano Se	11.35 ^{a}	40.58 ^{a}	3.34 ^{a}
SEM	0.30	0.49	0.05
Significance	*	*	*

a-e: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means
NDV: Newcastle disease vaccine GSH-Px: Glutathione peroxidase

Data on the effects of dietary addition of inorganic, organic and nano forms of zinc or selenium on blood biochemical parameters are given in table 15, while those of immunity index, activity of glutathione peroxidase and testosterone levels of 44–week–old turkey toms are shown in Tables 16.

As given in Table 15, no significant differences were observed in serum glucose levels among the different experimental groups of turkey toms due to dietary treatments.

Serum levels of total protein and blood hemoglobin for toms fed diets supplemented with inorganic, organic and nano forms of zinc or selenium were significantly higher ($P \leq 0.05$) than those of the controls. Serum levels of albumin for toms fed diets supplemented with inorganic and nano forms of zinc or selenium were significantly higher ($P \leq 0.05$) than those of the controls. Dietary addition of organic and nano forms of zinc or selenium for toms caused significant elevations ($P \leq 0.05$) in serum globulin levels as compared to that of the controls. Dietary addition of inorganic, organic and nano forms of zinc or selenium for toms caused significant reductions ($P \leq 0.05$) in serum levels of total lipids and cholesterol as compared to those of the controls.

Dietary supplementation with organic, nano forms of zinc or with inorganic, organic and nano forms of selenium resulted in significant increases ($P \leq 0.05$) in blood haematocrit values (%) of turkey toms compared with that of the controls.

The results presented in Table 16 showed that dietary organic and nano forms of zinc or selenium of turkey toms caused significant increases ($P \leq 0.05$) in serum antibody titres against Newcastle disease vaccine as compared to that of the controls. The results showed also significantly higher means of serum ($P \leq 0.05$) of GSH-Px activity by supplementation of organic and nano forms of Zn or Se of turkey toms compared to that of the controls.

The results revealed also that the plasma testosterone concentrations of turkey toms fed different forms of Zn or Se were significantly higher ($p<0.05$) compared with the control group.

The mechanism by which added dietary Zn or Se reduce serum cholesterol concentration is not clearly understood yet. Theoretically, blood cholesterol may be decreased due to the inhibition of its bio-synthetic pathway or increasing its catabolism and excretion via the enter-hepatic circulation.

The present results agree with those of **Idowu *et al.* (2011**), who found that serum glucose concentrations were not affected by supplementation of Zn sources to laying hens.

In agreement with the present results, **Parák and Straková (2011)**, who reported that dietary supplementation of organic zinc (100 mg /kg) significantly decreased levels of plasma total cholesterol of breeding cocks as compared to given the inorganic zinc and the control group. **Poirirer *et al.* (2002)** found that blood plasma levels of cholesterol low density lipoprotein cholesterol plus very low density lipoprotein cholesterol were significantly decreased when Se was added in the diet of hamsters.

In line with the present results, **Selim *et al.* (2015)** reported that packed cell volume and blood level of hemoglobin of broiler chicks were significantly increased by dietary supplementation with organic or nano forms of Se as compared to the addition inorganic selenium. The present results also agree with those of **Kidd *et al.* (1994)**, who found that supplemental dietary organic zinc improve immunity in young turkeys; they found that E.coli clearance from blood was significantly improved in poults receiving Zn-methionine.

Kidd *et al.* (1992) showed that zinc-methionine supplementation of diets fed to broiler breeder increased cellular immunity of progeny. **Hegazy and Adachi (2000)** indicated that dietary supplementation with Se of chickens increased antibody immune response. The present results also agree with **Amen and Al-Daraji (2011b)**, who showed that dietary supplementation with zinc (50, 75 and 100 mg Zn/kg) significantly increased blood plasma concentrations of testosterone hormone at 54, 58 and 66 weeks of age of Cobb 500 broiler breeder males**.**

The present results also agree with **Rama Rao *et al.* (2013)** showed that activity of glutathione peroxidase in plasma increased linearly with dietary addition of Se to broiler chickens. Similar results were also obtained by **Wang and Xu (2008**), who indicated that dietary Se-yeast supplementation significantly increased GSH-Px activity in plasma of broiler chickens. Additionally, **Gajcevic *et al.* (2009)** found that GSH- Px activity in blood increased by dietary addition of organic Se (0.4 ppm) compared with laying hens given lower level of organic Se (0.2 ppm).

4.10. Egg fertility and hatchability of turkey hens:

As presented in Table 17), significantly higher ($P \leq 0.05$) percentages of egg fertility, hatchability of total eggs and hatchability of fertile eggs were achieved by

Table (17) Effects of dietary inorganic, organic and nano forms of zinc or selenium on egg fertility and hatchability of turkey hens from 32-44 weeks of age. (Exp. 1)

Dietary treatments	Egg Fertility (%)	Hatchability of total eggs (%)	Hatchability of fertile eggs (%)
Control (Basal diet)	93.22 [d]	88.38 [c]	94.78 [b]
Basal diet + Inorganic Zn	95.56 [bc]	92.09 [b]	96.36 [a]
Basal diet + Organic Zn	97.48 [a]	94.73 [a]	97.17 [a]
Basal diet + Nano Zn	97.76 [a]	94.77 [a]	96.93 [a]
Basal diet + Inorganic Se	95.44 [c]	91.89 [b]	96.27 [a]
Basal diet + Organic Se	97.18 [ab]	94.05 [ab]	96.77 [a]
Basal diet + Nano Se	97.14 [ab]	94.30 [ab]	97.06 [a]
SEM	0.52	0.79	0.39
Significance	*	*	*

a-d: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

hens fed diets supplemented with inorganic, organic and nano forms of zinc or selenium than those of the controls (Exp. 1).

These results agree with those reported by **Abdel Galil and Abdel Samad (2004**), who showed that dietary supplementation with 0.5 ppm Se or Zn (100 mg/kg diet) improved egg fertility and hatchability of eggs in Dokki-4 and Bandara hens. **Amen and Al-Daraji (2011a)** found that dietary Zn supplementation (50, 75 or 100 ppm) led to significantly increases in fertility and hatchability traits of Cobb 500 broiler breeders.

