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## Research Article

# EFFECTS OF DIETARY SUPPLEMENTATION OF INORGANIC, ORGANIC AND NANO SELENIUM ON MEAT PRODUCTION AND MEAT QUALITY PARAMETERS OF A DUAL PURPOSE CROSSBRED CHICKEN

**PRASOON S.[1*], JAYANAIK[2], MALATHI V.[3], NAGARAJ C.S.[4] AND NARAYANASWAMY H.D.[5]**
[1,2]Department of Poultry Science, Veterinary College, Bangalore, 560024, Karnataka Veterinary Animal and Fisheries Sciences University, Bidar, 585401, India
[3]Department of Livestock Production Management, Veterinary College, Bangalore, 560024, Karnataka Veterinary Animal and Fisheries Sciences University, Bidar, 585401, India
[4]AICRP on Poultry, Veterinary College, Bangalore, 560024, Karnataka Veterinary Animal and Fisheries Sciences University, Bidar, 585401, India
[5]Karnataka Veterinary Animal and Fisheries Sciences University, Bidar, 585401, Karnataka, India
*Corresponding Author: Email- prasoon@kvasu.ac.in

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**Abstract:** An experiment was conducted at Department of Poultry Science, Veterinary College, Bangalore to evaluate meat production parameters of Giriraja dual purpose chicken reared in deep litter system under standard management conditions fed on different sources and levels of selenium in feed. 384 straight run Giriraja day old chicks were equally allotted to eight treatment groups having four replicates in each. Control group (T1) was fed on basal broiler diet without added selenium in premix. Experiment group T2 and T3 were fed on basal diet enriched with 150 and 300 ppb sodium selenite, while feed for T4 and T5 were enriched with 150 and 300 ppb selenium yeast respectively. Nano selenium at 50, 150 and 300 ppb levels were added to basal diet to form feed for T6, T7 and T8. Live weight, feed intake, feed conversion ratio and dressing yield at 8 weeks of age was not influenced by selenium supplementation. Drip loss was decreased ($P \leq 0.05$) by dietary supplementation of selenium yeast at 150 ppb (1.81) and nano selenium at 300 ppb (1.60) and 50 ppb (2.07) and 300 ppb (1.83) levels than negative control (2.62). Cooking loss was reduced ($P \leq 0.05$) by supplementation of selenium yeast at 300 ppb (4.56) and nano selenium at 50 ppb (5.66), 150 ppb (5.27) and 300 ppb (4.65) levels than the negative control (8.63). Organic and nano selenium supplementation improved water holding capacity of meat while production parameters and carcass characteristics were not affected.

**Keywords:** Selenium, Nano selenium¸ Organic Selenium, Carcass yield, Drip loss

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## Introduction

Commercial poultry are developed by intense selection and breeding strategies since last seven decades for efficient and optimum production performance. Further improvement in production is possible through nutritional and managemental interventions. Supplementation of essential nutrients helps in improving the productive performance of chicken. Micronutrients or trace minerals have vital role in numerous metabolic, enzymatic and biochemical reactions ultimately leading to improved growth rate, production performance and feed efficiency. Trace minerals play a very important role in the mechanism of nutrient circulation in the animal body. Deficiency or imbalance of any one or more micronutrients results in deficiency disease, metabolic disorders, poor growth rate and low production. Selenium (Se) is a biologically important trace mineral having a plethora of biological functions in the living system [1], and have a major role as a part of selenoproteins in biological system. Research on Se has attracted interest because of its essentiality in biological system along with low tolerance level in animals. As a part of Glutathione peroxidase, it is an integral part of antioxidant system of body [2], which determines antioxidant status of birds and animals by reducing lipid peroxidation in tissue [3]. Reduced tissue peroxidation maintains stability of proteins and maintains cell membrane integrity. Similarly, Selenium enhances metabolism of thyroid hormones, which are important for normal growth and development of animals [4, 5]. Selenium content of feed ingredients may vary depending on the Se level in the cultivated soil [6] and the fertilizers used.

