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Effect of Selenium-based Diets on Zootechnical Performance, Hematological Parameters, and Relative Weight of Internal Organs in Broiler Chickens

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ABSTRACT

Two sources of selenium are commonly used in poultry nutrition, the organic and the inorganic forms. This study was carried out to investigate the comparative effect of Sasso broiler breeder feed supplemented with sodium selenite (SS) and selenomethionine (SM) on the zootechnical performance, hematology, and hatching process of chickens. A total of 120 female broiler breeders and 12 roosters of Sasso strain at 47 weeks were equally assigned to three treatments with four replicates per each, including 10 breeders crossed with 1 rooster. The treatment groups were broiler breeders fed a basal diet without selenium supplementation (control), chickens fed the basal diet supplemented with SS, and breeders fed the basal diet supplemented with SM. The inclusion level of each selenium was 0.2 ppm. The collected data included feed intake and egg weight during 8 weeks. In the end, blood samples were collected for hematological investigations. A total of 150 hatching eggs were collected from each treatment. After recording their weight, the eggs were incubated at adequate temperature and relative humidity. On day 18 of incubation, the eggs were weight again, candled, and transferred into the hatcher. Each egg was individually checked every 3 hours during the last 3 days of incubation for hatching events determination. The results showed that breeders fed SM had the lowest feed conversion ratio. There was an increase in the majority of blood parameters in breeders fed SM, compared to other treatments. The lowest duration of the hatching events was observed with breeders fed SM, and consequently, they had the best hatching rate but without any significant difference in the chicks' quality and their weight of internal organs at the hatch. In conclusion, this study demonstrated that using selenium is beneficial, especially in the organic form, which appeared to be more efficient, compared to the inorganic form.

Keywords: Broiler Chicken, Hatching events, Hematology, Selenomethionine, Sodium selenite

INTRODUCTION

Selenium is an essential element in poultry nutrition, and its bioavailability and efficacy depend on its chemical form (Surai et al., 2018). In fact, egg fertility, hatchability, and post-hatch performance are related to the breeds, age of the flock, or incubation conditions of eggs (King'ori, 2011). Moreover, embryonic growth and normal development might also depend on the supply of all required nutrients within the egg, and this supply of nutrients originates from the maternal diet (Wilson, 1997). Nevertheless, nutrient deficiencies or their surplus in poultry nutrition causes serious problems, such as a reduction in chickens' growth and egg production. According to Wilson (1997), the deficiencies or excess of selenium may cause cessation of egg production, and consequently affect embryo development negatively. Due to the relationship between offspring's performance and the maternal diets of poultry, several studies have focused on the improvement of the breeder's nutrition (Kidd, 2003; Aigueperse et al., 2013). As Alagawany et al. (2021a, b) mentioned, delivering a proper amount of minerals to chickens' bodies is important for optimum health and physiological functions. Therefore, there has been a growing interest in the supplementation of poultry diets with some micronutrients. Among the vital trace elements

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required for the body's normal functioning, selenium has a significant role in maintaining optimal health (Muhammad et al., 2016). Hegazy and Adachi (2000) noted that selenium supplementation in poultry feed increases antibody production. Many studies have investigated the comparative effects of the two forms of selenium supplementation in poultry feed on reproductive and growth performances (Mikulski et al., 2009; Delezie et al., 2014; Maja et al., 2018). Traditionally, selenium was used in its inorganic form (sodium selenite) in poultry feeding, but nowadays, there is a growing interest in its organic form. Studies have revealed that the supplementation of organic selenium, especially L-selenomethionine, positively affected poultry performance (Mahmoud and Edens, 2003). Additionally, L-selenomethionine has indicated a higher selenium transfer into the eggs compared to sodium selenite and selenium yeast (Delezie et al., 2014). Similar to this finding, Maja et al. (2018) found that L-selenomethionine supplementation was the best method for the enrichment of selenium in the egg since it could be considered an excellent source of highly bioavailable selenium in the human diet. Despite several studies conducted on the effect of sources of selenium on commercial broilers, there is a paucity of information on the effects of selenium-based diets on broiler breeders, particularly on their hatching and post-hatch quality. Therefore, the present study aimed to compare the performance of breeders fed different sources of selenium in terms of their zootechnical and hematological parameters as well as their progeny performance.