Namra *et al.* (2009) showed that supplemental dietary organic Zn (zinc methionine) at 50 mg/kg diet resulted in a significant improvement in egg fertility of laying Japanese quail compared with the control group.

The improved egg fertility, observed here, harmonize with the observation of **Agate *et al.* (2000)** that dietary organic Se supplementation of laying hen improved the environment of the sperm storage tubules in the hen's oviduct, allowing sperm to live longer, there by prolonging its fertilizing capability.

In harmony with the present results, **Hanafy *et al.* (2009)** indicated that supplemental dietary organic Se (Sel-Plex^{TM}) of laying hens led to an increased fertility and hatchability of fertile eggs. Since the hatching process is considered to be a time of oxidative stress the improved antioxidant defenses induced added dietary Se or Zn during embryonic development could potentially increase the hatchability of eggs.

4.11. Effect of feeding diets supplemented with different forms of Se or Zn to turkey toms on egg fertility and hatchability:

As presented in Table 18, significantly higher percentages of egg fertility ($P \leq 0.05$) were achieved due to feeding the diets supplemented with organic and nano forms of zinc or selenium compared with the control group. No significant differences were observed in percentage, of egg fertility among the remaining experimental groups of turkey toms (Exp. 2).

Percentages of hatchability of total eggs were positively affected by feeding the turkey toms on diets supplemented with inorganic, organic and nano forms of zinc or selenium compared with their control counterparts.

Percentages of hatchability of fertile eggs were positively affected ($P \leq 0.05$) by feeding the turkey toms on diets supplemented with organic forms of zinc and selenium compared with those of the controls. No significant differences were observed in percentage of hatchability of fertile eggs among the remaining experimental groups of turkey toms.

The observed increase in hatchability of eggs in response to supplementation of organic and nano forms of Zn and Se in toms diets might be related to their positive effect on semen quality of toms. In this regard, **Hassan *et al.* (2003**) reported a significant increase in egg fertility and hatchability percentages due to dietary supplementation with zinc plus methionine or phytase in Bandarah laying hens.

Bowling *et al.* (2003) reported that the sperm mobility (or the ability of sperm cell to move through a thickened solution) semen quality.

Table (18) Effects of dietary inorganic, organic and nano forms of zinc or selenium to turkey toms on egg fertility and hatchability from 32-44 weeks of age. (Exp. 2)

Dietary treatments	Egg Fertility (%)	Hatchability of total eggs (%)	Hatchability of fertile eggs (%)
Control (Basal diet)	93.49 ^{b}	86.46 ^{c}	92.47 ^{b}
Basal diet + Inorganic Zn	95.26 ^{ab}	90.23 ^{ab}	94.71 ^{ab}
Basal diet + Organic Zn	97.02 ^{a}	93.56 ^{a}	96.42 ^{a}
Basal diet + Nano Zn	96.46 ^{a}	91.54 ^{ab}	94.90 ^{ab}
Basal diet + Inorganic Se	95.04 ^{ab}	90.09 ^{b}	94.77 ^{ab}
Basal diet + Organic Se	96.94 ^{a}	93.26 ^{ab}	96.21 ^{a}
Basal diet + Nano Se	96.31 ^{a}	90.96 ^{ab}	94.43 ^{ab}
SEM	0.63	1.01	0.80
Significance	*	*	*

a-c: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

4.12. Semen quality of turkey toms:-

Data on the effects of dietary supplementation with inorganic, organic and nano selenium and zinc on some parameters of semen quality of 38-week-old turkey toms are shown in Table 19 (Exp. 2).

Ejaculate volumes of toms fed diets supplemented with organic Se or organic Zn were significantly higher ($P \leq 0.05$) than those of the control toms; means of ejaculate volume of the other experimental groups were comparable to those of their control counterparts.

Turkey toms fed the diets supplemented with different forms of Zn or Se produced semen of significantly higher ($P \leq 0.05$) sperm concentrations compared with their controls, with the exception of toms fed inorganic Zn-supplemented diet which had sperm concentration comparable to that of their controls.

Semen produced by turkey toms fed the diets supplemented with organic and nano Zn or Se characterized with significantly higher ($P \leq 0.05$) advanced motility and percent live sperms compared with those of the control toms. Means of advanced motility of the other experimental groups were not significantly different from that of the controls.

Semen produced by turkey toms fed the diets supplemented with organic and nano Zn or Se had significantly lower ($P \leq 0.05$) percentages of abnormal sperms compared with that of the control toms, while abnormal sperms of the other experimental groups were insignificantly comparable to that of their control group.

Semen of toms fed the diets supplemented with organic Se contained significantly lower ($P \leq 0.05$) percentage of dead sperms compared with their

Table (19) Effects of dietary inorganic, organic and nano forms of zinc or selenium on some parameters of semen quality of 38-week-old turkey toms (Exp. 2)

Dietary treatments	Ejaculate Volume (ml)	Sperm concentration ($10^6/mm^3$)	Advanced Motility %	Live sperms %	Dead Sperms %	Abnormal sperms %
Control (Basal diet)	0.382^{b}	3.92^{d}	71.69^{c}	81.64^{c}	8.06^{a}	10.29^{a}
Basal diet + Inorganic Zn	0.387^{ab}	4.06^{d}	71.60^{c}	80.26^{c}	7.95^{ab}	11.78^{a}
Basal diet + Organic Zn	0.400^{a}	5.75^{a}	78.70^{a}	86.53^{a}	7.91^{ab}	5.54^{c}
Basal diet + Nano Zn	0.393^{ab}	4.33^{c}	74.29^{b}	84.35^{b}	7.94^{ab}	7.70^{b}
Basal diet + Inorganic Se	0.386^{ab}	4.24^{c}	72.36^{c}	80.95^{c}	7.92^{ab}	11.12^{a}
Basal diet + Organic Se	0.402^{a}	5.62^{a}	79.03^{a}	87.39^{a}	7.89^{b}	4.71^{c}
Basal diet + Nano Se	0.394^{ab}	4.49^{b}	75.24^{b}	84.91^{b}	7.94^{ab}	7.15^{b}
SEM	0.005	0.05	0.63	0.49	0.04	0.49
Significance	*	*	*	*	*	*

a-d: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
*: significant at $P \leq 0.05$ SEM: Standard error of the means

controls. Means of percent dead sperms of the other experimental groups did not significantly differ from that of the controls (Table 19).

