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Effect of Feeding Nano-Selenium Supplemented Diets on Growth and Immunological Performance of Broiler Chickens

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ABSTRACT

Background and Objective: Selenium, being a micro-mineral has been used by researchers to fortify poultry meat due to the increased demand for safer and increased animal protein by consumers. This is because it is well known for its role in chicken growth and immune competence. This study examined the effects of supplementing varying levels of dietary nano-selenium on growth performance and immunological parameters of broiler chickens. **Materials and Methods:** A total of 200 1-day old *Arbor acre* broiler chickens were used for the study and distributed into five treatments, four replicates with 10 birds each using a completely randomised design. Data on growth performance and immunological parameters were taken and analysed using a one-way analysis of variance and Duncan's multiple range Test was used to separate the means. **Results:** The supplementing dietary nano-selenium to broiler chickens significantly improved ($p<0.05$) growth performance (body weight gain 2115.72, 2182.98, 2171.64 and 2262.84 at $NSe_{0.10}$, $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$, respectively), apparent nutrient digestibility (dry matter 89.02 and 87.20% at $NSe_{0.20}$ and $NSe_{0.25}$, respectively at the starter phase and crude fibre 89.54 at $NSe_{0.25}$ during the finisher phase) and immunological parameters (immunoglobulin A 1.82 at $NSe_{0.20}$) measured. **Conclusion:** The present study showed that both growth performance and immunity of broiler chickens can be improved when fed nano selenium supplemented diets.

KEYWORDS

Arbor acre, nano-selenium, immunoglobulin, dry matter, crude fibre, growth performance

INTRODUCTION

Selenium (Se) is one of the major micronutrients that has captured the attention of many animal nutritionists which is due to the numerous biological functions it has in growth[1], immune competence[2,3] and antioxidant activity[4]. Despite the numerous roles it plays, Se has been reported to be among the most deficient minerals in the chicken diet, thus, resulting in low productivity[5]. Furthermore, when Se is supplied in excess quantities, it leads to environmental pollution since they are excreted through their faeces[6].

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Due to these reasons, researchers have continued to search for other acceptable forms in which Se can be included in the diets of chickens that will meet the requirement of animal products and minimise the effects of environmental pollution by ensuring optimal absorption. As such, supplementing this mineral in nano form arises.

The National Research Council[7] (1994) recommended 0.3 ppm nano Se inclusion in the diets of broiler chickens, but recommendation made by the NRC was based on studies conducted in temperate countries which may not be adequate for broiler chickens reared in the tropical countries like Nigeria. Therefore, this study was carried out to determine the effect of supplementing varying dietary levels of nano Se on the growth and immune response of broiler chickens.

MATERIALS AND METHODS

Study area and duration, experimental birds, design, management and diets: The experiment was carried out at the Old Poultry Teaching and Research Unit of the Department of Animal Production, School of Agriculture and Agricultural Technology, Federal University of Technology (FUT), Minna, Niger State, Nigeria. The study was carried out from December, 2020 to January, 2021.

The 200 1-day *Arbor acre* breed of broiler chicks used for the study were purchased at Yammfy Farms, Ilemona, Kwara State, Nigeria. They were randomly distributed to five treatments using a Completely Randomised Design (CRD). The experiment lasted for seven weeks. Treatment 1 served as the control which had 0 levels of nano Se while treatments 2, 3, 4 and 5 had 0.10, 0.15, 0.20 and 0.25 mg kg^{-1} levels of nano Se and were tagged $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$, respectively. Each treatment had four replicates with 10 birds per replicate. A deep litter system of rearing was used during the period of the study.

The diet used for the study was sourced from Hybrid Feeds Limited, Kaduna, Kaduna State, Nigeria. It was subjected to proximate analysis at the Department of Animal Production, Federal University of Technology, Minna. Graded levels of nano-Se ranging from 0.10-0.25 mg kg^{-1} were added to the treatments. The chickens were served both feed and water *ad libitum*.

