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Influence of Dietary Selenium Nanowires on Growth Performance of Broiler Chicken

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Abstract

Selenium (Se) nanowires have been prepared using simple precursors by hydrothermal redox route method. Se nanowires have been synthesized by mixing sodium selenite and hydrazine hydrate under suitable conditions. X-ray diffraction analysis reveals that Se nanoparticles in hexagonal structure and no secondary phase were observed. The average grain size of the nanoparticles is found to lie in the range of 25 to 35 nm. TEM images reveal that Se nanowires diameter ranging from 35 to 45 nm. The present research focuses on the effects of prepared Se nanowires on the growth performance of broiler chickens. To study the comparative effects of Se nanowires and Sodium selenium on thirty number of Vencobb broiler chicks were wing banded, weighed and randomly allotted to three groups with ten chicks in each group. Their weight gain was taken for consecutive six weeks to observe the effect of dietary Se nanowires over growth utilization of birds. There were three different diets prepared with T_1 control standard diet, T_2 Standard diet + Sodium selenite 0.3mg/Kg diet and T_3 Standard diet + Selenium nanowires 0.3mg/Kg diet respectively. The percent retention of weight was highest in T3 group as compare to T1 and T2 which was supplemented 0.3 mg Se/kg of feed. Therefore it was concluded that supplementation of selenium nanoparticles 0.3 mg/kg diet of poultry enhances the growth rate in the broiler birds.

Keywords: Selenium nanowires, Nutrient utilization, weight gain, TEM, Vencobb broiler chicks.

INTRODUCTION

Selenium is a trace mineral essential to maintain good health in animals and human beings. Selenium is incorporated into proteins to form selenoproteins, which are important antioxidant enzymes. These antioxidant enzymes prevent oxidative damage to body tissues. Unfortunately, in many parts of the world, major food ingredients contain inadequate level of selenium resulting in selenium deficiency in human and animal nutrition. In commercial poultry production, selenium needs to be supplemented to overcome various stressors (Chun fan *et al*., 2009). Selenium is involved in antioxidant defense system; thereby influencing the livability and production in broiler chickens. Selenium is added to poultry diet as sodium selenite or sodium selenate. These inorganic forms of selenium have low transfer efficiency from feed to tissues and can't be added at higher levels in feed due to toxic nature (Beck et al 2007). To overcome the toxicity of selenium, organic sources were also tried.

Selenium is essential for the activity of multiple components of the human and animal immune system. Se deficit damages both cellular and humoral immunity (Artur *et al*., 2003). Selenium supply to animals may be increased using selenium nanoparticles with more bioavailability and least toxicity as reported in studies on mice (Huali Wang *et al*., 2007). To enrich poultry products with selenium so as to provide the selenium requirement of human beings, selenium nanoparticles can be supplemented through diet because of its low toxicity and higher bioavailability. The toxicity of nano-selenium is 7 times lower than that of inorganic selenium and 3 times lower than that of organic selenium (Peng *et al*., 2007).

Products of nanotechnology have begun to be applied in the area of nutritional

supplements and have become largely available and usable now. A good example may be nano-elements, including nano-selenium (nano-Se), with noted significant increase of chemical reactivity. Effects of nano-Se on yield, meat quality, immune functions, oxidization resistance, and Se levels in tissues of broilers were studied by (Cai *et al*., 2012). (Attia *et al*., 2010) stated that addition of inorganic Se improved the productive performance of Gimmizah breeding hens. Effect of inorganic Se supplementation on growth performance, meat quality, and antioxidant status of broilers was also studied by (Yang *et al*., 2012). In the control group, 0.3 mg/kg inorganic Se (Na_2SeO_3) was added to the diets while in the experimental group, 0.3 mg/kg organic Se (Se-enriched yeast) was added to the same basal diets. The results show that Se could increase daily weight gain.

Dlouha *et al*. (2008) studied the effects of supplementation of dietary sodium selenite and sodium enriched alga Chlorella on the growth performance of sexed broiler cockerels Ross 308. Dietary supplementation with Se-CH increased body weight. Also (Heindl *et al*., 2010) confirmed that Se addition influenced body weight in 21 day old and 35 day old broiler chickens. Significantly higher body weight at 35 days of age was determined in chickens Feeding of selenized yeast increased the live body weight of chickens compared with the controls (Rozbicka *et al*., 2012). Therefore, selenium nanowires can be used as feed additive to enrich selenium in poultry products. Hence, the present study was conducted to determine the effect of prepared selenium nanoparticles on the growth performance and activities of antioxidant enzymes of broiler chickens.

