



Nano-Selenium and Nano-Curcumin in Diet of Broiler Chicken

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Dietary Supplementation of Nano-Selenium and Nano-Curcumin Effect on Lipid Profile and Growth Performance in Broiler Chicken

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ABSTRACT

The present study was conducted in Ven-Cobb broiler chickens to evaluate the dietary influence of nano-selenium (Nano-Se) and nano-curcumin on lipid profile and growth performance. A total of 360 broiler chicks were divided into four groups and each group comprised 90 chicks. Chickens kept in group I was fed with a broiler basal diet and it served as the control group. While chickens kept in groups II, III and IV were fed with nano-Se (0.3 mg/kg diet), nano-curcumin (200 mg/kg diet) and combination (0.15 + 100 mg/kg diet) of both, respectively. The serum lipid profile was estimated on days 21st, 28th, 35th and 42nd. Significantly ($P < 0.05$) higher levels of serum high-density lipoprotein cholesterol, Significantly ($P < 0.05$) lower serum cholesterol levels were observed in Group III and IV compared to Group I. Significant ($P < 0.05$) improvement in body weight and feed conversion ratio (FCR) were recorded in Group II and IV compared to Group I on sixth week. In Group III, nano-curcumin supplementation significantly ($P < 0.05$) reduced the body weight with reduction in abdominal fat content and improved FCR was noticed. It is concluded that supplementation of nano-Se at 0.15 mg/kg diet and nano-curcumin at 100 mg/kg diet in broiler chicken feed improves the production performance and exerts a hypolipidemic effect in broiler chickens.

KEYWORDS: Body weight, Cholesterol, Chicken, Nano-selenium, Nano-curcumin

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INTRODUCTION

Poultry production has experienced a major shift with the prohibition of the use of antimicrobials and antibiotics as growth promoters (Gernat et al., 2021). Novel Nanoparticles (NP) provide many beneficial effects in preclinical research over the conventional preparations, including superior solubility and stability, have high surface area to volume ratio, physical activity and chemical stability, impart better tissue penetration and even enable them to cross cell membranes, enhanced tissue targeting and minimized side effects (Rajendran et al., 2013; Swain et al., 2018). Phytochemical substances act as anti-oxidants and are being used for optimizing gut health in poultry (Shehata et al., 2022). Nano-delivery of phytochemical micronutrients is essential under stressful conditions have been recommended to improve the health of the public and animals for decades in folk medicine (Vaiserman et al., 2020).

Selenium can modify plasma lipoproteins by decreasing the low-density lipoprotein cholesterol and plasma triglycerides and increasing the high-density lipoprotein-cholesterol (Iizuka et al., 2001). It also shows positive influences on the growth performance of broiler chickens (Hegazy and Adachi, 2000). Selenium enriched poultry meat will fulfil the recommended dietary Se allowance of the consumers (Thane and Bates, 2001).

Turmeric (*Curcuma longa*) is widely used as a spice, colouring and flavouring agent in most Indian food recipes and as herb in traditional medicine. Curcuminoids, such as curcumin, demethoxycurcumin and bisdemethoxycurcumin, are yellowish turmeric pigments having extensive hypocholesterolemic activities (Cousins et al., 2007). Nanoparticles increase the bioavailability of curcumin powder and have wide applications in the field of medicine and nutrition (Rai et al., 2015). Turmeric

exerts profound positive effect on lowering blood triglyceride, total cholesterol, LDL-C and improving the blood HDL-C levels in laying hens (Kermanshahi and Riasi, 2006). Supplementation of curcumin increases thyroid hormone concentrations and reduces abdominal fat deposition by acting on the expression of genes related to lipogenesis and lipolysis (Xie et al., 2019).

However, the perusal of literature revealed less information and knowledge on the role of nano-nutraceuticals supplementation in poultry. Therefore, this study was undertaken to evaluate the effects of nano-Se and nano-curcumin supplementation on growth performance and lipid profile in broilers chickens to improve the meat quality by reducing the fat content to maintain the health status of consumers.