Preparation of nano-selenium: Nano-Se was prepared using the biological method as described by Vyas and Rana[8] using scent leaf (*Ocimum gratissimum*) extract. This is because this method has been proven to be non-toxic, compatible with pharmaceutical and biomedical applications and less time-consuming. The preparation was carried out at the Centre for Genetic Engineering and Biotechnology, Bosso Campus, Federal University of Technology, Minna.

Growth performance and immunological parameters: Feed intake of the birds was recorded daily by subtracting the feed left over after 24 hrs from the quantity of feed offered to the animal as described by Owen *et al.*[9] while the body weight gain was calculated as the difference between the final weight and the initial weight as described by Owen *et al.*[9]. The feed conversion ratio was calculated as the ratio of total feed intake to total weight gain as described by Mohapatra *et al.*[10]. Immune response was measured at the end of the 7th week by collecting blood from the chickens at their wing vein to assess for antibody titre against Newcastle Disease.

Ethical consideration: This was waived by the ethical committee of the Federal University of Technology, Minna, Niger State, Nigeria.

Statistical analysis: Statistical Package for Social Science (SPSS) version 9.3 was used to analyse the data collected at a 5% significance level.

RESULTS

The results of the effects of feeding varying dietary levels of nano-Se on the growth performance of broiler birds aged 0-7 weeks are presented in Table 1. The results showed that nano-Se had effects ($p<0.05$) on all the growth parameters measured except the initial weight and FCR.

Birds on dietary treatments $NSe_{0.10}$, $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$ had similar ($p>0.05$) final body weight and weight gain. Similarly, there were no significant differences ($p>0.05$) in the final body weight and weight gain of birds on dietary treatments $NSe_{0.00}$ and $NSe_{0.15}$. However, birds on treatments $NSe_{0.10}$, $NSe_{0.20}$ and $NSe_{0.25}$ treatments had higher ($p<0.05$) final body weight and body weight gain than the birds on the $NSe_{0.00}$ treatments.

The feed intake results showed that birds on dietary treatments $NSe_{0.15}$ and $NSe_{0.25}$ had similar ($p>0.05$) values. Birds on $NSe_{0.10}$ and $NSe_{0.15}$ diets also had similar ($p>0.05$) feed intake values. Similarly, there was no significant difference ($p>0.05$) in birds fed dietary $NSe_{0.00}$ and $NSe_{0.10}$ treatments. However, birds on $NSe_{0.20}$ treatments had higher ($p<0.05$) feed intake values compared to those birds on $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.25}$ treatments.

Birds fed dietary $NSe_{0.00}$, $NSe_{0.15}$ and $NSe_{0.20}$ treatments had similar ($p>0.05$) mortality values. Birds fed $NSe_{0.10}$ and $NSe_{0.25}$ treatments also had similar ($p>0.05$) mortality values. However, birds on $NSe_{0.00}$, $NSe_{0.15}$ and $NSe_{0.20}$ treatments had higher ($p<0.05$) mortality compared to birds on $NSe_{0.10}$ and $NSe_{0.25}$ treatments.

Results of the effects of feeding different dietary levels of nano selenium on the apparent nutrient digestibility of broiler birds are presented in Table 2. The results showed that feeding supplemental nano Se of varying levels had effects ($p<0.05$) on only the dry matter (DM) and crude protein (CP) of broiler birds at the starter phase. Supplementing nano Se in the diet of broiler birds had no effects ($p>0.05$) on other parameters (ash, ether extract, crude fibre and nitrogen-free extract) measured at this phase.