Dietary supplementation with organic or nano forms of Zn or Se positively affected the percentages of live sperms of turkey toms compared with the control toms. But means of percent live sperms in semen of the remaining experimental groups of toms were not significantly different from that the control.

The present results on semen quality criteria of turkey toms are in agreement with a previous report by **Abdallah *et al.* (2014**), who observed that dietary organic minerals (Zn or Se) supplementation caused significant increase in sperm concentration, percent live sperm, sperm output and sperm motility of Gimmizah cockerels compared with inorganic minerals.

Moce *et al.* (2000) showed that dietary zinc supplementation increased sperm production of rabbit bucks as compared to those fed non-supplemented diet. The current results agree also with those reported by **Słowińska *et al.* (2011)**, who found that the semen collected from 31 to 55 weeks old British United Turkeys fed the diet supplemented with Se had a higher sperm concentration and total number of sperm compared with control toms. They also found that the highest percentage of motile spermatozoa was recorded in the group fed the diet containing organic Se.

In agreement with the present results, **Hanafy *et al*. (2009)** showed that semen ejaculate volume, advanced motility percentage, alive sperm percentage and sperm concentration were significantly increased by addition of organic Se to Bandarah local cock's diet from 40 to 60 weeks of age diet.

Similarly, **Edens and Sefton (2009)** reported that dietary selenium supplementation improved normal sperm percentage in semen of roosters compared with their control group; with further improvement due to organic Se vs. inorganic Se. **Edens (2002)** concluded that dietary supplementation of organic Se can improve semen quality of cocks by decreasing the abnormalities of spermatozoal mid-pice damage. He also started that using an organic source reduces production of defective sperm, thereby having a positive effect on the fertilizing potential of the male.

The current results agree also with those reported by **Spring (2006)**, who reviewed that there were significant improvements in spermatozoa concentration and activity, when of male guinea fowls were fed diets supplemented with Se yeast compared with sodium selenite. **Renema (2006)** showed that broiler breeder males (between 45- 65 weeks of age) fed the diets supplemented with 0.2 mg organic Se/kg had significantly higher semen sperm concentration than the control ones. **Davtyan *et al.* (2006)** showed that the number of spermatozoa in cocks, semen was significantly higher by dietary addition of organic Se compared with those given the inorganic Se.

Oxidative stress has been reported to be the chief factor that adversely affects the viability of spermatozoa, leading to poor quality semen, and low fertility in Angora goats **(Bucak *et al.,* 2010)**. Oxidative stress is the result of imbalance between the generation of reactive oxygen species and the scavenging activities of antioxidants in the body. This imbalance can lead to sperm damage, spermatozoa deformity, and eventually male infertility **(Agarwal *et al,.* 2003).** The reproductive potential of turkeys can be enhanced by dietary supplementation with substances that can reduce oxidative stress in semen. Of these, the trace mineral Zn is of major impotance in this respect **(Sundaram *et al.* 2013)**.

Selenium has anti-oxidative properties through its involvement in the active site of the enzyme glutathione peroxidase which serves as the first line of defense against oxidative stress (**Moslemi and Tavanbakhsh, 2011).** Selenium protects testicular spermatozoa from toxic free radicals (**Klotz *et al,*. 2003),** leading to increased live and normal spermatozoa concentration, motility and fertilizing capacity (**Surai, 2000).** Zinc exhibits anti-oxidative activities and can scavenge reactive oxygen species from cells (**Sundaram *et al.*, 2013),** protects spermatozoal genetic materials (RNA and DNA chromatin), and plays an important role for successful fertilization (**Amen and Al-Daraji 2011a).**

The improved semen quality due to feeding the experimental diets in the present study may be as a result of the antioxidant and mineral homeostatic properties of selenium as reported by **Słowińska *et al.* (2011)**.

4.13. Dressing-out percentage and vital internal organs of turkeys:

Data on certain carcass traits of 44-week-old turkey hens or and toms are presented in Tables 20 and 21, respectively.

Results presented in Table 20 showed that there were no significant differences in relative weights of carcass yield, liver and heart of turkey hens among the different dietary treatments.

Table (20) Effects of dietary inorganic, organic and nano forms of zinc or selenium on relative weights of carcass and vital internal organs of 44-week-old turkey hens (Exp. 1)

Dietary Treatments	Carcass yield %	Liver %	Spleen %	Heart %	Ovary %	Oviduct %	Oviduct length (cm)
Control (Basal diet)	72.59	2.82	0.113 [d]	0.40	2.40 [b]	2.34 [c]	62.66 [bc]
Basal diet + Inorganic Zn	72.98	2.56	0.115 [bcd]	0.39	2.63 [a]	2.65 [b]	64.33 [b]
Basal diet + Organic Zn	73.46	2.39	0.122 [ab]	0.39	2.73 [a]	3.03 [a]	74.66 [a]
Basal diet + Nano Zn	73.38	2.58	0.120 [abc]	0.38	2.65 [a]	2.96 [a]	72.00 [a]
Basal diet + Inorganic Se	72.73	2.73	0.114 [cd]	0.39	2.39 [b]	2.21 [c]	60.66 [c]
Basal diet + Organic Se	73.19	2.69	0.125 [a]	0.39	2.70 [a]	2.91 [a]	72.66 [a]
Basal diet + Nano Se	73.18	2.55	0.123 [a]	0.39	2.71 [a]	2.84 [ab]	72.33 [a]
SEM	0.45	0.17	0.002	0.01	0.07	0.07	0.89
Significance	NS	NS	*	NS	*	*	*

a-d: Means in the same column bearing different superscripts differ significantly ($P \leq 0.05$).
NS: Not significant *: significant at $P \leq 0.05$ SEM: Standard error of the means