MATERIALS AND METHODS

The trial was conducted during the February and March month in the year 2020. In accordance with the guidelines established by the Committee for Control and Supervision of Experiments on Animals (Registration number 493/GO/ReBiBt-S/Re-L/01), this study was approved by the Institutional Animal Ethical Committee at the Veterinary College in Bengaluru, India (VCH/IAEC/2019/83). The Experiment on birds have been conducted at the Department of Poultry Science, Veterinary College of Bengaluru, India. The laboratory examinations were done at the Department of Veterinary Physiology, Veterinary College, Bengaluru, and the National Institute of Animal Nutrition and Physiology, Bengaluru, India. Nano-Se was prepared by simple precipitation method using ascorbic acid as a reducing agent and nano-curcumin was prepared by solvent-antisolvent precipitation method (Shwetha et al., 2022).

Experimental birds, grouping and management of the birds

The Venkateshwara Hatcheries Pvt Ltd, Bengaluru, India provided three hundred sixty (360) chicks aged one day old commercial Vencobb broiler

chicks for this study. They were raised at the Department of Poultry Science, Veterinary College, Bengaluru, India. We randomly divided the broiler chicks into four groups: Group I, II, III, and IV. Each group contained three replicates. Each group was having 90 birds with 30 chicks in one replicate. Each replicate group of chicks was housed in an independent pen in an open sided deep litter house. Chicks were subjected to brooding till three weeks of their age using incandescent bulbs. Chicks were provided with continuous light throughout the trial. Each pen was fitted with a semi-automatic bell type drinker and a hanging circular feeder.

Poultry feed was prepared at Department of Poultry Science, Veterinary College, Bengaluru and nano particles were prepared at National Institute of Animal Nutrition and Physiology, Bengaluru. The Nano-Se and Nano-curcumin as powder form were mixed with basal diet to supplement the broiler chickens.

The experimental birds were allotted to four dietary supplementation groups. Control group birds were fed on basal broiler diet. The supplemented groups such as Group II, III and IV birds were fed with nano-Se at 0.3 mg/kg, nano-curcumin at 200 mg/kg and combination of both nano-Se and nano-curcumin at 0.15 mg/kg + 100 mg/kg along with basal diet, respectively.

The dietary nutrient levels were based on National Research Council-recommended nutrient requirements for broiler chickens (Table 1) (NRC, 1994). The National Research Council (NRC) feeding standard is a widely accepted guideline for animal nutrition. It provides recommendations on the nutrient requirement for various animal species across the world. Chicks were fed with a pre-starter diet from 0 to 14 days, starter diet from 15 to 28 days and finisher diet from 29 to 42 days of age. Chicks were provided *ad libitum* feed and water throughout the study. Feeding of test diets commenced at zero-day of age and continued till the termination of the experiment *i.e.* upto six weeks of age

Table 1. Ingredient composition (kg / 100 kg of feed) of the experimental diets

Ingredients	Pre-starter diet (0 -14 days)	Starter diet (15-28 days)	Finisher diet (29-42 days)
Yellow maize	53.4	57.0	60.4
Soybean	41.0	35.7	31.00
Vegetable oil	02.2	04.0	05.50
*Mineral mixture	01.5	1.50	01.50
Dicalcium phosphate	01.0	0.90	00.80
Common Salt	00.3	0.30	00.30
**Vitamin Premix	00.2	0.20	00.15
DL-Methionine	00.2	0.20	00.18
B complex	00.01	0.10	00.10
***Antibiotic	00.03	-	-
Total	100	100	100
Nutrient Composition			
ME (kcal/kg)a	2948	3077	3129
Crude Protein (%)	22.9	20.0	17.9
Calcium (%)a	1.01	0.91	0.85
Phosphorus (%)a	0.46	0.37	1.0.355
Lysine (%)a	1.4	1.18	1.03
Methionine (%)	0.49	0.39	0.342
Selenium (ppm)	0.08	0.10	0.08

*Mineral Mixture: Each 100 g contains: Magnesium Oxide: 1.48 g, Ferrous Sulphate: 6.0 g, Copper Sulphate: 0.05 g, Manganese Sulphate: 0.04 g, Potassium Iodide: 0.001 g, Zinc Sulphate: 1.0 g, Potassium Chloride: 17.09 g and Sodium Selenate: 0.001 g

**Vitamin Premix: Each 100 gm contains Vitamin AD₃ (Vitamin A: 10,00,000 IU/g, Vitamin D: 200000 IU/g) - 0.165 g, Vitamin K₃: 0.103 g, Vitamin E: 2.4 g, Thiamine mononitrate: 0.206 g, Riboflavin: 0.513 g, Pyridoxine hydrochloride: 0.309 g, Cyanocobalamin: 0.00031 g, Folic Acid: 0.103 g, Niacin: 4.124 g, Ca-D-pantothenate: 1.031 g, Biotin: 1.5 g, Maltodextrin: 89.545 g.