MATERIALS AND METHODS

Study design

The experiment was conducted at Ayodele poultry farm. The experiment lasted 8 weeks, from September to November 2020, with an average temperature of 27°C. A total of 120 breeder hens and 12 roosters of 47 weeks of age from the Sasso strain were assigned to 3 treatment groups. Each treatment had 4 replicates of 10 breeders and 1 rooster each. Four weeks adaptation period was observed during which the experimental broiler breeders were fed a diet without selenium supplementation. The chicks were fed a basal diet (granulated form) without selenium supplementation during an adaptation period of 4 weeks. After that period, two sources of selenium were supplemented to the breeders' diet at 0.2 mg/kg of feed. The two types of selenium were provided by ORFFA additives Bv (Netherlands). The dietary treatments were breeders fed a basal diet with no selenium supplemented (Control), breeders fed a basal diet with sodium selenite (SS), and breeders fed a basal diet with selenomethionine (SM). The roosters were fed a diet with no selenium supplementation. All the breeders were fed according to the recommendation of the Sasso breeder's feeding program (Table 1). The chickens were raised in an opened poultry house, and water was given *ad libitum* to all the treatments.

Table 1. Breeders feed composition

Ingredients (kg)	Breeders	Rooster
Maize	62	56
Wheat bran	8	28.9
Soya bean	3	0
Soya bean meal	9	0
Lysine	0.2	0.4
Methionine	0.1	0.2
Oyster shell	6	2.5
Brewery by product	5	12
Concentrate	6.7	0
TOTAL	100	100
Nutritional content		
Metabolizable energy (Kcal/Kg)	2734.16	2658.33
Crude protein (%)	16.8	12.79
Fat (%)	3.96	4.04
Crude fiber (%)	4.29	5.38
Lysine (%)	0.92	0.7
Methionine (%)	0.45	0.41
Methionine + Cyst (AAS)	0.66	0.58
Calcium (%)	2.1	0.92
Phosphorous (%)	0.51	0.49

Data collection

Performance parameters

From the first week of the dietary selenium supplementation to the end of the trial, daily feed intake and the average weight of eggs laid daily were determined per treatment. The data were then used to calculate the feed conversion ratio (FCR) using the following formulas.

Daily feed intake per bird = Weight of feed giving - weight of the leftover / Number of birds

Average egg weight = Total weight of daily egg collected / Number of eggs collected

FCR = Daily feed intake / Average egg weight

Hematology

At the end of the experiment, 2 ml of blood was collected randomly from the jugular vein of six breeders per treatment using a syringe of 5 cc. The blood samples were collected into a set of sterilized bottles containing ethylene diamine tetraacetic acid (EDTA) for the determination of hematological parameters, such as packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC), and hemoglobin concentration (HGB).

Hatching events evaluation

On the 18 days of incubation, all the eggs were individually candled, and the fertile eggs were transferred to the hatcher under controlled temperature and humidity conditions. From the 457 hours to the 502 hours of incubation, all the eggs were individually checked every 2 hours for internal piping (IP), external piping (EP), or hatching. Then, the time interval between IP-EP, EP-Ha, and IP-Ha was calculated to determine the duration of each event.

Relative organs weight

A total of six hatched chicks per treatment were at hatch. They were weighed individually and were sacrificed through cervical dislocation. Organs, such as liver, yolk sac, and heart, were removed and weighed. Their relative weight was determined through the formula below.

Organ proportion (calculated as relative organ weight) = Weight of organ / Live weight of chick x 100

Statistical analysis

The statistical analysis of the data was performed using Graph pad prism version 8.0.2 as a statistical package. Data obtained were expressed as mean ± SEM and they were compared using a one-way analysis of variance. Tukey test was then used to find means that are significantly different from each other. The differences were considered statistically significant at $p < 0.05$.

RESULTS

Performance and egg weight of chickens

Table 2 shows the effect of selenium-based feed supplementation on the daily feed intake per breeder, egg weight, and FCR of broiler breeders. The dietary treatments significantly affected all mentioned parameters ($p < 0.05$). The feed intake was significantly higher in the breeders fed SS ($p < 0.05$), and the lowest was observed with the control. The egg weight of SM breeders was significantly higher than those of the SS group ($p < 0.05$), but comparable to those of the control group. The FCR of SS breeders was higher than those of SM and the control group, whose values were similar ($p > 0.05$).