Chickens fed diets containing $NSe_{0.10}$, $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$ treatments had similar ($p>0.05$) DM contents digestibility. The DM contents digestibility of chickens fed dietary $NSe_{0.00}$, $NSe_{0.10}$ and $NSe_{0.15}$ treatments were also similar ($p>0.05$). However, the digestibility values of the DM contents of chickens fed supplemental $NSe_{0.00}$ treatments were significantly lower ($p<0.05$) than the values recorded for chickens fed supplemental $NSe_{0.20}$ and $NSe_{0.25}$ treatments.

The CP content digestibility of chickens fed supplemental $NSe_{0.00}$, $NSe_{0.10}$ and $NSe_{0.15}$ diets had similar ($p>0.05$) values. Supplementing $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.20}$ diets to broiler chicks had no significant difference ($p>0.05$) in CP digestibility. Similarly, there were no effects ($p>0.05$) in the CP contents digestibility of birds fed $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$ treatments. However, chickens fed dietary $NSe_{0.25}$ treatments had significantly higher ($p<0.05$) CP digestibility values compared to values recorded for birds fed dietary $NSe_{0.00}$ and $NSe_{0.10}$ treatments.

At the finisher phase, results of the digestibility showed that supplementing nano Se in the diets of broiler birds had effects ($p<0.05$) on only the DM and crude fibre (CF) contents whereas supplemental nano Se had no effects ($p>0.05$) on other parameters (ash, ether extract, crude protein and nitrogen free extract) measured at this phase.

Chickens fed diets containing $NSe_{0.10}$, $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$ had similar ($p>0.05$) DM digestibility values. The DM digestibility of birds fed dietary $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.20}$ treatments was also similar ($p>0.05$). However, chickens supplemented with dietary $NSe_{0.25}$ had a DM digestibility value which was significantly higher ($p<0.05$) compared to those birds on $NSe_{0.00}$ treatments.

Table 1: Growth performance of broiler chickens fed nano selenium supplemented diets aged 0-7 weeks

Parameters	$NSe_{0.00}$	$NSe_{0.10}$	$NSe_{0.15}$	$NSe_{0.20}$	$NSe_{0.25}$	SEM	p-value
Initial weight (g)	61.75	61.53	61.27	61.86	62.16	0.227	0.821
Final body weight (g)	1943.25^{b}	2177.25^{ab}	2244.25^{a}	2233.50^{a}	2325.00^{a}	45.712	0.047
Weight gain (g)	1881.50^{b}	2115.72^{a}	2182.98^{ab}	2171.64^{a}	2262.84^{a}	45.670	0.047
Feed intake (g)	4213.36^{d}	4382.93^{cd}	4453.90^{bc}	4907.86^{a}	4606.33^{b}	59.503	0.001
FCR	2.24	2.07	2.04	2.26	2.04	0.043	0.148
Mortality (%)	6.25^{a}	0.00^{b}	5.00^{a}	6.25^{a}	1.50^{b}	1.483	0.001

FBW: Final body weight, FCR: Feed conversion ratio, NSe: Nano selenium (mg kg^{-1}) and a, b, c, d with similar superscripts along the rows are not significantly different ($p<0.05$) from each other

Table 2: Apparent nutrient digestibility of broiler birds fed nano-Se supplemented diets

Parameters	$NSe_{0.00}$	$NSe_{0.10}$	$NSe_{0.15}$	$NSe_{0.20}$	$NSe_{0.25}$	SEM	p-value
Starter digestibility							
Dry matter	79.21^{b}	82.52^{ab}	87.61^{ab}	89.02^{a}	87.20^{a}	1.410	0.024
Ash	76.38	80.05	72.85	75.09	71.79	1.287	0.295
Ether extract	78.94	79.62	79.34	83.78	70.92	1.946	0.357
Crude protein	72.87^{c}	75.28^{bc}	79.74^{abc}	82.79^{ab}	86.22^{a}	1.669	0.039
Crude fibre	78.69	84.51	82.56	79.46	78.92	0.940	0.190
NFE	82.33	82.34	84.12	76.70	75.26	1.797	0.487
Finisher digestibility							
Dry matter	81.51^{b}	88.74^{ab}	84.82^{ab}	89.65^{ab}	91.32^{a}	1.418	0.036
Ash	78.18	81.85	74.76	74.89	74.79	1.422	0.470
Ether extract	80.82	81.52	81.25	84.71	83.29	1.791	0.970
Crude protein	81.87	77.38	80.37	84.87	88.32	1.783	0.383
Crude fibre	80.38^{b}	80.23^{b}	80.30^{b}	84.26^{ab}	89.54^{a}	1.171	0.013
NFE	84.56	84.54	86.52	76.87	81.02	1.804	0.520