*** Antibiotic: Oxytetracycline – Used only for 5 days in pre-starter diet for prophylactic measures.

ME: Metabolisable energy

Approximately 2.5 mL of blood was collected via brachial vein from randomly selected six broiler chickens in each group on days 21, 28, 35 and 42 during morning hours between 7:30 and 9:30 AM (Kelly and Alworth, 2013). The blood samples were processed for the separation of serum by centrifugation. Separated serum samples were stored at -80 °C until serum total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C), and high density lipoprotein cholesterol (HDL-C) level by the biochemical method.

Plasma lipid Profile estimation

The total cholesterol (Allain et al., 1974), triglycerides (McGowan et al., 1983) and high-density lipoprotein cholesterol (Tietz, 2012) were determined using commercially available reagent kits manufactured by Transasian Bio Medicals Ltd., Baddi, Dist. Solan, Himachal Pradesh, India. These contents were determined using colorimetric automatic biochemical analyzer.

Growth performance

The chickens were weighed every week by using the digital *weighing machineto* to determine the average daily weight gain (**ADG**). In each replicate daily feed consumption was recorded by discarding the uneaten feed and replenishing the fresh feed and the feed conversion ratio (**FCR**) was determined. The abdominal fat pad, spleen, liver, kidney, thymus and bursa were removed and recorded to the nearest 0.001g using a monopan balance.

Statistical analysis

The statistical analyses were carried out using the GraphPad Prism' software version 5.01 (2007). The data regarding lipid profile, growth performance and Ab titres were analysed with ANOVA using the Bonferroni post-test ($P < 0.05$). The values were expressed as Mean \pm Standard Error and the level of significance ($P < 0.05$) or non-significance ($P > 0.05$) was determined at p-value of 0.05.

RESULTS AND DISCUSSION

Serum lipid profile

The serum cholesterol and triglycerides levels were significantly ($p < 0.05$) lower in Groups III and IV compared to control group on day 21, 28, 35 and 42 (Table 2). The observations in curcumin supplemented groups are in agreement with the reports of Malekizadeh et al. (2011) in laying hens, Saraswati et al. (2013) in Japanese quails and Fallah and Mirzaei (2016) in broiler chicks supplemented with turmeric at different levels. Nano-curcumin was found to influence the lipid metabolism and inhibit lipid peroxidation. The addition of curcumin to animal diet will enhance the body metabolism (Srinivasan, 2005) and it has a hypolipidemic and anti-oxidative effects in chickens (Arshami et al., 2013). Concerning plasma lipid, the use of pure curcumin at low doses in feed reduces cholesterol levels in broilers (Rajput et al., 2013). Curcumin plays an important role in the reduction of abdominal fat deposition by decreasing the hepatic and plasma lipid profile and affecting the expression levels of genes related to lipogenesis and lipolysis by the action of acetyl CoA carboxylase (ACC), fatty acid synthase, sterol regulatory element binding protein-1c, ATP-citrate lyase, peroxisome proliferator-activated receptor α and carnitine palmitoyl transferase-I in broilers (Xie et al., 2019; Chen et al., 2014b). Increase in the peroxisome proliferator-activated receptor- α ligand reduces total cholesterol and triglycerides by supplementing selenium nanoparticles (Vunta et al., 2007). An organic selenium diet decreased the cholesterol concentration and improved tibia mineralization in layers (Attia et al., 2010). The reduction in serum cholesterol levels recorded in the present study could be due to the stimulation of conversion of cholesterol to bile acid, to eliminate the cholesterol from the body due to increased activity

of cholesterol-7- α hydrolase or inhibition of the activity of HMG Co-A reductase (Dalalet al., 2018).