2. Materials and Methods

2.1. Experimental: A simple and very mild redox route has been used to synthesize selenium nanowires. In this study we used sodium selenite (Na_2SeO_3) as the selenium source and water as the solvent. Ammonia or alkali is not necessary in our experiment because Na_2SeO_3 can dissolve in water to form clear alkalescent solution (pH = 8). In a typical procedure, 1 mmol sodium selenite (Na_2Se0_3) was dissolved in 25 mL distilled water and 0.1 mmol hydrazine hydrate (N_2H_4 .H_2O) was added and the solution was stirred to form a homogeneous solution. The solution was transferred into a stainless steel autoclave with a Teflon liner, which was then filled with distilled water to 80% of its capacity. The autoclave was sealed and maintained at 120°C for 24 hrs, then allowed cool to room temperature. The supernatants were removed and the deposited precipitate was collected and washed with distilled water and ethanol several times and then dried in oven at 80°C for 5 hours. Then, the prepared selenium is placed in the middle of a muffle furnace in silica crucible. The samples have been annealed at 150°C for 1 h.

X-ray diffraction studies have been carried out using PANalytical x-ray diffractometer, surface morphology of the samples has been studied using scanning electron microscope (JEOL-JSMS, 800-V). Transmission electron microscope (TEM) images of the prepared Se have been recorded using a Philips TECNAI F20 microscope. Compositional analysis of the samples has been studied using energy dispersive analysis of X-rays (JEOL Model JED -2300).

2.2. Experimental birds: One day old straight run Vencobb broiler chicks obtained from commercial hatchery at Namakkal were utilized in the biological trial. Thirty numbers of a day old Vencobb broiler chicks were wing banded, weighed and randomly allotted to three groups with ten chicks in each group.

The birds were reared in cages under standard managemental practices from 1 day old to six weeks of age. The experim-ental broiler birds were vaccinated against Ranikhet disease on day 7 and 21, and Infectious Bursal Disease at the age of day 14. This was a continuous study of the same treatment groups. The grower birds were

provided 24 hours free access to clean drinking water.

2.3: Experimental Diet: The broiler basal diet was formulated to meet nutrient requirements according to the Indian Standard 5672 (1992) except Se for the experimental feedings. Samples of the experimental feed were analysed for dry matter, crude protein, ether extract, crude fiber and acid insoluble ash as per (AOAC 1995). Calcium and phosphorus was measured according to the method modified by (Talapatra *et al*. 1940). The broiler starter and finisher diets were fed ad libitum to the birds from 1 to 21 and 22 to 42 days of age respectively. At the end of every week, body weight of the individual birds was recorded. The inclusion levels of the feed ingredients in broiler starter and finisher diet are given in Table 1.

Table.1: Ingredients and nutrient composition (% DM) of broiler starter and finisher diet

Ingredients		Broiler starter	Broiler finisher
Maize (%)	-	55.8	41.5
Soyabean meal (%)	-	41.5	33.0
Di calcium phosphate (%)	-	1.5	1.5
Calcite (%)	-	2.1	1.5
Salt (g/100kg)	-	400	400
Methionine (g/100kg)	-	360	320
Supplements (g/100kg)			
Mineral mixture 1	-	100	100
Nutrient composition	-		
Dry matter	-	90.25	90.35
Crude protein	-	22.23	19.21
Crude fibre	-	3.04	882.78
Ether extract	-	2.27	2.60
Total ash	-	6.57	5.09
Nitrogen free extract	-	65.8	70.32
Acid insoluble ash	-	0.64	1.30
Calcium	-	1.49	0.80
Total phosphorus	-	0.62	0.53
Methionine* (g/100kg)	-	140	30
ME (kCal/kg) *	-	2795	2897

The experiment was designed to find out the impact of adding nanocrystalline selenium supplement over the re-commended level on growth performance and antioxidant enzymes of broilers. Se nanowires and feed grade sodium selenite were used for this study. The experimental diet was formulated according to the standards prescribed in B.I.S (1992). The dietary treatments of the experiment group were presented in Table 2.

Table.2: Dietary treatment of the experiment group

Treatment	Experimental diets
T1	Standard diet
T2	Standard diet + Sodium selenite 0.3mg/Kg diet
T3	Standard diet + Selenium nanoparticles 0.3mg/Kg diet

Note: T1: Control

3. RESULTS AND DISCUSSION

Figure 1 shows the X-ray diffraction pattern of the prepared Se nanoparticles. The diffraction peaks at 2θ (degrees) of 23.57°, 29.73°, 41.28°, 43.68°, 45.43°, 51.72°, 56.07°, 65.24° and 71.60° are respectively indexed as the (100), (101), (110), (102), (111), (201), (112), (210) and (113) planes of Se. It is observed that the diffraction peaks in the 2θ range measured can be indexed as the hexagonal structure of Se with lattice constants a = 4.354Å and c = 4.931Å, which are in good agreement with those on the standard card (JCPDS card No. 06-0362). The sharpness of the diffraction peaks suggests that the product is well crystallized. The crystallite size of selenium is calculated using Scherrer's equation,

$$D = \frac{K\lambda}{\beta \cos\theta}$$

where, D is the grain size, K is a constant taken to be 0.94, λ is the wavelength of the x-ray radiation, β is the full width at half maximum and θ is the angle of diffraction. The crystallite size has been calculated and is found to be in the range of 25-35 nm for the prepared Se nanoparticles.