Table (21) Effects of dietary inorganic, organic and nano forms of zinc or selenium on relative weights of carcass and vital internal organs of 44-week-old of turkey toms (Exp. 2)

Dietary treatments	Carcass yield %	Liver %	Spleen %	Heart%	Testes %
Control (Basal diet)	75.48	1.65	0.136	0.38	0.33 [d]
Basal diet + Inorganic Zn	75.76	1.64	0.130	0.41	0.35 [cd]
Basal diet + Organic Zn	75.48	1.62	0.130	0.41	0.50 [a]
Basal diet + Nano Zn	75.79	1.65	0.133	0.38	0.43 [b]
Basal diet + Inorganic Se	75.10	1.58	0.133	0.40	0.36 [c]
Basal diet + Organic Se	75.44	1.61	0.130	0.40	0.51 [a]
Basal diet + Nano Se	75.35	1.64	0.130	0.41	0.45 [b]
SEM	0.48	0.04	0.004	0.01	0.009
Significance	NS	NS	NS	NS	*

a-d: Means in the same column bearing different superscripts differ significantly ($P\leq0.05$).
NS: Not significant *: significant at $P\leq0.05$ SEM: Standard error of the means

The results showed that turkey hens fed inorganic, organic and nano forms of Zn and organic and nano forms of Se exhibited significantly higher relative weights of ovary and oviduct than their control counterparts.

The results also showed that turkey hens fed diets supplemented with organic and nano forms of Zn and Se exhibited a significant increase in relative weights of spleen and oviduct length compared with their control group (Table 20).

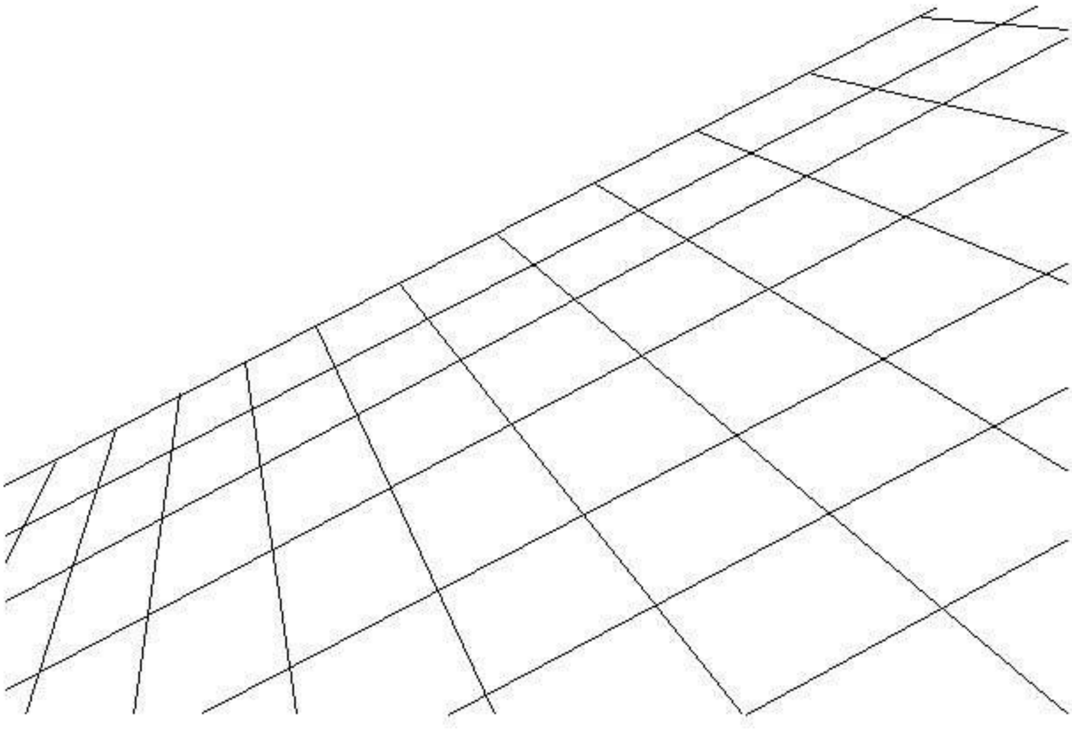
The increased oviduct length in the present experiment coincided with the increment of egg production for hens fed organic and nano forms of Zn and Se compared with hens fed the control diet. Organic and nano forms of Zn and Se might increase egg production by preventing the liver cell damage, which is the major site for egg yolk lipid and protein synthesis. Dietary supplementation with organic and nano form of Zn and Se can also improve egg production by facilitating the release of vitellogenin from the liver or by increasing its concentration in the blood circulation.

Results given in Table 21 indicated that there were no significant differences in relative weights of carcass yield, liver, spleen and heart of turkey toms due to the effect of dietary treatments. The current results also showed that relative weights of toms, testes fed diets supplemented with organic and nano forms of Zn or with inorganic, organic and nano forms of Se were significantly higher compared with the control group.

The present results agree with those of **Hanafy *et al.* (2009)**, who indicated that relative weights of ovary, testes and spleen were significantly increased by addition of organic Se supplementation of Bandarah hens.

On the other hand, **Rama Rao *et al.* (2013)** found that relative weights of ready to cock yield, giblets, liver and spleen were not affected by addition of organic Se to broiler diets. Also, **Osman and Ragab (2007)** found that no significant effect of dietary supplementation of zinc-methionine on the carcass traits such as (liver, gizzard, spleen and heart) of Hubbard broiler chicks. **Namra *et al*.(2008)** found that supplementation of different sources of dietary Zn had no significant effect on most of the carcass traits of Japanese quail chicks.

SUMMARY AND CONCLUSION



5. SUMMARY AND CONCLUSION

The present study was carried out at Mehalet Mousa Animal Production Research Station, Kafr El-Sheikh, belonging to the Animal Production Research Institute, Agricultural Research Center, Ministry of Agriculture, Egypt. This experiment aimed to study using some antioxidants for improving the productive and reproductive performance in turkeys.