Food and Drug Administration, USA [7] approved the use of selenium as sodium selenate or selenite in poultry feed at levels of 0.3 mg/kg while NRC, 1994 approved usage of 0.15 mg/kg Se in feed. Inorganic selenium is poor in absorption, less efficient in transferring to meat and eggs, and to supply and maintain selenium reserve in the body [8]. Nowadays less toxic better bioavailable organic forms of selenium are used widely in feed industry as a source of Se. Selenoproteins such as Selenocysteine and selenomethionine are absorbed via an active amino acid transport mechanism in body [9], whereas, selenite is absorbed by simple diffusion [10]. Nano-materials having size in nanoscale at least in one dimension may have different physical and chemical characteristics compared to the inorganic bulk material [11] and various studies are undergoing nowadays to explore their efficiency, efficacy and adverse effects as a feed additive for livestock and poultry. Nano-materials exhibit novel properties, like high surface activity, great specific surface area, lot of surface active centers, and high catalytic efficiency [12]. Due to both high surface reactivity and advantage of size effect, nanoparticle has been already used in pharmaceutical applications to increase the bioavailability of drugs and for targeting therapeutic agents to particular organs [13]. It has been reported that nanoparticles showed new characteristics of transport and uptake and exhibited higher absorption efficiencies than their conventional counterparts [14]. The current study was designed to compare efficiency of sodium selenite, selenium yeast and nano selenium on meat characteristics and meat quality of Giriraja Chicken.

## Materials and Methods

An experiment was conducted at Department of Poultry Science, Veterinary College, Bangalore to evaluate the effects of supplementation of various sources and levels of selenium on meat characteristics and meat quality of Giriraja chicken reared on broiler diet [1] up to 8 weeks. A total of 384 Giriraja day old chicks were randomly distributed to 8 treatment groups having four replicates in each in a randomised block design and fed on various levels of Se [Table-1] by means of Sodium selenite (SS), selenium yeast (SY) and nano selenium (NS). Treatment groups were fed on broiler prestarter up to 21 days, starter from 22 to 42 days and finisher from 43 to 56 days, respectively. Two birds each from a replicate were slaughtered at 8th week to analyse carcass yield and meat quality parameters.

Table-1 Description of the experimental groups, sources and levels of selenium supplemented

| Experiment group | | Experiment Diet | Levels of Se |
|---|---|---|---|
| $T_1$ | Control | Basal diet | Nil |
| $T_2$ | SS150 | Basal diet + SS | 150 ppb |
| $T_3$ | SS300 | Basal diet + SS | 300 ppb |
| $T_4$ | SY150 | Basal diet + SY | 150 ppb |
| $T_5$ | SY300 | Basal diet + SY | 300 ppb |
| $T_6$ | NS50 | Basal diet + NS | 50 ppb |
| $T_7$ | NS150 | Basal diet + NS | 150 ppb |
| $T_8$ | NS300 | Basal diet + NS | 300 ppb |

### Growth Performance

Body weight and feed intake were measured using a digital weighing balance and feed conversion ratio (FCR) was calculated.

### Carcass Yield

Weight of the carcass, breast muscle, thigh muscles and abdominal fat were measured by using a digital balance and expressed as per cent live weight.

### Drip Loss

Carcass drip loss was calculated by using fresh meat sample as per the method described by Honikel (1998) [15]. Breast muscles of uniform size were weighed and suspended in hanging position in a fastened air filled plastic bag using metal hooks. Bag containing suspended meat samples were kept at 40C for 24 hours. Meat samples were blotted dry and weighed. Drip loss was expressed as a percentage loss of the initial weight and calculated by the formula,

Drip loss= [(Initial weight-Final weight)/Initial weight] X100

### Cooking Loss

Breast muscles of uniform size were individually weighed and packed in heat resistant cooking bags. These bags were placed in a continuously boiling water bath, with the bag opening extending above the water surface for 20 to 30 minutes. When the samples attained an internal temperature of 75°C, samples were removed from the water bath, cooled in ice slurry and held in chilled conditions (1 to 5°C) until equilibrated. The meat is then taken out of the bag, blotted dry and weighed. The cooking loss is expressed as per cent loss from the initial sample weight [15].