Significantly ($p < 0.05$) higher serum HDL-C levels were noted in groups II, III and IV compared to control group at days 21, 28, 35 and 42 (Table 2). The findings in nano-Se supplemented groups are in agreement with the reports of Surai and Dvorska (2002), Radwan et al. (2015) in layers, who reported higher levels of serum HDL-C in Se and nano-Se supplemented birds, respectively. Damian and Konrad (2018) also reported an increased level of its HDL fraction in egg yolk and plasma of laying hens supplemented with nano-Se. Incorporation of Se-enriched Japanese radish sprouts in feed led to increased HDL-C concentration and decreased triglyceride and cholesterol concentrations due to hypo-lipidemic effect of selenium by changing the excretion of cholesterol and bile acids (Hossain et al., 2010). The increased level of HDL-C in Group III could be attributed to inhibiting effect of curcumin on lipoprotein- α (Panahi and Khalili, 2017). Further, the lower dose of curcumin administration exerts a higher effect on HDL cholesterol level increment (Alwiet et al., 2008). Curcumin might influence HDL functionality and might modulate markers of HDL function, such as apolipoprotein (apo-AI), cholesteryl ester transfer protein, lecithin cholesterol acyl transferase, paraoxonase 1, myeloperoxidase activities which subsequently improve the HDL (Ganjali et al., 2017). Curcuminoid supplementation could reduce lipoprotein and increase HDL-C, which might reduce the risk of a cardiovascular event (Panahi and Khalili, 2017). Thus, from the study it was concluded that the nano-Se and nano-curcumin can significantly reduce cholesterol and triglycerides and improve the HDL-C in broiler chickens. This study explored an interesting way of modifying the lipid profile of chicken meat by reducing the oxidation stress.

Table 2. Effect of dietary supplementation of Nano-Se and nano-curcumin on the lipid profile in broiler chickens

Parameter	Days	Group I	Group II	Group III	Group IV
Total Cholesterol (mg/dL)	21 Days	118 ^y ± 2.17	99.3 ^x ± 2.01	97.9 ^x ± 2.41	102.06 ^x ± 2.42
	28 Days	123 ^y ± 4.96	104 ^x ± 3.48	95.4 ^x ± 1.25	100 ^x ± 4.47
	35 Days	123 ^y ± 3.36	101 ^x ± 1.48	96.6 ^x ± 1.29	98.6 ^x ± 2.44
	42 Days	126 ^y ± 1.20	105 ^x ± 2.06	94.7 ^x ± 5.49	101 ^x ± 3.60
Triglycerides (mg/dL)	21 Days	84.6 ^x ± 2.07	80.4 ^x ± 1.95	75.3 ^x ± 3.12	78.9 ^x ± 4.42
	28 Days	86.9 ^y ± 2.44	76.4 ^x ± 3.06	72.8 ^x ± 2.36	76.2 ^x ± 2.13
	35 Days	87.2 ^y ± 2.36	77.0 ^x ± 2.69	73.7 ^x ± 3.22	74.1 ^x ± 1.78
	42 Days	92.4 ^y ± 2.34	80.4 ^x ± 4.03	74.5 ^x ± 2.43	76.4 ^x ± 2.44
High Density Lipoprotein - Cholesterol (mg/dL)	21 Days	65.5 ^x ± 1.28	66.4 ^x ± 1.31	75.87 ^y ± 2.38	75.0 ^y ± 1.09
	28 Days	68.0 ^x ± 1.67	76.3 ^y ± 1.78	77.5 ^y ± 2.88	75.4 ^y ± 1.80
	35 Days	65.1 ^x ± 1.34	76.6 ^y ± 2.02	79.0 ^y ± 2.11	78.5 ^y ± 2.60
	42 Days	66.4 ^x ± 1.31	75.9 ^y ± 2.40	75.1 ^y ± 1.77	76.5 ^y ± 1.79

Dietary Treatment; Group I = control; Group II= Nano-Selenium at 0.3 mg/kg of diet; Group III= Nano-curcumin at 200 mg/kg of diet Group IV = Nano-Selenium at 0.15 and Nano-curcumin at 100 mg/kg of diet. The values with different superscript in a row (x, y) differ significantly (P< 0.05).