Hematological parameters of chicks

The result of the hematology profile is presented in Table 3. The analysis of variance showed that the different sources did not significantly affect most of the leucocyte counts ($p > 0.05$). However, the basophile percentage was significantly influenced by the dietary selenium supplementation ($p < 0.05$). The control group had the highest basophil concentration, while the SS group observed the lowest. The WBC measurements showed no significant difference ($p > 0.05$) between the control and SM group. Nevertheless, the blood cell counts, such as WBC, RBC, HGB, and PLT, were affected by the dietary supplementation of selenium. The WBC, RBC, and HGB were significantly higher ($p < 0.05$) in SM group, while PLT was significantly lower ($p > 0.05$) in the same group.

Duration of hatching events

The incubation parameters duration is shown in Table 4. Selenium did not significantly affect the duration of IP occurrence and the total incubation duration ($p > 0.05$). However, the EP and hatching durations were significantly influenced by the sources of selenium ($p < 0.05$). The EP duration was shorter ($p < 0.05$) in the SM breeders, compared to the control group, while the EP of SS breeders was similar ($p > 0.05$) to that of the control and SM groups. The shortest hatching duration was recorded in the SM group, and the highest value in the SS group ($p < 0.05$). There was no significant difference between SS and control groups in terms of hatching duration ($p > 0.05$).

Chicks' quality at the hatch

The supplementation of breeders' diets with different sources of selenium significantly affected the hatching rate ($p < 0.05$). Chicks from breeders fed the organic selenium had the highest rate, and the control group had the lowest. No difference was observed in the chicks' quality at hatch (Table 5).

Organs' weight of chick at the hatch

The effect of selenium-based feed supplementation on chicks' organ relative weight at hatch is shown in Table 6. The treatments showed no significant difference in chicks' weight at hatch ($p > 0.05$). The bursa, heart, yolk sac, and chicks' weight without yolk sac were not affected by the dietary treatment. However, the relative weight of the liver was significantly influenced by the dietary selenium inclusion in the breeders' diet, with the SM group having the highest relative weight ($p < 0.05$).

Table 2. Effect of diets supplemented with two dietary sources of selenium on daily feed intake per breeders per day, egg weight and feed conversion ratio

Parameters \ Treatments	Control	SS	SM	P-value
FI (g)	118.9 ± 0.64^{c}	123.1 ± 0.41^{a}	120.6 ± 0.32^{b}	0.4084
Egg weight (g)	55.00 ± 0.86^{ab}	52.79 ± 0.97^{b}	56.92 ± 0.98^{a}	0.0107
FCR	2.16 ± 0.01^{b}	2.31 ± 0.04^{a}	2.10 ± 0.01^{b}	<0.0001

[abc] Means in the same row with different subscripts are significantly different at $p < 0.05$. SS: Sodium Selenite, SM: Selenomethionine: FI: Feed Intake: FCR: Feed conversion ratio

Table 3. Effect of diets supplemented with two dietary sources of selenium on the hematological parameters of broiler chickens

Parameters \ Treatments	Control	SS	SM	P-value
WBC ($10/^{9}$L)	134.5 ± 0.16^{b}	151.9 ± 11.70^{b}	183.6 ± 1.68^{a}	0.0009
Lymp (%)	33.50 ± 5.92	34.75 ± 7.46	44.50 ± 5.62	0.4443
Mono (%)	14.00 ± 3.49	7.50 ± 4.66	4.00 ± 2.45	0.1999
Oesino (%)	9.75 ± 2.25	13.75 ± 4.96	11.50 ± 2.22	0.7144
Neut (%)	28.75 ± 6.97	33.75 ± 8.09	37.75 ± 4.70	0.6521
Baso (%)	3.5 ± 2.26^{a}	0.57 ± 0.12^{b}	2.00 ± 0.77^{ab}	0.0438
HGB (g/dl)	10.90 ± 0.25^{b}	11.43 ± 0.67^{b}	13.40 ± 0.06^{a}	0.0026
RBC (10^{12}/L)	1.93 ± 0.01^{c}	2.26 ± 0.15^{b}	2.76 ± 0.02^{a}	<0.0001
MCV (fL)	133.5 ± 2.27	127.0 ± 1.96	129.9 ± 2.90	0.2203
MCHC (g/dl)	33.53 ± 0.33	33.60 ± 0.22	44.80 ± 12.53	0.8030
PCV (%)	35.25 ± 1.69	31.15 v 1.48	32.48 ± 1.29	0.1978
PLT (%)	178 ± 1.67^{a}	117.7 ± 30.02^{ab}	$63. \pm 0.95^{b}$	0.0020