NFE: Nitrogen-free extract, SEM: Standard error of mean and a, b, c with similar superscripts along the rows are not significantly different ($p<0.05$) from each other

Table 3: Response of some immunological parameters on broiler chickens fed nano-Se supplemented diets

Parameters (%)	$NSe_{0.00}$	$NSe_{0.10}$	$NSe_{0.15}$	$NSe_{0.20}$	$NSe_{0.25}$	SEM	p-value
Thymus	2.95	2.72	2.62	3.21	2.41	0.165	0.654
Bursa	2.06	1.93	2.08	2.06	1.77	0.062	0.503
Spleen	1.91^{ab}	1.92^{ab}	1.56^{bc}	1.99^{a}	1.49^{b}	0.072	0.049
IgG	4.00^{ab}	3.98^{ab}	3.94^{ab}	3.62^{b}	4.43^{a}	0.231	0.048
IgA	2.62^{a}	2.85^{a}	2.74^{a}	1.82^{b}	2.55^{ab}	0.133	0.050
IgM	1.93	2.25	2.11	1.74	2.11	0.080	0.319

NSe: Nano-Selenium (mg kg^{-1}), IgG: Immunoglobulin G, IgA: Immunoglobulin A, IgM: Immunoglobulin M, SEM: Standard error of mean and a, b, c with similar superscripts along the rows are not significantly different ($p<0.05$) from each other

The CF digestibility of chickens fed supplemental $NSe_{0.20}$ and $NSe_{0.25}$ diets had similar ($p>0.05$) values. Similarly, there were no effects ($p>0.05$) in the CF digestibility in birds fed $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.20}$ diets. However, chickens fed dietary $NSe_{0.25}$ had significantly higher ($p<0.05$) CF digestible value compared to those birds on $NSe_{0.00}$, $NSe_{0.10}$ and $NSe_{0.15}$ diets.

Table 3 shows the effect of feeding different levels of nano-Se on the immunological parameters of broiler chickens. The results showed that supplementing nano-Se in the feeds of broiler chickens had effects ($p<0.05$) on the spleen, immunoglobulin G (Ig G) and immunoglobulin A (Ig A) measured. However, the thymus, bursa and immunoglobulin M were not influenced ($p>0.05$).

Birds fed dietary $NSe_{0.00}$, $NSe_{0.10}$ and $NSe_{0.20}$ treatments had similar ($p>0.05$) spleen values. Birds on $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.25}$ diets also had similar ($p>0.05$) spleen values. Birds fed supplemental $NSe_{0.20}$ diet, however, had higher ($p<0.05$) spleen values compared to those birds on $NSe_{0.15}$ and $NSe_{0.25}$ treatments.

The results of immunoglobulin G (Ig G) showed that birds fed diets containing $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.25}$ treatments had similar ($p>0.05$) values. There were no significant differences ($p>0.05$) in the IgG of broiler birds fed dietary $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NS_{0.20}$ treatments. However, birds fed supplemental $NSe_{0.25}$ treatments had higher ($p<0.05$) numbers of Ig G than those fed $NSe_{0.20}$ treatments.