Abdominal fat

In the present study, significantly lower abdominal fat weights (% Live Body weight) were noted in nano-particles supplemented groups (Group II, III and IV) in comparison to the control group (Group I) at day 21, 28, 35 and 42 (Table 3). There were no significant differences in abdominal fat weights (% Live Bodyweight) among nano-particles supplemented groups (Group II, III and IV) at days 12, 28, 35 and 42.

Schafer et al. (2004) reported that selenium deficiency can interfere with the normal conversion of α -linolenic (ALA) into eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, which can result in an increased omega-6: \uparrow omega-3 ratio in the liver of rats. Kim et al. (2012) suggested that selenium may induce inhibition of adipocyte hypertrophy and abdominal fat accumulation by

differential regulation of the gene expression for fatty acid β -oxidation in rats. Significant decrease in abdominal fat mass, adipocyte size and adiponectin, which are associated with lipid metabolism. Dietary selenium had a potential effect on the modulation of the composition of fatty acids in chicken meat particularly reducing the content of atherogenic fatty acids and increasing the health promoting n-3 PUFA (Del-Puerto et al., 2017). Xie et al. (2019) reported significantly decreased absolute and relative abdominal fat weight in the 2,000 mg/kg curcumin supplemented broiler chickens and concluded that curcumin plays an important role in reducing abdominal fat deposition by decreasing the hepatic and plasma lipid profile and affecting the expression levels of genes related to lipogenesis and lipolysis including fatty acid synthase, sterol regulatory element binding protein-1c, ACC and ATP-citrate lyase. Less acetyl CoA availability in broiler chickens

treated with curcumin may lead to a decrease in the triglyceride synthesis. This hypothesizes that curcumin may directly stimulate the β -oxidation

pathway in hepatocytes and catalysing the conversion of triglyceride to fatty acids and glycerol (Herbst et al., 2003).

Table 3. Effect of dietary supplementation of Nano-Se and nano-curcumin on abdominal fat percentage in broiler chickens

Days	Group I	Group II	Group III	Group IV
21 Days	0.29 ^{y, a}	0.21 ^{x, a}	0.20 ^{x, a}	0.20 ^{x, a}
	±0.03	±0.01	±0.00	±0.00
28 Days	0.35 ^{y, b}	0.28 ^{x, b}	0.27 ^{x, b}	0.28 ^{x, b}
	±0.01	±0.01	±0.01	±0.01
35 Days	0.50 ^{y, c}	0.45 ^{x, c}	0.43 ^{x, c}	0.41 ^{x, c}
	±0.02	±0.01	±0.01	±0.01
42 Days	0.59 ^{y, d}	0.52 ^{x, d}	0.50 ^{x, d}	0.49 ^{x, d}
	±0.02	±0.01	±0.01	±0.01

Dietary Treatment; Group I = Control; Group II= Nano-Se at 0.3 mg/kg of diet; Group III= Nano-curcumin at 200 mg/kg of diet Group IV = Nano-Se at 0.15 and Nano-curcumin at 100 mg/kg of diet. The values with different superscript within a row (x, y) and within a column (a, b, c, d) differ significantly (P<0.05)

Growth performance

The body weight increased significantly (P<0.05) from third week to sixth week in Group II compared to Group I (Table 4). Significantly (P<0.05) higher body weight gain was observed in Group II compared to Group III during fourth, fifth and sixth weeks. The weekly body weight gain was significantly (p < 0.05) higher in Group II compared to Group I on third week and sixth week of age. In Group III, weekly body weight gain was significantly (P < 0.05) low compared to Group II on fifth and sixth weeks of age. Weekly body weight gain was significantly (P < 0.05) higher in Group IV compared to Group I from second week to third week of age (Table 5). The mean FCR in Group II, III and IV was significantly (P < 0.05) better than the control group on sixth week (Table 6).

Mahmoud et al. (2016), Ahmadi et al. (2018) and Bakhshalinejad et al. (2018) reported higher body weight gain in broiler chickens with supplementation of nano-Se. Selenium could act as a bio-corrector being apart of more than 200 hormones involved in regulating many physiological functions of all organs and systems and is used as feed additive to enhance growth and development in broiler chickens (Konkov et al., 2015). Selenium is the cofactor and activator of 5' deiodinase enzyme, which is a key enzyme of triiodothyronine (T₃)

synthesis and T₃ is the growth control component of animals particularly in poultry by controlling the body's energy and protein assimilation (Arthur et al., 1992). The improved FCR in Group II could be attributed to increased concentrations of an active form of thyroid hormones (Mohapatra et al., 2014). Therefore, supplementation of Se could increase the growth performance of chickens possibly due to increased protein digestibility and energy utilization (Skrivan et al., 2012; Chen et al., 2014a).