Cooking loss= [(Initial weight-Final weight)/Initial weight] X100

### Statistical Analysis

The data collected were analyzed statistically by ANOVA using SPSS 20 statistical software as per the method described by Snedecor and Cohran (1994) [16] at 5 per cent confidence level.

## Results and Discussion

### Growth Performance

Body weight, feed intake and FCR at 8th week was not influenced by selenium supplementation [Table-2] which may be due to the balanced diet supplemented to all treatment groups. The results obtained in this study agreed with earlier studies [17-19] where no significant change in body weight of chicken was noticed as influenced by dietary supplementation of organic selenium in comparison to inorganic selenium. Supplementation of nano selenium also did not produce any significant difference in cumulative body weight of Giriraja birds which agreed with the earlier reports [20, 21, 22] of similar body weight for broiler birds supplemented with organic and nano selenium in feed. Contraictory to the results obtained in the present study Xu *et al*., (2015) [23], Wang *et al*. (2016) [24], Ravindran and Elliott (2017) [25] and Zia *et al*. (2017) [26] reported increased body weight for broilers supplemented with organic source of selenium compared to inorganic source. While Bagheri *et al*. (2015) [27], Mahmoud et al. (2016) [28] and Bakhshalinejad *et al*. (2018) [29] noticed increased body weight gain in chicken supplemented with nano selenium compared to other sources. Cumulative feed intake of iriraja chicken was not affected by supplementation of sodium selenite, selenium yeast and Nano selenium up to 8th week of age. Results in the experiment was in agreement with Gocmen *et al*. (2016) [18], Dalia *et al*. (2017) [19], Moghaddam et al. (2017) [20] and Li *et al*. (2018) [22] who observed no significant difference in feed intake of chicken due to selenium supplementation which might be due to balanced diet fed to all treatment groups. But, higher feed intake in dietary selenium supplemented groups was reported by Bagheri et al. (2015) [27], Ravindran and Elliott (2017) [25] and Zia *et al*. (2017) [26] which was in opposition to the present study. In agreement with the study, Tayeb and Quader (2012) [30] and Da Silva *et al*. (2010) [31] reported that the dietary supplementation of inorganic and organic sources of selenium at varying levels resulted in no significant differences in feed conversion ratio in broiler chicken. Similarly, research conducted by utilising various levels of sodium selenite and organic selenium by Rao *et al*., 2013 [32] (0, 0.1, 0.2, 0.3 and 0.4 mg /kg diet), Rajashree *et al*., 2014 [33] (0.25 and 0.5 mg/kg), Dalia *et al*., 2017 [19] (0.3 mg/kg) and Ravindran and Elliott, 2017 [25] (0.3 mg/kg) reported no significant difference in FCR between treatment groups. Similar FCR was reported for broiler birds reared both in thermoneutral and heat stressed environment when supplemented with 0, 0.5 and 1 mg/kg Se in feed [17]. Study on FCR in broilers as influenced by nano selenium supplementation at 0.0, 0.3, 0.5, 1.0, or 2.0 mg/kg to the basal diet by Cai *et al*. (2012) [34] revealed no significant difference between treatments. Moghaddam *et al*. (2017) [20] and Li *et al*. (2018) [22] supplemented 0.3 mg Se/kg as organic selenium and nano selenium in chicken feed and observed no significant difference in FCR.

Table-2 Effect of supplementation of SS, SY and NS on Production Parameters of Giriraja chicken at 8 weeks of age

| Treatment groups | Body weight | Feed intake | FCR |
|---|---|---|---|
| $T_1$ (control) | 1445.25±15.70 | 3056.00±1.48 | 2.18±0.02 |
| $T_2$ (SS150) | 1453.64±25.36 | 3052.40±1.68 | 2.17±0.04 |
| $T_3$ (SS300) | 1472.78±24.04 | 3051.35±1.56 | 2.13±0.04 |
| $T_4$ (SY150) | 1509.85±30.32 | 3052.94±1.27 | 2.08±0.04 |
| $T_5$ (SY300) | 1528.06±18.34 | 3052.92±1.94 | 2.05±0.02 |
| $T_6$ (NS50) | 1453.67±25.72 | 3053.54±1.28 | 2.16±0.04 |
| $T_7$ (NS150) | 1483.77±38.39 | 3052.31±2.66 | 2.12±0.05 |
| $T_8$ (NS300) | 1507.36±13.66 | 3052.65±2.57 | 2.08±0.02 |