Two experiments were carried out. In experiment 1, 84 Bronze female turkeys, 32 weeks of age were used. The turkey hens were randomly distributed into 7 experimental groups; each consisted of three equal replications. The turkey hens were individually housed in battery cages. In experiment 2, 63 Bronze male turkeys (toms), 32 weeks of age were used. The toms were randomly distributed into 7 experimental groups; each consisted of three equal replications. Toms of each experimental group were kept in three floor pens. The experimental period lasted 12 weeks (from 32 to 44 weeks of age). The birds were fed a yellow corn-soybean meal basal diet supplemented with the tested feed additives.

The experimental diets were as follows:

1- Basal diet (control group) without added znic or selenium.
2- Basal diet + inorganic zinc (zinc oxide) 100 mg/kg diet.
3- Basal diet + organic zinc (zinc methionine) 100 mg/kg diet.
4- Basal diet + nano zinc (zinc oxide nanoparticles) 40 mg/kg diet.
5- Basal diet + inorganic selenium (sodium selenite) 0.3 mg/kg diet.
6- Basal diet + inorganic selenium (sodium selenite) 0.3 mg/kg diet.

7- Basal diet + nano selenium (selenium nano particles) 0.15 mg/kg diet.

This study was conducted to estimate the following criteria:

- Live body weight, body weight gain, feed consumption and feed conversion ratio of turkey toms and hens.
- Egg production rate and egg weight.
- Egg quality (some interior and exterior parameters of egg quality).
- Fertility and hatchability of eggs.
- Some blood constituents (glucose, total protein, albumin, globulin, total lipids, cholesterol, haemoglobin, haematocrit value, glutathione peroxidase, antibody titers against NDV of turkey toms and hens, testosterone hormone of turkey toms and estrogen hormone of turkey hens.
- Semen quality (some criteria of semen quality, including ejaculate volume, sperm motility, sperm cell concentration and percentages of live, abnormal and dead sperms) of turkey toms.
- Some carcass traits and vital internal organs of turkey toms and hens.

Results obtained could be summarized as follows:

- Final body weight and body weight gain of turkey hens and toms and feed conversion rate were not affected by dietary treatments during the whole experimental period from 32-44 weeks of age.
- Feed intake was significantly decreased ($P \leq 0.05$) by inorganic, organic or nano forms of zinc or selenium supplementation of turkey hens and toms as compared to those of the controls during the entire experimental period.

- Significantly increases were observed in hen-day egg production rate and egg weight of hens fed the diet supplemented with organic and nano forms of zinc or with inorganic, organic and nano forms of selenium as compared to that of the controls.

- Inorganic, organic and nano forms of zinc or selenium supplementation of turkey hens diets significantly improved ($P \leq 0.05$) their feed conversion ratio as compared to that of the controls.

- Relative weights of egg components, egg shape index, egg yolk index and yolk color score were not significantly affected by dietary treatments.

- Turkey hens fed diets supplemented with organic or nano forms of Se produced eggs with thicker egg shells and better albumen quality as measured by Haugh units as compared to the controls.

- Serum levels of total protein and concentrations of blood haemoglobin for turkey hens and toms fed diets supplemented with inorganic, organic and nano forms of zinc or selenium were significantly higher ($P \leq 0.05$) than those of the controls.

- Serum levels of albumin of turkey hens fed diets supplemented with organic Zn were significantly higher ($P \leq 0.05$) than those of the controls.

- Serum globulin concentrations of turkey hens fed the diets supplemented with nano Zn or nano Se were significantly higher ($P \leq 0.05$) than those of the controls.

- Serum levels of glucose in turkey hens and toms were not affected by dietary treatments.

- Serum levels of total lipids and cholesterol in turkey hens and toms fed diets supplemented with inorganic, organic and nano forms of zinc or selenium were significantly decreased ($P \leq 0.05$) as compared to the control group.

- Antibody titers to NDV of turkey hens and toms and plasma esterogen concentration of turkey hens fed diets supplemented with organic or nano forms of zinc or selenium were significantly increased ($P \leq 0.05$) as compared to their controls.

- Glutathione peroxidase activity was significantly increased ($P \leq 0.05$) by dietary supplementation with organic or nano forms of Zn or with inorganic, organic or nano forms of Se of turkey hens as compared to their controls counterparts.

- Serum levels of albumin of turkey toms fed diets supplemented with inorganic or nano forms of zinc or selenium were significantly higher ($P \leq 0.05$) than those of the controls.

- Serum globulin concentrations and glutathione peroxidase activity of turkey toms fed the diets supplemented with organic or nano forms of Zn or Se were significantly higher ($P \leq 0.05$) than those of the controls.

-. Plasma testosterone concentration of turkey toms fed the diets supplemented with inorganic, organic or nano forms of zinc or selenium were significantly higher ($P \leq 0.05$) than those of the controls.

- Significantly higher ($P \leq 0.05$) percentages of egg fertility, hatchability of total eggs and hatchability of fertile eggs were achieved by turkey hens fed diets supplemented with inorganic, organic or nano forms of zinc or selenium compared to those of the controls.

- Significantly higher ($P \leq 0.05$) percentages of egg fertility, live sperms and sperm motility were achieved by turkey toms fed diets supplemented with organic or nano forms of zinc or selenium compared with those of the controls.

- Significantly higher ($P \leq 0.05$) percentages of total hatchability were achieved by turkey toms fed diets supplemented with inorganic, organic or nano forms of zinc or selenium compared with the control group.

- Significantly higher ($P \leq 0.05$) percentages of fertile hatchability and ejaculate volume were achieved by turkey toms fed diets supplemented with organic forms of zinc or selenium compared with their control counterparts.

- Sperm concentrations were significantly higher ($P \leq 0.05$) in turkey toms fed diets supplemented with the tested minerals, with the exception of that of toms fed inorganic Zn-supplemented diet which was insignificantly comparable to sperm concentrations of the control toms.

- Significantly lower ($P \leq 0.05$) percentages of abnormal sperms were achieved by turkey toms fed diets supplemented with organic or nano forms of zinc or selenium compared with their control ones.

- Carcass traits of turkey hens (relative weights of carcass yield, liver and heart) were not significantly affected by dietary treatments.