[abc] Means in the same row with different subscripts are significantly different at $p < 0.05$. SS: Sodium Selenite, SM: Selenomethionine. WBC: White blood cell, Lymp: Lymphocyte; Mono: Monocyte, Oesino: Oesinophile, Neut: Neutophile, Baso: Basophile, HGB: Hemoglobin, RBC: Red blood cell, MCVMean corpuscular volume, MCHC: Mean corpuscular hemoglobin concentration, PCV: Packed cell volume, PLT: Platelet

Table 4. Effect of diets supplemented with two dietary sources of selenium on hatching events duration

Parameters (Hours) \ Treatments	Control	SS	SM	P-value
Internal piping	9.95 ± 0.70	10.70 ± 0.83	8.75 ± 0.75	0.2073
External piping	17.19 ± 0.79^{a}	15.25 ± 0.79^{ab}	13.95 ± 0.92^{b}	0.0220
Hatching	23.38 ± 0.83^{a}	23.74 ± 0.79^{a}	19.62 ± 1.32^{b}	0.0078
Incubation	486.9 ± 0.81	486.0 ± 0.75	485.2 ± 0.78	0.3357

[ab] Means in the same row with different subscripts are significantly different at $p < 0.05$. SS: Sodium Selenite, SM: Selenomethionine, FI: Feed Intake, FCR: Feed conversion ratio.

Table 5. Effect of diets supplemented with two dietary sources of selenium on chicks' quality at hatch

Parameters (Hours) \ Treatments	Control	SS	SM	P-value
Hatching rate (%)	56.10 ± 0.06^{c}	83.12 ± 0.01^{b}	88.00 ± 0.23^{a}	<0.0001
Chicks' quality (%)	90.20 ± 2.26	88.80 ± 1.72	87.00 ± 2.65	0.6451

[abc] Means in the same row with different subscripts are significantly different at $p < 0.05$. SS: Sodium Selenite, SM: Selenomethionine, FI: Feed Intake, FCR: Feed conversion ratio

Table 6. Effect of diets supplemented with two dietary sources of selenium on chicks' organs relative weight at hatch

Parameters (Hours) \ Treatments	Control	SS	SM	P-value
Weight at hatch (g)	38.66 ± 3.20	35.95 ± 1.87	37.17 ± 4.62	0.8566
Bursa (g)	0.11 ± 0.01	0.10 ± 0.01	0.11 ± 0.01	0.8809
Heart (g)	0.79 ± 0.05	0.63 ± 0.01	0.77 ± 0.13	0.3708
Liver (g)	2.36 ± 0.09^{a}	1.85 ± 0.13^{b}	2.20 ± 0.15^{a}	0.049
Yolk (g)	10.96 ± 1.08	13.71 ± 1.34	12.58 ± 1.71	0.4299
Chick weight without yolk sac (g)	81.16 ± 1.52	80.21 ± 0.79	80.35 ± 2.56	0.9212

[ab] Means in the same row with different subscripts are significantly different at $p < 0.05$. SS: Sodium Selenite, SM: Selenomethionine