### Carcass Yield

Carcass characteristics of Giriraja chicken studied on 56th day did not differ significantly due to supplementation of sodium selenite, selenium yeast and nano selenium [Table 3]. Average defeathered weight per cent, dressed weight per cent, Ready to cook yield per cent, breast meat yield per cent, thigh yield per cent and abdominal fat per cent was similar between treatment groups which may be due to balanced basal diet. This result agreed with many previous studies conducted using inorganic, organic and nano selenium. Earlier research conducted by using inorganic and organic source of selenium at varying concentrations between 0.1 to 0.9 mg/kg in feed by Tayeb and Quader (2012) [30], Yang *et al*. (2012) [35], Chen *et al*., (2014) [36] and Rajashree et al. (2014) [33] reported similar average values for carcass yields and dressing per cent between experiment groups.

Table-3 Effect of supplementation of SS, SY and NS on Carcass yield

| Treatment groups | | Defeathered weight (%) | Dressed weight (%) | Ready to cook yield (%) | Breast meat yield (%) | Thigh yield (%) | Abdominal Fat (%) |
|---|---|---|---|---|---|---|---|
| T1 | Control | 83.69±0.41 | 68.55±0.48 | 73.69±0.44 | 10.40±0.17 | 6.39±0.10 | 1.59±0.11 |
| T2 | SS150 | 83.76±0.40 | 66.88±0.49 | 72.36±0.54 | 10.58±0.41 | 6.53±0.09 | 1.56±0.27 |
| T3 | SS300 | 83.46±0.74 | 68.62±0.35 | 73.67±0.31 | 10.67±0.26 | 6.42±0.11 | 2.13±0.25 |
| T4 | SY150 | 83.15±0.43 | 68.05±0.46 | 72.93±0.47 | 10.50±0.32 | 6.16±0.15 | 2.42±0.30 |
| T5 | SY300 | 83.11±0.39 | 68.59±0.91 | 73.86±0.83 | 10.93±0.25 | 6.39±0.13 | 1.36±0.31 |
| T6 | NS50 | 82.18±0.48 | 67.26±0.94 | 72.29±0.85 | 10.41±0.23 | 6.23±0.14 | 1.59±0.21 |
| T7 | NS150 | 84.19±0.86 | 68.35±0.98 | 73.32±0.91 | 10.77±0.40 | 6.17±0.09 | 1.91±0.51 |
| T8 | NS300 | 84.77±0.82 | 67.98±0.68 | 73.19±0.52 | 10.73±0.32 | 6.31±0.05 | 1.65±0.21 |