Improvement in body weight by supplementation of curcumin or turmeric to chickens was recorded by Rahmani et al. (2017) and Johannah et al. (2018), which is contradictory to the results of current findings in Group III. Innovative nano-technological applications have been developed by now to enhance the oral bioavailability and bioactivity of selenium and curcumin to increase the increase the productivity in poultry by improving the immune status of the birds (Shwetha et al., 2023). Improved FCR seen in Group III was similar to the findings of Mehala and Moorthy (2008), Gumus et al. (2018), Johannah et al. (2018), and Gogoi et al. (2019) in poultry. Based on the results of Group II and Group III, for Group IV, it is observed that the nanoparticle feed additives could exert a positive role on growth performance and FCR in broiler chickens.

Table 4. Effect of dietary supplementation of Nano-Se and Nano-curcumin on cumulative body weight (grams) in broiler chickens

Week	Group I	Group II	Group III	Group IV
Week 0	45.7 ^{x, a} ± 0.26	46.8 ^{x, a} ± 0.57	45.5 ^{x, a} ± 0.53	45.5 ^{x, a} ± 0.40
Week 1	139 ^{x, b} ± 1.69	140 ^{x, b} ± 1.16	133 ^{x, b} ± 1.44	139 ^{x, b} ± 1.24
Week 2	300 ^{x, c} ± 2.39	315 ^{x, c} ± 5.52	310 ^{x, c} ± 2.59	329 ^{y, c} ± 2.10
Week 3	513 ^{x, d} ± 5.61	549 ^{y, d} ± 5.33	530 ^{xy, d} ± 3.02	579 ^{z, d} ± 3.02
Week 4	898 ^{x, e} ± 6.96	939 ^{y, e} ± 6.08	909 ^{x, e} ± 5.51	982 ^{z, e} ± 4.12
Week 5	1480 ^{x, f} ± 9.13	1532 ^{y, f} ± 8.48	1467 ^{x, f} ± 7.37	1587 ^{z, f} ± 6.51
Week 6	2032 ^{x, g} ± 15.89	2111 ^{y, g} ± 15.04	2014 ^{x, g} ± 10.12	2173 ^{z, g} ± 9.16

Dietary Treatment; Group I = Control; Group II= Nano-Se at 0.3 mg/kg of diet; Group III= Nano-curcumin at 200 mg/kg of diet Group IV = Nano-Se at 0.15 and Nano-curcumin at 100 mg/kg of diet. The values with different superscripts within a row (x, y, z) and within column (a, b, c, d, e, f, g) differ significantly (P<0.05)

Table 5. Mean ± SE values of weekly body weight gain (g) in different groups of broiler chickens supplemented with Nano-Selenium and nano-curcumin

Week	Group I	Group II	Group III	Group IV
Week 1	93.1 ^{x, a} ± 1.54	93.2 ^{x, a} ± 1.26	87.9 ^{x, a} ± 1.27	93.8 ^{x, a} ± 1.57
Week 2	161 ^{y, b} ± 1.49	175 ^{xy, b} ± 5.17	177 ^{y, b} ± 1.4	189 ^{y, b} ± 1.85
Week 3	213 ^{x, c} ± 3.46	233 ^{y, c} ± 2.69	220 ^{x, c} ± 2.20	249 ^{y, c} ± 2.27
Week 4	384 ^{z, d} ± 5.28	390 ^{xy, d} ± 3.96	378 ^{x, d} ± 4.36	403 ^{z, d} ± 3.29
Week 5	582 ^{x, f} ± 3.11	592 ^{yz, e} ± 5.39	558 ^{x, e} ± 4.15	606 ^{z, f} ± 3.99
Week 6	552 ^{x, e} ± 9.88	579 ^{yz, e} ± 7.83	546 ^{x, e} ± 4.72	585 ^{z, e} ± 6.20