DISCUSSION

The present study aimed to compare the effect of broiler breeders' diets supplemented with two sources of selenium (organic and inorganic) on the zootechnical and hematology parameters, hatching parameters, and chicks' internal organs' relative weight at the hatch. Generally, dietary selenium supplementation could significantly affect the performance parameters. Although breeders fed SS had the highest feed intake, their egg weight was the lowest. The best FCR was observed with breeders fed with the organic selenium indicating that the metabolism pathways of the two kinds of selenium are different, as previously shown by several other authors (Lyons et al., 2007; Surai and Fisinin, 2014; Brandt-Kjelsen et al., 2017). As stated by Marković et al. (2018), the organic forms of selenium-containing selenomethionine (Se-Met) and selenocysteine (Se-Cys) play a key role in biological processes since they are more active and less toxic, have higher bioavailability, and accumulate at higher levels in all tissues, compared to the inorganic form of selenium. Similarly, Whanger (2002) mentions that selenium is better absorbed in the organic form. Selenomethionine is made of methionine (an essential amino acid precursor of protein synthesis) and selenium, with the mean concentration of proteins being 12.5 g per 100 g of whole raw fresh egg (Réhault-Godbert et al., 2019). Although breeders fed with SM consumed a lower amount of feed, the average weight of their eggs was higher. The methionine contained in the SM probably participated in the constitution of the egg protein. However, the obtained results of the current study are not in accordance with that of Attia et al. (2010), indicating no significant difference in the sources of selenium but a significant difference in the level of supplementation while comparing the effect of the breeders' diet supplemented with SM and SS on the egg weight. In the present study, selenium supplementation significantly affected the total RBC, WBC, and HGB, and the highest values were obtained in the Selenium groups, especially the SM group. This result demonstrated that selenium supplementation had no adverse effect on the health status of the breeders. In contrast, it improved their well-being, especially those fed diets supplemented with SM. This was illustrated by the best zootechnical performances observed with the SM group. In addition, it has been shown by Altan et al. (2000) that the exposure of broilers to a stress condition, especially temperature, decreases blood parameter concentration. The highest concentrations observed in the present study with the selenium group revealed the anti-stress role of selenium. However, the findings of the present study contradicted those of Liu et al. (2019), indicating a non-significant effect of selenium supplementation on hematological parameters despite its high level (3 mg of selenium yeast per kg of feed). The difference in the results might be attributed to the selenium content of the basal diet. According to Gupta and Gupta (2000) and Surai (2007), selenium content in different soils usually varies from 0.1 to 2 mg/kg but with slight deviations from this indicator. Thus, tropical and subtropical soils contain relatively high levels of selenium greater than 0.30 mg/kg. The average selenium concentration in temperate and desert soils is between 0.14 and 0.30 mg/kg, while its concentration in a temperate and humid climate is deficient (less than 0.12 mg/kg, Tan et al., 2002).

The improved performance observed with the organic selenium in terms of the performance and hematological parameters significantly influenced the incubation performance. The hatching process is a stressful period for hatching chicks. This stress is accompanied by the production of free radicals, which alter the normal progression of the hatching process. The best hatching process observed with the SM group was indicative of the antioxidant capacity attributed to organic selenium, although no significant effect between organic and inorganic selenium was observed on the hatched chicks' quality.

The comparison of diets supplemented with different sources of selenium showed no significant difference in the internal organs except the liver's relative weight, which was significantly higher in the SM group. Consequently, chicks from this group will probably perform well after hatch. According to Zaefarian et al. (2019), the heavy liver size of broilers during the early post-hatch leads to efficient nutrient metabolization due to lower feed intake and endogenous enzyme secretion.

CONCLUSION

The present study evaluating the efficiency of broiler diets supplemented with two sources of selenium showed that the zootechnical and hatching egg performance of chicks has improved with the organic selenium. In fact, the organic form had a positive effect on the hematological parameters, leading to a positive effect on feed conversion ratio and then incubation parameters, such as hatching events length and hatching rate. Briefly, this study demonstrated that organic selenium supplementation has an impact on the physiological activities of broiler breeders. This could indicate a probable transfer of selenium in the hatching eggs and its effect on the developing embryo. Therefore, there is a need to evaluate the egg quality, the welfare of the developing embryo, and the subsequent performance of the progeny of broiler breeders fed organic selenium, compared to non-organic selenium supplementation.

DECLARATION

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Authors' contribution

This research work was designed and carried out by Kwassi Tona with the contributions of the above-mentioned co-authors. Wéré Pitala validated the protocol and the final version of the manuscript, Souglman Fiougou helped with fieldwork and data collection, Amen Ayawo Nenonene contributed to the design and statistical analysis, while Emmanuel OKE and Adeboye Fafiou assisted in the revision of the manuscript. All authors read and approved the final manuscript.

Competing interests

The author declares no existence of any form of conflict of interest related to this manuscript. There are also no financial, personal, or other relationships with other people or organizations related to this study.

Ethical consideration

All authors have checked the ethical issue, such as plagiarism, consent to publish, data fabrication and falsification, and redundancy.

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