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NUTRITION

Effects of high selenium and fat supplementation on growth performance and thyroid hormones concentration of broilers

Stella E. Chadio [a,*], Athanasios C. Pappas [b], Anastasios Papanastasatos [a], Dionysia Pantelia [a], Aikaterini Dardamani [b,1], Konstantinos Fegeros [b], George Zervas [b]

[a] Department of Anatomy and Physiology of Domestic Animals, Faculty of Animal Science and Aquaculture, Agricultural University of Athens, Athens, Greece
[b] Department of Nutritional Physiology and Feeding, Faculty of Animal Science and Aquaculture, Agricultural University of Athens, Athens, Greece

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SUMMARY

A total of 400, as hatched, broilers were used to investigate the effect of increase of selenium and energy intake on thyroid hormone metabolism, growth and liver fatty acid profile. There were 5 replicates of 4 dietary treatments namely, TA (0.289 mg Se per kg diet and adequate energy content), TB (0.583 mg Se per kg diet and adequate energy content), TC (0.267 mg Se per kg diet and 9% increase of energy content) and TD (0.576 mg Se per kg diet and 9% increase of energy content). Diets were isonitrogenous. Zinc L-selenomethionine complex was used to increase Se content and corn oil was used to increase the energy content. The experiment lasted 42 days. Broiler growth performance was not significantly affected by dietary treatments. Liver glutathione peroxidase (GPx) activity increased ($P < 0.05$) in broilers fed high Se and energy diets compared to other ones. Whole blood GPx activity was higher in Se supplemented groups however, it was reduced by age. Thyroid hormone concentrations were unaffected by dietary treatments. A significant increase of linoleic and arachidonic acid concentration ($P < 0.001$) was observed in the liver of broilers fed diets with moderately increased energy content and supplemented with Se compared to those fed diets with moderately increased energy content alone. In conclusion, zinc L-selenomethionine complex and moderate increase of energy content did not affect growth rate or thyroid hormone metabolism but led to increased liver fatty acid content and hepatic GPx activity.

Introduction

Selenium (Se) is a nutrient of fundamental importance to mammalian and avian biology. As selenocysteine, Se is a component of selenoproteins with important enzymatic functions. Among them glutathione peroxidases play an antioxidant defence role, preventing lipid-free radical chain reactions that cause peroxidative damage [1]. Se is also required for the expression of the selenoenzymes type I iodothyronine deiodinase (ID-I) and type II iodothyronine deiodinase (ID-II), which are crucial in the generation of the active hormone 3,3′5-tri-iodothyronine (T_3) [2–4].

Se status alterations may affect proper thyroid function. Although the effects of Se deficiency on thyroid hormone metabolism have been studied extensively in a number of animals [5,6] including chicken [7], very little is known about the influence of excess Se on thyroid hormone metabolism and selenoenzyme activities. In humans, Se supplementation led to variable results, depending on the Se status of the examined population group, extending from non to substantial changes in thyroid function [8–12]. Under this context, the form of Se (inorganic or organo-Se compounds) may also affect body Se reserves built and bioavailability [13,14]. According to the National Research Council (NRC) published recommendations [15] the Se concentration of poultry diet should be 0.15 mg Se per kg. However, recent European Union (EU) legislation approves concentration up to 0.5 mg Se per kg [16], whereas commercially used concentration is usually higher than NRC and lower than the EU one [17,18].

High energy intake appeared to be another factor influencing thyroid hormones concentration [19]. In rats, obesity induced by high-fat diets increased ID-I activity and caused normal circulating concentrations of T_4 and T_3, but increased reverse T_3 levels [20]. Furthermore in humans, without a history of thyroid disease,

* Corresponding author at: Department of Anatomy and Physiology of Domestic Animals, Faculty of Animal Science and Aquaculture, Agricultural University of Athens, 75 Iera Odos Str, 11855, Athens, Greece. Tel.: +30 2105294428; fax: +30 2105294388.
E-mail address: shad@aua.gr (S.E. Chadio).
[1] Present address: Ministry of Rural Development and Food, Directorate of Agricultural Extension, 207 Patision and 19 Skalistiri, 112 53, Athens, Greece.

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Table 1
The diet formulation, calculated analysis and determined levels of selenium of the experimental diets.

	Energy content			
	Adequate		Increased	
	Starter diet (0–21 d)	Grower diet (22–42 d)	Starter diet (0–21 d)	Grower diet (22–42 d)
Ingredients (g/kg)				
Maize	622.6	716.9	566.1	666.0
Soybean meal (45%)	326.4	229.0	341.7	243.0
Wheat bran	7.7	16.2	-	3.1
Corn oil	–	–	50.0	50.0
Limestone	11.2	10.4	10.9	10.1
Dicalcium phosphate	19.2	14.9	19.6	15.4
Sodium chloride	5.6	4.5	5.6	4.5
Methionine	2.5	2.4	2.1	2.5
Lysine	0.8	1.7	–	1.4
Premix[a]	4.0	4.0	4.0	4.0
Calculated analysis (g/kg)				
ME (MJ/kg)	12.00	12.47	13.10	13.61
Crude protein	210.00	175.00	210.00	175.00
Sodium	2.20	1.80	2.20	1.80
Ca	10.00	8.50	10.00	8.50
Available P	5.00	4.20	5.00	4.20
Methionine + Cystine	8.90	7.80	8.54	7.80
Lysine	12.00	10.00	11.65	10.00
Determined analysis (μg/kg)				
Treatment[b]	Se added[c]		Se determined	
TA	–		289 ± 14	
TB	300		583 ± 19	
TC	–		267 ± 29	
TD	300		576 ± 21	