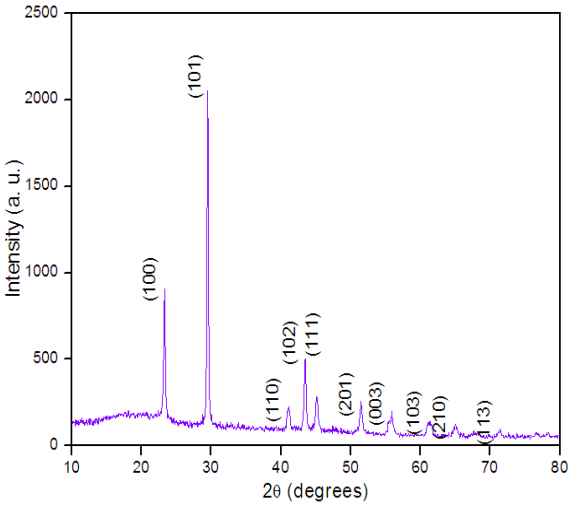

Figure 1: X-ray diffraction pattern of Se nanowires

The surface morphology of Se samples has been studied using scanning electron microscope (SEM). Figure 2 shows the SEM image of the prepared Se is nanowires. Figure 3 shows the energy dispersive x-ray analysis (EDAX) result for the Se sample. In the EDAX, Se is the only element detected, indicating that the sample is highly pure.

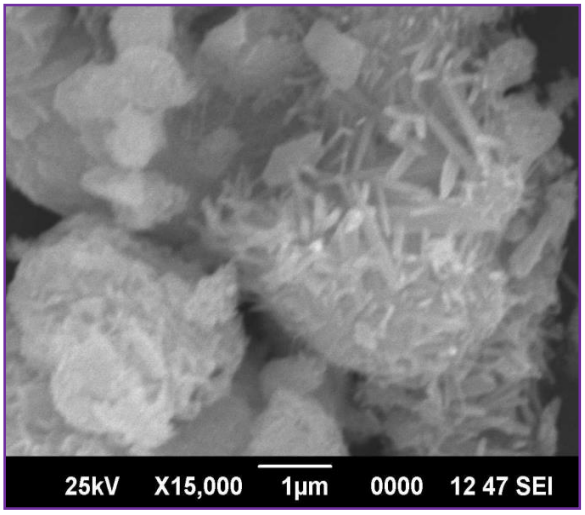

Figure. 2: SEM image of Se as prepared Se nanowires

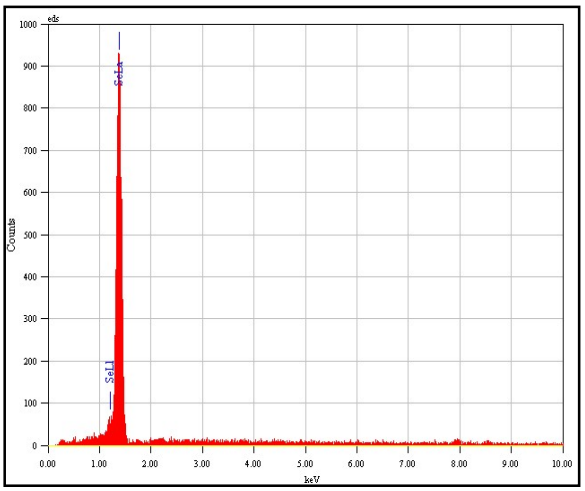

Figure. 3: EDS spectra of as prepared Se nanoparticles

The high resolution transmission electron microscope (TEM) images of prepared Se nanowires are shown in Figure 4a. The image shows that the nanowires are straight and uniform with an average diameter of about 35 to 45 nm. Figure 4b shows the selected area electron diffraction (SAED) pattern of the prepared Se nanowires. Selected area electron diffraction image (Fig. 4b) exhibit diffraction rings corresponding to the (100), (101), (110), (102), (111) and (201) directions of the hexagonal phase of Se. The d spacing values obtained for all the diffraction rings from the SAED pattern match very well with that of hexagonal Se are in close agreement with the values obtained from X-ray diffraction studies.