Bagheri et al. (2015) [27] and Moghaddam *et al*. (2017) [20] reported similar results with both nano and organic selenium at 0.3 or 0.5 mg/kg in feed in which selenium supplementation did not affect carcass traits and organ weights of broiler chicken. Jokic *et al*. (2009) [37] and Rao *et al*. (2013) [32] reported no significant influence in ready to cook yield as influenced by supplementation of organic selenium to broiler chicken at varying levels. Selim et al. (2015) [38] observed results opposing the current study where they evaluated the effect of dietary inclusion of inorganic, organic and nano forms of selenium in broiler chicken and stated significantly improved dressing percentage for 0.3 mg/kg nano selenium supplemented group (2.5 % better than inorganic Se). Jokic *et al*. (2009) [37], Rao *et al*. (2013) [32] and Rajashree *et al*. (2014) [33] reported uniform breast meat yield between experiment groups supplemented with 0, 0.3, 0.6 and 0.9 mg Se/kg feed without any significant ($P > 0.05$) difference between groups. Breast muscle yield and thigh muscle yield of broiler chicken were not affected by dietary supplementation of organic selenium compared to inorganic selenium at 0.3 mg/kg level [35] and by supplementation of nano and organic selenium at 0.3 mg/kg [20]. Study conducted by Hosseini-Mansoub (2011) [39] to assess the effects of replacing sodium selenite (SS) by Se-yeast (SY) at 0.1, 0.2 and 0.3 mg/kg in feed for male broilers revealed similar per cent weight for thigh meat and significantly increased weight per cent for breast meat. Mahmoud et al., (2016) [28] reported increased breast meat yield for nano selenium supplemented heat stressed chicken at 0.3 mg/kg selenium in feed. Similarly, Ravindran and Elliott (2017) [25] recorded significantly increased breast meat yield for organic selenium supplemented group. Hosseini-Mansoub (2011) [39], Rao *et al.* (2013) [32], Rajashree *et al*. (2014) [33] and Ravindran and Elliott (2017) [25] observed no significant change in abdominal fat per cent by supplementing various concentrations (0, 100, 200, 300 or 400 ppb Se in diet) of organic selenium in commercial broiler chickens. Safdari-Rostamabad *et al*. (2017) [40] and Mahmoud *et al.,* (2016) [28] reported significant reduction in abdominal fat percentage when heat stressed birds were supplemented with nano selenium in feed. Similarly, significant decrease in abdominal cavity fat was noticed by Bagheri *et al.* (2015) [27] by supplementing 0.5 mg/kg Nano-Se.

## Drip Loss

As shown in Table 4, drip loss was significantly reduced in organic selenium supplemented groups (1.81 and 1.60 respectively for SY150 and SY300) and 300 ppb nano selenium supplemented group (1.83) than the control group (2.62) and sodium selenite supplemented groups (2.57 and 2.58 respectively for SS150 and SS300). This indicated that the selenium supplementation in basal diet reduced drip loss from meat. Similar to current study, Edens *et al.* (1996) [41] and Ravindran and Elliott (2017) [25] recorded reduced drip loss in broiler chicken fed on selenium supplemented feed. Downs *et al*., (2000) [42] observed 17 per cent reduction in cooking loss of chicken breast muscle when sodium selenite was replaced by organic selenium to supply between 0.1 and 0.3 ppm selenium. Similarly, earlier studies by Edens (2001) [41], Choct et al., (2004) [43], Mikulski et al. (2009) [44], Wang et al. (2011) [24] and Yang et al. (2012) [35] reported reduced drip loss from broiler meat due to dietary supplementation of organic selenium in the form of selenomethionine than sodium selenite. Cai *et al*., (2012) [34] noted a linear and quadratic ($P < 0.01$) reduction in the drip loss percentage on day 42 in broiler birds supplemented with accenting levels of nano selenium. Visha *et al*. (2017) [45] stated that the mean drip loss (%) in the breast muscle of selenium yeast (0.3 ppm) and all nano selenium supplemented groups (0.15, 0.3 and 0.6 ppm) decreased significantly than the control and inorganic selenium supplemented groups at 24 and 48 h. Rajashree *et al*. (2014) [33] and Gogmen *et al*. (2016) [18] observed improved meat water holding capacity for organic selenium supplemented group at the rate of 0.5 ppm and 0.6 ppm, respectively. Huff-Lonergan and Lonergan, (2005) [46] stated that meat oxidation could decrease the sensitivity to hydrolysis, weaken protein degradation, and reduce water reserves among the myofibrils, thus resulted in increased drip loss of the meat. Against the result obtained in the present study, Payne and Southern (2005) [47], Boiago *et al*. (2014) [48] and Chen *et al*. (2014) [36] reported that drip loss was not affected by the source of selenium supplemented in broiler chicken feed. Similarly, Li *et al*. (2018) [22] noticed no significant difference in drip loss due to dietary supplementation of sodium selenite, selenium yeast and nano red element selenium.