Birds in treatments $NSe_{0.00}$, $NSe_{0.10}$, $NSe_{0.15}$ and $NSe_{0.25}$ had similar ($p>0.05$) values of the Ig A. The birds on $NSe_{0.20}$ and $NSe_{0.25}$ diets also had similar ($p>0.05$) Ig A values. However, birds fed dietary $NSe_{0.20}$ treatment had lower ($p<0.05$) Ig A values than birds fed dietary $NSe_{0.00}$, $NSe_{0.10}$ and $NSe_{0.15}$ treatments.

DISCUSSION

Supplementing dietary nano-Se significantly improved both the final body weight and the body weight gain of the broiler chickens from 0-7 weeks of the experiment. This means supplementation of this mineral was better utilised. This might be because of the attributes of nanoparticles which include high catalytic efficiency, larger surface area and strong adsorbing ability as reported by Zhang *et al.*[11] thus, allowing the mineral to enter the bloodstream and improve these parameters. The improvement observed in the final weight and weight gain with Nano Se supplementation at and above 0.15 mg kg^{-1} feed could mean that these levels are most adequate for these parameters. Alabi *et al.*[12] reported that different dietary levels of nutrients optimized different parameters. These findings were similar to those of Salim *et al.*[13] who recorded significant differences in both the final body weight and body weight gain of broiler chickens at 0-7 weeks of the experiment. Similarly, studies by Khan *et al.*[14] showed a significant increase in body weight and body weight gain in Ross broiler chicks given supplemental selenomethionine (Se-Met) and nano-Se diets when compared with birds in groups fed selenite selenium (SeS). They discovered that when Se-Met or nano-Se was added to diets, there was an increase in body weight and gain in proportion to the increase in dietary Se levels.

Supplementation of nano-Se in the diet of broiler chicks showed a significant difference in the feed intake across the treatment groups of birds aged 0-7 weeks. This could be due to the numerous roles selenium plays in the growth[1,15] of broiler birds as studies have shown tremendous improvement in the growth of broiler chickens fed selenium-supplemented diets. This was similar to the results obtained by Yang *et al.*[16] and Ravindran and Elliott[17] who reported higher feed intake in dietary Se supplemented groups of broiler chickens. On the other hand, studies carried out by Cai *et al.*[2] and Liu *et al.*[18] showed no significant differences in the F.I of broiler chickens aged 0-8 weeks supplemented with dietary nano-Se. This may have to do with the environment in which the authors carried out their studies as it has been established that at low temperatures, the birds eat more while at high temperatures, the birds eat less.

Supplementing nano-Se in the diets of broiler birds significantly affected their mortality rate. Birds fed the basal diet recorded higher mortality rates than those birds in the nano-Se supplemented group. This could be due to the differences in the form of Se in the diet as higher absorption and assimilation rates which subsequently increase the level of the immune system of birds have been reported in nano-Se diets compared to either organic or inorganic forms.

Many studies have been carried out on the relationship between selenium and growth performance[19,20], carcass characteristics[21,22] and haematological parameters[23], but there is a paucity of data on the effect of nano Se dietary supplementation on the apparent nutrient digestibility of broiler chickens.

In the present study, the varying levels of dietary nano Se had an influence on the apparent nutrient digestibility of broiler birds both at the starter and finisher phases of the experiment.

At the starter phase, chickens fed supplemental nano Se diet had higher dry matter (DM) digestibility implying that chickens were able to digest the DM more compared to those fed the basal diet. Furthermore, the chickens fed $NSe_{0.15}$, $NSe_{0.20}$ and $NSe_{0.25}$ diets had higher crude protein digestibility values weight gain observed in birds fed nano selenium supplemented diets since proteins are known to improve the growth of chickens and the numerous roles played by selenium in the growth of poultry birds have been reported by Yoon *et al.*[1].

Broiler chickens fed nano Se supplemented diets had higher DM digestibility than the birds fed basal diet during the finisher phase. A similar trend was observed for crude fibre (CF) as birds on nano Se supplemented diets digested the CF more than those in the control group. This could be due to monogastric species' high intestinal selenium absorption, which is highly dependent on the form of selenium in the diet[24].