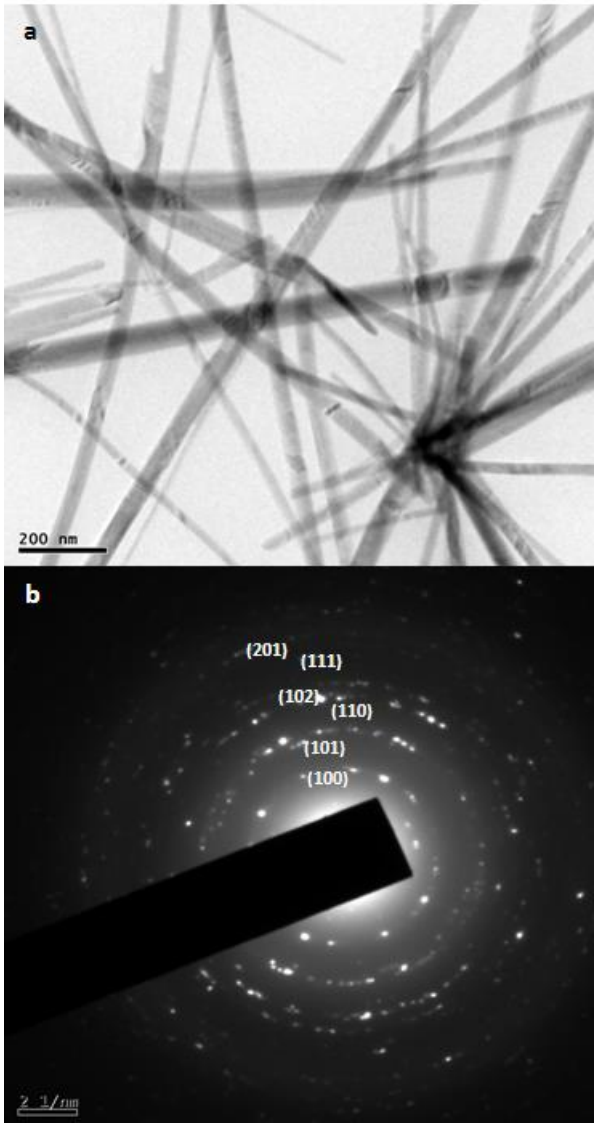

Figure.4: TEM image of Se nanoparticles (a) TEM morphology of Se NPs and (b) SAED images of as prepared Se NPs.

3.1. Body weight analysis: The growth performance and feed utilization of grower birds supplemented with different Se sources are presented in Table 2. This experiment was continued in two phases: Starter phase (1-21 days) and finisher phase (22-42 days), the body weight of individual birds that achieved at the end of every week is reported. The effects of selenium supplementation on mean body weight of broiler chicken from 1 to 6 weeks of age are presented in Table 3.

Table. 3 : Mean (± SE) body weight (g) of broilers fed supplemental selenium

Treatment	Day-old	I	II	III	IV	V	VI
T1	44.91± 0.84	130.18±4.08	290.97±11.23	577.62±16.23	939.94±27.78	1345.98±26.87	1869.49±41.27
T2	45.63± 0.63	131.03±3.19	302.67±8.94	569.30±18.42	941.00±26.32	1366.65±34.89	1893.43±56.33
T3	45.38± 0.68	132.65±3.72	306.97±12.73	596.75±22.66	976.80±34.04	1383.62±53.64	1903.27±61.15

T1 - Control, T2 - Sodium Selenite and T3 - Selenium nanowire\particles
***Mean values are based on body weight of 10 birds per treatment**

Body weight was observed to be significantly different in treated groups compared to the control group with increase in growth performance of broiler (P <0.05). The mean body weight (g) recorded at the age of 6th week was 1893 and 1903 for the group T2 and T3 respectively compared to 1869 in control (T1). The mean body weight increased slightly among the treatment groups.

The observation of this study concurs with the findings of Colnago *et al*., 1984, observed an increase in weight with increasing selenium levels (Xia *et al*.,2005), observed that the chicken had higher (P<0.05) growth performance at concentration range of 0.4-1.0 mg/kg with Se nanowire than Sodium selenite. Similarly, Chunxiang *et al*., (2007) observed Se nanowires diet significantly increased the growth recital of goats (P <0.05). The present study indicated that the growth recital of growing was improved by dietary of Se nanowire compared with the control and the dietary of Sodium selenite. The improvement of growth recital suggested that the superior performance of nanowires may be attributed to their smaller particle size.

Conclusion

In present study, Selenium (Se) nanowires have been prepared by hydrothermal redox route method. X-ray diffraction analysis reveals that the Se nanoparticles exhibit hexagonal structure. The average grain size of the nanoparticles is found to lie in the range of 25 to 35 nm. TEM images reveal that Se nanowires diameter ranging from 35 to 45 nm. It could be concluded from this study that the selenium nanowires supplementation of local vancobb chicken diets with 0.30 mg/kg was effective in increasing the growth performance from one day of hatch to 6 weeks of age improved productivity, physiological and immunological traits including parameter such as live body weight. Therefore, the Se nanowires could be an essential form of selenium supplementation in dietary chicks.

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