- Carcass traits of turkey toms (relative weights of carcass yield, liver, spleen and heart) were not significantly affected by dietary treatments.

- Significantly higher ($P \leq 0.05$) length of oviduct and relative weight of spleen were recorded for turkey hens fed diets supplemented with organic or nano forms of zinc or selenium compared with their controls.

- Relative weights of ovary and oviduct of turkey hens were significantly increased ($P \leq 0.05$) due to feeding the diets with inorganic, organic or nano forms of Zn or with organic or nano forms of Se compared with the control hens.
- Relative weight of testes was significantly increased ($P \leq 0.05$) in turkey toms fed the diets supplemented with organic or nano forms of Zn or with inorganic, organic or nano forms of Se compared with the control toms.

CONCLUSION

It can be concluded that dietary supplementation with organic or nano forms of znic (100 or 40 mg/kg diet, respectively) or organic or nano forms of selenium (0.3 or 0.15 mg/kg diet, respectively) can induce beneficial effects on productive and reproductive performance of turkeys.

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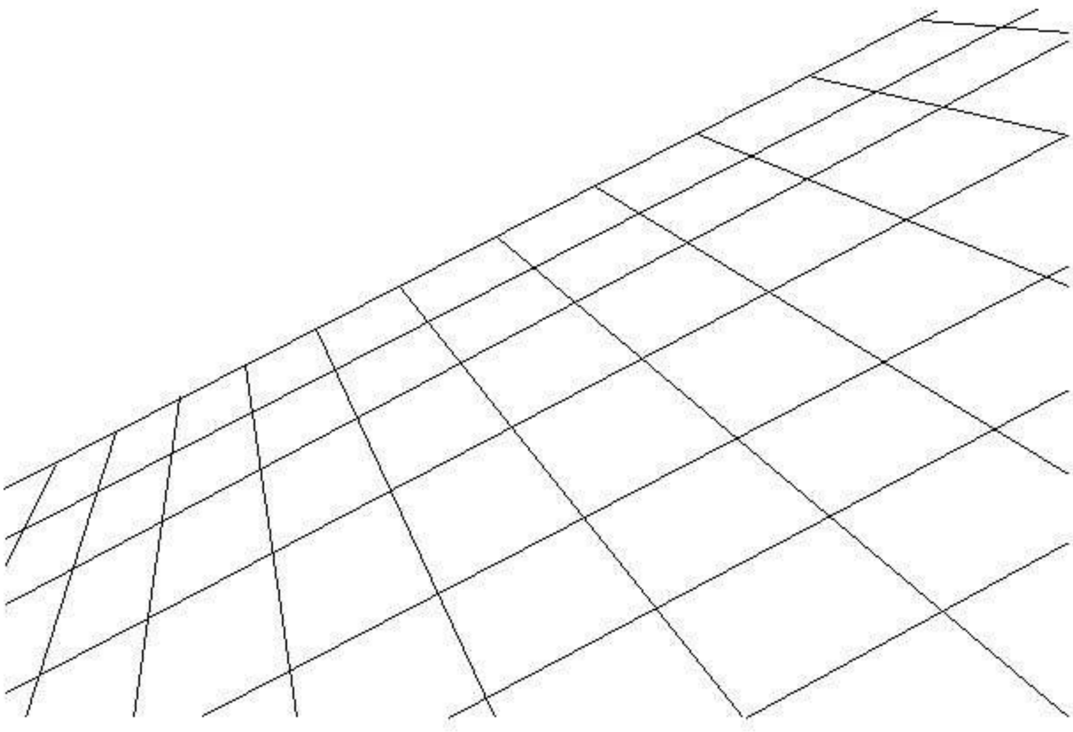

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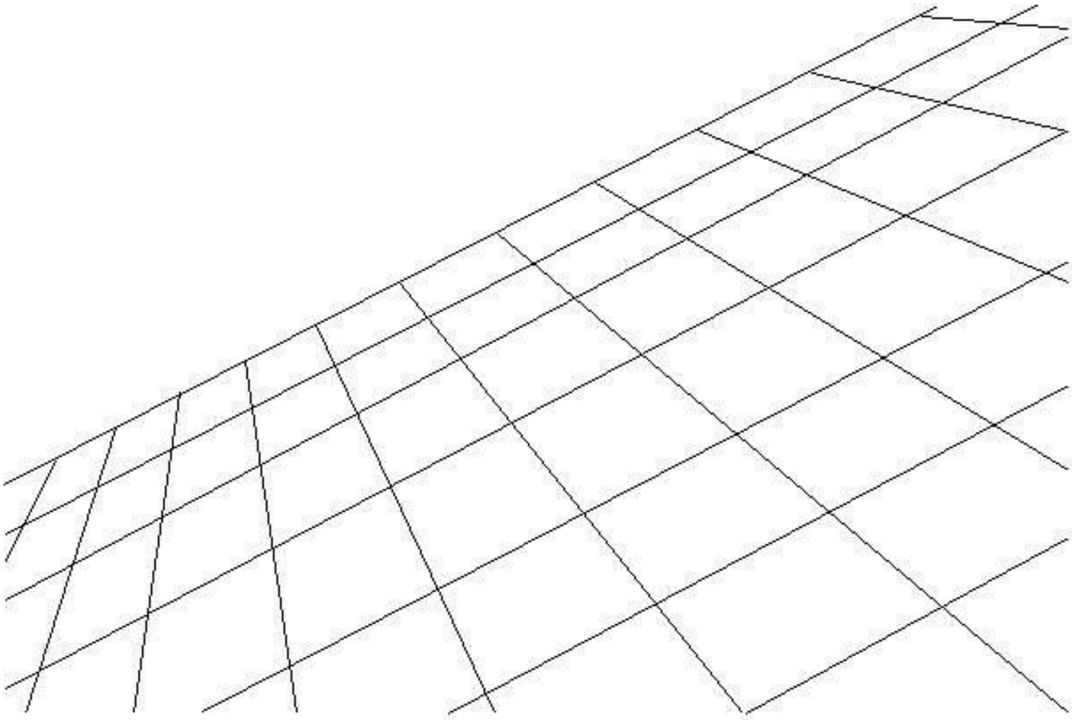
ARABIC SUMMARY