In the present study, the supplementation of dietary nano Se in the feed of broiler chickens significantly improved spleen, immunoglobulin G, Ig G and immunoglobulin A, Ig A. This could be attributed to the enhanced activity of cytokines as a result of nano Se supplementation. Nano minerals have been reported to possess a larger surface area, larger active surface centres, more catalytic efficiency, transfer capability and higher surface absorption and stability than other forms of selenium, resulting in a better immunological response[25]. When these cytokines are released, there is an improvement in nutrient absorption and cell development leading to the production of immunogenic chemicals[26]. This was in agreement with Zhang *et al.*[27] who reported that the supplementation of Se in chicken diets improved their immunological parameters. However, these results were contrary to those of Rao *et al.*[28] who reported that supplementing various concentrations (0, 100, 200, 300 or 400 μg kg^{-1} diet) of organic Se to broiler chickens did not influence the production of antibodies that are specific for Newcastle disease virus vaccine. The differences might be because the authors were interested mainly in Newcastle disease.

Furthermore, the supplementation of dietary nano Se at 0.20 mg kg^{-1} diet led to the improved relative weight of the spleen of broiler birds. This could be due to the fast speed of nanomaterial transport and uptake compared to other forms seen in the basal diet. This improves the performance of lymphoid organs by increasing the activity of glutathione peroxidase[29]. This finding was in agreement with that of Shabani *et al.*[30] who recorded a significant improvement in the spleen of broiler chickens fed dietary nano Se. On the contrary, Swain and Johry[31] and Cai *et al.*[2] revealed no significant differences in the relative weight of the spleen in broiler chickens fed varying levels of dietary nano Se. This may be due to the higher supplementation of nano Se made by these authors.

Supplementing dietary nano Se in the diet of broiler birds at the rate of 0.20 mg kg^{-1} diet led to a significantly lower IgA of broiler birds compared to birds fed the basal diet. The IgA is the first line of defence in the resistance against infection. This might imply that the birds when not diseased, thus, there was no need for its production. Selenium is well known to have an influence on the immune response of broiler chickens and when administered in a nano form, there is increased absorption and transport. This was in agreement with the result obtained by Dalia *et al.*[32] who also reported a significant difference in the Ig A while studying the influence of bacterial organic selenium on certain parameters of broiler chickens. However, nano selenium-supplemented diets had no significant effect in the immunoglobulin A of broiler chickens[2]. The results of this research show that nano selenium is better utilised by broiler chickens as against its conventional forms as a result of its high absorbing ability and large surface area. The information gotten from this study may be useful in formulating and preparing the feeds of broiler chickens. Based on the results of the findings, it is recommended that 0.20 mg kg^{-1} diet of nano selenium should be included in the diet of broiler chickens.

CONCLUSION

The results of the experiment showed that supplementing nano selenium in the diet of broiler chickens affected their growth performance, nutrient digestibility and immunological parameters. The growth parameters were positively influenced by the supplementation of nano selenium. There was also a diets at both starter and finisher phases. Furthermore, chickens fed an $NSe_{0.20}$ mg kg^{-1} supplemented diet had better immune response compared to those chickens fed the basal diet.

SIGNIFICANCE STATEMENT

The research gives insight into the effects of varying dietary levels of nano-selenium on the growth and immunological performance of broiler chickens. There is paucity of data on the effect of selenium in the humoral immunity of poultry and pigs. Only a few studies have found a beneficial effect of dietary Se supplementation in chickens on the production of particular antibodies by Infectious Bursal Disease (IBD) vaccines. This may be due to the form in which the selenium was supplemented to the diet of the experimental animals. The information from this study may be useful in formulating and preparing the feeds for chickens as nano-selenium has been proven to possess strong absorbing ability as against its conventional forms.

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