[a] Premix supplied per kg of diet: 12000 IU vitamin A (retinyl acetate), 2000 IU vitamin D3 (cholecalciferol), 440 mg vitamin E (DL-α-tocopheryl acetate), 4 mg vitamin K3, 3 mg thiamin, 6 mg riboflavin, 4 mg vitamin B6, 0.03 mg vitamin B12, 30 mg nicotinic acid, 12 mg pantothenic acid, 1.5 mg folic acid, 0.08 mg biotin, 200 mg vitamin C, 350 mg choline, 2 mg iodine, 40 mg iron, 100 mg manganese, 15 mg copper, 0.25 mg cobalt, 0.2 mg selenium, 80 mg zinc.

[b] In TA treatment, broilers were fed a commercial diet with adequate Se and energy content (0.289 mg Se per kg diet), in TB, broilers were fed the TA diet with 0.3 mg added Se per kg of diet (0.583 mg Se per kg diet), in TC, broilers were fed the TA diet with 9% increase of energy content (0.267 mg Se per kg diet) and in TD treatment, broilers were fed the TA diet with 0.3 mg added Se per kg of diet and 9% increase of energy content (0.576 mg Se per kg diet).

[c] Availa-Se 1000, Zinc L-selenomethionine complex, (Zinpro Corporation, USA) was added only in Se-supplemented diets (TB and TD) to supply additionally 0.3 mg Se per kg of diet.

body mass index and waist circumference were positively associated with serum thyroid-stimulating hormone (TSH) and free T_3, but not free T_4 [21].

Data on the effects of simultaneous increase of Se and energy intake in avian species are limited. Given the fact that development of modern broiler strains has increased their growth potential and the need for high energy intake [22], a study was designed to investigate whether concomitant increase of Se and energy content in broiler diets affects thyroid hormone levels and selenoenzyme activity.

Materials and methods

Four hundred (400), as hatched, day-old, Cobb broilers were used in total. The broilers were obtained from a commercial hatchery. All animals were cared for according to applicable recommendations of directive 2010/63/EU of the European Parliament and the Council of the European Union. There were five replicate pens of four dietary treatments namely TA, TB, TC and TD, randomly allocated in the house. Pen was the experimental unit. Each replicate was assigned to a clean concrete floor pen (2 m^2) and birds were raised on a wheat straw shavings litter. There were 20 broilers per pen, 100 per treatment. In TA treatment, broilers were fed a commercial diet with adequate Se and energy content (0.289 mg Se per kg diet), in TB, broilers were fed the TA diet with 0.3 mg added Se per kg of diet (0.583 mg Se per kg diet), in TC, broilers were fed the TA diet with 9% increase of energy content (0.267 mg Se per kg diet) and in TD treatment, broilers were fed the TA diet with 0.3 mg added Se per kg of diet and 9% increase of energy content (0.576 mg Se per kg diet). Diets were isonitrogenous. Zinc L-selenomethionine complex (ZnSeMet) was used to increase Se content (Availa-Se 1000, Zinpro Corporation, Eden Prairie, Minnesota, USA) and corn oil was used to increase the energy content.

The duration of the experiment was 42 days with housing and care of broilers, conforming to the guidelines of the Faculty of Animal Science and Aquaculture of the Agricultural University of Athens. The broilers were raised in a house where light and ventilation were controlled. The lighting program was 23 h of light and 1 h of darkness. Heat was provided with a heating lamp per pen. The broilers were fed a starter diet to the 21st day of their life and a grower diet to the 42nd day (Table 1). Feed and water were provided *ad libitum*. At the end of the 2nd, 4th and 6th week of the study, one broiler per replicate pen was sacrificed with electrical stunning so that liver and whole blood samples were collected for determination of enzymatic activity and thyroid hormones concentration. Whole blood samples were collected in EDTA treated tubes (Aptaca, Canelli, Italy). Furthermore, for the detection of T_3 and T_4 levels blood was collected in heparin treated tubes (Aptaca, Canelli, Italy) and centrifuged at 1700 × *g* at 4 °C for 10 min (Hereaus Biofuge stratos, Kendro Laboratory Products, Langenselbold Germany) and the obtained plasma samples were kept at −20 °C until analysis. During the experimental period, body weight and feed intake were recorded weekly and at the end of the experimental period body mass gain, feed consumption and feed to gain ratio (FCR) were calculated.

Se was determined in feed using inductively coupled plasma mass spectrometry, ICP-MS (Perkin Elmer, Elan 9000, Perkin Elmer Life and Analytical Sciences Inc., Waltham, MA, USA) as described previously [23] (Table 1).