Dietary Treatment; Group I = Control; Group II= Nano-Se at 0.3 mg/kg of diet; Group III= Nano-curcumin at 200 mg/kg of diet Group IV = Nano-Se at 0.15 and Nano-curcumin at 100 mg/kg of diet. The values with different superscripts within a row (x, y, z) and within a column (a, b, c, d, e, f, g) differ significantly (P<0.05)

Table 6. Feed conversion ratio in different groups of broiler chickens supplemented with Nano-Selenium and nano curcumin

Week	Group I	Group II	Group III	Group IV
Week 1	1.59 ^{y, a}	1.60 ^{y, a}	1.52 ^{x, a}	1.59 ^{y, a}
	± 0.01	± 0.01	± 0.01	± 0.01
Week 2	1.70 ^{y, b}	1.70 ^{y, b}	1.60 ^{x, b}	1.71 ^{y, b}
	± 0.01	± 0.01	± 0.02	± 0.02
Week 3	1.74 ^{y, b}	1.69 ^{xy, b}	1.66 ^{x, c}	1.74 ^{y, bc}
	± 0.02	± 0.01	± 0.01	± 0.01
Week 4	1.75 ^{z, b}	1.68 ^{xy, b}	1.68 ^{x, c}	1.74 ^{z, b}
	± 0.01	± 0.02	± 0.01	± 0.01
Week 5	1.82 ^{x, c}	1.77 ^{x, c}	1.77 ^{x, d}	1.79 ^{x, c}
	± 0.02	± 0.01	± 0.01	± 0.01
Week 6	1.97 ^{y, d}	1.81 ^{x, c}	1.84 ^{xy, e}	1.83 ^{xy, c}
	± 0.02	± 0.01	± 0.01	± 0.01

Dietary Treatment; Group I = Control; Group II= Nano-Se at 0.3 mg/kg of diet; Group III= Nano-curcumin at 200 mg/kg of diet Group IV = Nano-Se at 0.15 and Nano-curcumin at 100 mg/kg of diet. The values with different superscripts within a row (x, y) and within a column (a, b, c, d) differ significantly (p < 0.05).

Table 7. Economics / Cost effectiveness of the study

Particular	Group- I	Group II	Group- III	Group IV
Cost of chicks @ Rs. 35/chick	3150	3150	3150	3150
Average prestarter feed consumed by each bird	423	447	418	474
Prestarter feed consumed by 90 birds in kgs	38.1	40.2	37.6	42.6
Cost of pre prestarter feed @ Rs 42/kg	1599	1690	1579	1791
Average starter feed consumed by each bird	1041	1052	1001	1136
Starter feed consumed by 90 birds in kgs	93.7	94.7	90.1	102
Cost of pre starter feed @ Rs 40/kg	3749	3789	3607	4089
Average finisher feed consumed by each bird	2146	2096	1991	2157
Finisher feed consumed by 90 birds in kgs	194	189	179	194
Cost of pre finisher feed @ Rs 40/kg	7727	7547	7167	7767
Total feed consumed in kgs	325	324	307	339
Cost of Nanoselenium @ Rs 500/g (0.3 mg/kg diet)	-	48.5	-	-
Cost of Nanocurcumin @ Rs 2/g (200 mg/kg diet)	-	-	123	-
Cost of Nanoselenium (0.15 mg/kg diet) and Nanocurcumin (100 mg/kg diet)	-	-	-	25.4 +67.8 = 93.2
Production cost for 90 birds	16225	16176	15626	16889
Average body weight at the end of 6 weeks	2033	2111	2014	2174
Total weight of 90 birds in kgs	183	190	181	195
Sale of birds @ Rs. 100/kg live weight	18297	19003	18131	19562
Benefit	2071	2826	2505	2672
Cost benefit	12.7%	17.4%	16.0%	15.5%
Benefit Percentage compared to Group I	-	36.43 %	25.04 %	28.99 %

CONCLUSION

The dietary supplementation of nano-Se and nano-curcumin to broiler chickens exerted significant hypocholesterolemic effect and also reduced abdominal fat accumulation to produce lean and healthy meat in commercial broiler production. The combination of these two substances may enhance their protective effects and provide additional health benefits. Further research is needed to fully understand the interaction effect between Selenium and Curcumin.

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