جامعة المنصورة
كلية الزراعة
قسم إنتاج الدواجن

دراسات على استخدام بعض مضادات الأكسدة لتحسين الكفاءة التناسلية فى الرومى

رسالة مقدمة من

مايكل عادل لبيب جورجي

بكالوريوس في العلوم الزراعية (إنتاج الدواجن) - كلية الزراعة - جامعة كفر الشيخ، ٢٠٠٦
ماجستير العلوم الزراعية (إنتاج الدواجن) - كلية الزراعة - جامعة المنصورة، ٢٠١٣

كجزء من المتطلبات للحصول علي درجة دكتوراه الفلسفة في العلوم الزراعية
(إنتاج الدواجن)

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لجنة الإشراف

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جامعة المنصورة - كلية الزراعة مكتب العميد

٧٢٤٥

إقرار حداثة

أقر أنا الباحث/ **مايكل عادل لبيب جورجي** المسجل لدرجة الدكتوراه بقسم إنتاج الدواجن، كلية الزراعة، جامعة المنصورة.

بأن الموضوع المتعلق برسالة الدكتوراه المقدمة تحت عنوان: "دراسات على استخدام بعض مضادات الأكسدة لتحسين الكفاءة التناسلية فى الرومى".

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اسم الباحث/ مايكل عادل لبيب جورجي

التوقيع:

قسم إنتاج الدواجن، كلية الزراعة، جامعة المنصورة

الملخص العربى

- تم اجراء التجربة فى محطة بحوث الانتاج الحيوانى بمحله موسى، كفرالشيخ التابعة لمعهد بحوث الانتاج الحيوانى، مركز البحوث الزراعية، وزارة الزراعة ، مصر. وهذه التجربة تهدف الى دراسة تأثير بعض مضادات الاكسدة لتحسين الاداء الانتاجى والتناسلى فى الرومى.
- تم اجراء تجربتين، فى التجربة الاولى تم استخدام عدد ٨٤ طائر (انثى) من سلالة الرومى البرونز، عمر ٣٢ اسبوع واستخدام عدد ١٠ ديك من سلالة الرومى البرونز فى نفس العمر. وزعت اناث الرومى بطريقة عشوائية الى ٧ معاملات تجريبية، واحتوت كل معاملة على ثلاثة مكررات متساوية، تم تسكين الاناث بطريقة فردية فى بطاريات. فى التجربة الثانية تم استخدام عدد ٦٣ ديك من سلالة الرومى البرونز عمر ٣٢ اسبوع واستخدام عدد ٧٠ طائر (انثى) من سلالة الرومى البرونز فى نفس العمر. وزعت الديوك بطريقة عشوائية الى ٨ معاملات تجربية ، احتوت كل معاملة على ٣ مكررات متساوية، تم تسكين الديوك أرضيا. استغرقت التجربة ١٢ اسبوع من عمر ٣٢- ٤٤اسبوع. غذيت الطيور بعليقة اساسية (كنترول) مكونة من ذرة صفراء وكسب فول الصويا مضاف اليها الاضافات الغذائية.

وكانت المعاملات كالتالى:

المعاملة الاولى:- وهى المجموعة المقارنة (كنترول) وأعطيت العليقة الاساسية فقط بدون اى اضافات من الزنك او السلينيوم.

المعاملة الثانية: العليقة الاساسية + زنك غيرعضوى بمعدل ١٠٠ مجم/كجم عليقة.

المعاملة الثالثة: العليقة الاساسية + زنك عضوى بمعدل ١٠٠ مجم/كجم عليقة.

المعاملة الرابعة: العليقة الاساسية + نانو زنك بمعدل ٤٠ مجم/كجم عليقة.

المعاملة الخامسة: العليقة الاساسية + سلينيوم غير عضوى بمعدل ٠.٣ مجم/كجم عليقة.

المعاملة السادسة: العليقة الاساسية + سلينيوم عضوى بمعدل ٠.٣ مجم/كجم عليقة.

المعاملة السابعة: العليقة الاساسية + نانو سلينيوم بمعدل ٠.١٥ مجم/كجم عليقة.

اهم القياسات فى هذه الدراسة :

- وزن الجسم - الزياده فى وزن الجسم - العلف المستهلك - معدل التحويل الغذائى لكل من ديوك واناث الرومى.
- معدل انتاج البيض – وزن البيض.
- جودة البيض (بعض القياسات الداخلية والخارجية لجودة البيض).
- نسبة الخصوبة والفقس للبيض.

- بعض قياسات الدم (الجلوكوز- البروتين الكلى - الالبيومين- الجلوبيولين- اللبيدات الكلية- الكوليسترول- الهيموجلوبين- الهيموتوكريت- مستوى انزيم البيروكسيديز- والاستجابة المناعية لمرض النيوكاسل لكل من ديوك واناث الرومى- مستوى هرمون التستيسترون لديوك الرومى- مستوى هرمون الاستروجين لاناث الرومى.
- قياس بعض صفات السائل المنوى (حجم السائل المنوى - الحركة التقدمية لحيوانات المنوية - تركيز الحيوانات المنوية - نسبة الاسبرمات الحية والميتة والمشوهة) فى ديوك الرومى.
- قياس بعض مواصفات الذبيحة لكل من ديوك واناث الرومى.