Table-4 Effect of supplementation of SS, SY and NS on drip loss and cooking loss

| Treatment groups | | Drip loss (%) | Cooking loss (%) |
|---|---|---|---|
| $T_1$ | Control | 2.62±0.18$^{a}$ | 8.63±0.59$^{a}$ |
| $T_2$ | SS150 | 2.57±0.29$^{ab}$ | 8.90±1.53$^{a}$ |
| $T_3$ | SS300 | 2.58±0.20$^{ab}$ | 6.97±0.80$^{ab}$ |
| $T_4$ | SY150 | 1.81±0.09$^{c}$ | 6.58±0.40$^{ab}$ |
| $T_5$ | SY300 | 1.60±0.16$^{c}$ | 4.56±0.40$^{b}$ |
| $T_6$ | NS50 | 2.07±0.03$^{bc}$ | 5.66±0.55$^{b}$ |
| $T_7$ | NS150 | 2.13±0.16$^{abc}$ | 5.27±0.85$^{b}$ |
| $T_8$ | NS300 | 1.83±0.12$^{c}$ | 4.65±0.47$^{b}$ |

Means within a column bearing different superscripts differ significantly ($P \leq 0.05$)

## Cooking Loss

Cooking loss was reduced significantly due to supplementation of nano selenium (5.66, 5.27 and 4.65 per cent respectively for NS50, NS150 and NS300) and 300 ppb selenium yeast (4.56) than the control group (8.63) and 150 ppb sodium selenite (8.90) supplemented group [Table 4]. Higher drip loss was recorded in control group and sodium selenite 150 ppb supplemented groups. In agreement with the present study, earlier studies by Mikulski et al. (2009) [44] and Yang et al. (2012) [35] reported significantly reduced cooking loss in 300 ppb organic selenium supplemented group than inorganic selenium supplemented group and the control. Similarly, Ravindran and Elliott (2017) [25] fed 0.3 and 0.4 mg/kg selenoprotein and inorganic selenite to birds and noted reduced cooking loss in organic selenium supplemented meat frozen for seven days. Li *et al*. (2018) [22] supplemented chicken feed with 0.3 mg Se/kg as sodium selenite, Selenium yeast and nano red element selenium for 40 days and observed reduced cooking loss in organic selenium supplemented group. Nano selenium supplemented groups showed comparable cooking loss with all treatment groups whereas, in current study decreased cooking loss was recorded for all nano selenium supplemented groups. Contradictory to the current study Boiago *et al.* (2014) [48] observed no change in cooking loss as influenced by selenium supplementation for broiler chicken. Increased drip loss and cooking loss from muscle tissue is due to reduced antioxidant status of birds. Meat oxidation could decrease the sensitivity to hydrolysis, weaken protein degradation, and reduce water reserves among the myofibrils, thus which would increase the juice loss from the meat [45]. This could be counteracted by the improved antioxidant status of birds that promotes the maintenance of cell membrane integrity [24] which might have resulted in reduced drip loss and cooking loss as a response to selenium supplementation. When the tissue has poor water holding capacity properties, loss of moisture and consequently loss of weight during storage is more. Freezing produces some changes in tissues, which reduces water holding capacity after thawing [48]. The loss of water holding capacity observed was partly due to increased denaturation of protein and partly due to enhanced movement of water into extracellular space during storage.

## Conclusion

Body weight, feed intake and FCR at 8 weeks of age were not influenced by selenium supplementation. Drip loss was reduced due to selenium supplementation. Drip loss was decreased significantly by supplementation of 150 and 300 ppb selenium yeast and 50 and 300 ppb nano selenium. Cooking loss was reduced by supplementation of 300 ppb selenium yeast and 50, 150 and 300 ppb levels of nano selenium.

**Application of research**: Trace minerals are integral part of many biologically important molecules and have important role in many cellular activities and thereby in productive performance of living organisms in minute quantities.

**Research Category**: Poultry Science, Nutrition

**Abbreviations**:
ppb: parts per billion, SS: Sodium Selenite, SY: Selenium Yeast, NS: Nano Selenium, FCR: Feed conversion ratio

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