ويمكن تلخيص اهم النتائج كالتالى :

- لم يتأثر الوزن النهائى للجسم وكذلك معدل الزيادة فى وزن الجسم لكل من ديوك واناث الرومى وايضا معدل التحويل الغذائى للديوك معنويا بالمعاملات الغذائية خلال فترة التجربة من عمر ٣٢-٤٤ اسبوع.
- لوحظ انخفاض معنوى فى معدل استهلاك العلف للاناث والديوك عند إضافة الزنك أو السلينيوم فى كل من الصورة الغيرعضوية، العضوية اوالنانو مقارنة بالكنترول خلال فترة التجربة من عمر ٣٢-٤٤ اسبوع.
- سجلت زيادة معنوية فى معدل انتاج البيض ووزن البيض الناتج من الاناث التى تغذت على عليقة مضاف اليها الزنك فى الصورة العضوية او النانو او السلينيوم فى الصورة الغير عضوية، العضوية او النانو مقارنة بالكنترول.
- اضافة الزنك او السلينيوم فى الصورة الغيرعضوية، العضوية أوالنانو تحسن معنويا معدل التحويل الغذائى للاناث مقارنة بالكنترول.
- لم يتأثر الوزن النسبى للمكونات الداخلية للبيضة، دليل القشرة، دليل الصفار أو درجة لون الصفار بالمعاملات الغذائية.
- تحسنت جودة البياض المقاس من خلال وحدات هاو وسمك قشرة البيضة معنويا لاناث الرومى التى تغذت على عليقة مضاف اليها السلينيوم فى الصورة العضوية أو النانو مقارنة بالكنترول.
- زاد معنويا مستوى البروتين الكلى والهيموجلوبين فى دم اناث وديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة الغيرعضوية، العضوية اوالنانو مقارنة بالكنترول.
- زاد معنويا مستوى الالبيومين فى دم إناث الرومى التى تغذت على عليقة مضاف اليها الزنك العضوي مقارنة بالكنترول.
- زاد معنويا مستوى الجلوبيولين فى دم إناث الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى الصورة النانو مقارنة بالكنترول.
- لم يتأثر معنويا مستوى الجلوكوز فى دم إناث وديوك الرومى بالمعاملات الغذائية مقارنة بالكنترول.

- إنخفض معنويا مستوى الليبيدات الكلية والكوليسترول فى دم اناث وديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة الغيرعضوية، العضوية أوالنانو مقارنة بالكنترول.
- تحسنت الاستجابة المناعية لمرض النيوكاسل معنويا لاناث وديوك الرومى وايضا مستوى هرمون الاستروجين للاناث معنويا عند إضافة الزنك او السلسنيوم فى الصورة العضوية او النانو مقارنة بالكنترول.
- زاد معنوبا مستوى نشاط انزيم الجلوتثيون بيروكسيديز عند تغذية اناث الرومى على عليقة مضاف اليها الزنك فى الصورة العضوية او النانو او السلينيوم فى الصورة الغيرعضوية، العضوية أوالنانو مقارنة بالكنترول.
- زاد معنويا مستوى الالبيومين فى دم ديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى الصورة الغير عضوية او النانو مقارنة بالكنترول.
- زاد معنويا مستوى الجلوبيولين ومستوى نشاط انزيم الجلوتثيون بيروكسيديز فى دم ديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى الصورة العضوية أو النانو مقارنة بالكنترول.
- زاد معنويا مستوى هرمون التيسيسترون لديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة الغيرعضوية، العضوية أوالنانو مقارنة بالكنترول.
- لوحظ زيادة معنوية فى كل من نسبة خصوبة البيض، نسبة الفقس للبيض الكلى ونسبة الفقس للبيض المخصب لاناث الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة الغيرعضوية، العضوية أوالنانو مقارنة بالكنترول.
- لوحظ زيادة معنوية فى نسبة خصوبة البيض، نسبة الحيوانات المنوية الحية والحركة التقدمية للاسبرمات لديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة العضوية أوالنانو مقارنة بالكنترول.
- لوحظ زيادة معنوية فى نسبة الفقس للبيض الكلى لديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة الغيرعضوية، العضوية أوالنانو مقارنة بالكنترول.
- لوحظ زيادة معنوية فى نسبة الفقس للبيض المخصب وحجم السائل المنوى عند تغذية ديوك الرومى على عليقة مضاف اليها الصورة العضوية من الزنك او السلينيوم مقارنة بالكنترول.
- لوحظ زيادة معنوية فى تركيز الحيوانات المنوية لديوك الرومى التى تغذت على عليقة مضاف اليها جميع المعاملات الغذائية ماعدا الديوك التى تغذت على عليقة مضاف اليها الزنك الغير عضوى لم تتأثر تركيز الحيوانات المنوية معنويا مقارنة بالكنترول.
- لوحظ انخفاض معنوى فى نسبة الحيوانات المنوية الشاذة لديوك الرومى التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة العضوية أوالنانو مقارنة بالكنترول.
- لم تتأثر مواصفات الذبيحة لاناث الرومى (الوزن النسبى لكل من الذبيحة - الكبد – القلب) معنويا بالمعاملات الغذائية مقارنة بالكنترول.

- لم تتأثر مواصفات الذبيحة لديوك الرومى (الوزن النسبى لكل من الذبيحة - الكبد - الطحال– القلب) معنويا بالمعاملات الغذائية مقارنة بالكنترول.
- لوحظ زيادة معنوية فى طول قناة البيض والوزن النسبى للطحال للاناث التى تغذت على عليقة مضاف اليها الزنك او السلينيوم فى كل من الصورة العضوية أوالنانو مقارنة بالكنترول.
- لوحظ زيادة معنوية فى الوزن النسبى للمبيض وقناة البيض للاناث التى تغذت على عليقة مضاف اليها الزنك فى كل من الصورة الغيرعضوية، العضوية أوالنانو أوإضافة السلينيوم فى الصورة العضوية او النانو مقارنة بالكنترول.
- لوحظ زيادة معنوية فى الوزن النسبى للخصية للديوك التى تغذت على عليقة مضاف اليها الزنك فى كل من الصورة العضوية أوالنانو أوإضافة السلينيوم فى كل من الصورة الغيرعضوية، العضوية أوالنانو مقارنة بالكنترول.

الخلاصة:

يستنتج من النتائج المتحصل عليها إن إضافة الزنك فى كل من الصورة العضوية أو النانو (١٠٠ او٤٠ مجم/كجم عليقة على التوالى) أو إضافة السلينيوم فى كل من الصورة العضوية أو النانو (٠.٣ او٠.١٥ مجم/كجم عليقة على التوالى) يمكن أن يحدث تأثيرات إيجابية على الاداء الانتاجى والتناسلى للرومى.