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Effect of organic selenium and omega-3 fatty acids on performance, antioxidant status and fatty acid composition of meat in broiler chickens

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ABSTRACT

A 2 × 3 factorial experiment was conducted to evaluate the effect of adding selenomethionine (0 and 0.3 ppm) and omega-3 fatty acid (0, 0.5 and 1% of diet) on performance, blood antioxidant capacity and fatty acid composition of meat in broiler chickens. The study was conducted using broiler chicks (180) that were assigned to 1 of the 6 dietary treatments. The significant interactions were observed between selenomethionine and omega-3 fatty acids for growth performance, dressing percentage, selenium and omega-3 fatty acids composition of meat, serum antibody titer against Newcastle disease and the lymphoid organ weights. The chickens with the highest body weight and dressing percentage were fed 0.3 ppm of selenomethionine with 0.5% of omega-3 fatty acid. The lowest fat value was found in the broilers that were fed 0.5% omega-3 fatty acid. Dietary selenomethionine significantly increased the selenium content of meat. The glutathione peroxidase (GPx) activity and thiobarbituric acid (TBA) value of muscle significantly increased as the levels of selenium and fat source increased in the diet. The highest serum antibody titer against Newcastle disease was recorded in chickens that were fed the highest levels of selenium and fat source. Thus it may be speculated that selenomethionine and omega-3 fatty acid enriched broilers diet improved growth performance, antioxidant status and meat composition.

Key words: Antioxidant status, Omega-3 fatty acid, Performance, Selenomethionine, Vencobb broiler

Consumer awareness towards health benefits from various value added foods is rising rapidly. Chicken meat as a source of preformed eicosapentenoic acid (EPA) and docosahexaenoic acid (DHA) should be taken into consideration when optimizing the nutritional value of chicken meat for the human consumer (Nyquist *et al*. 2013), which is formed from alpha-linolenic acid (ALA), a major omega-3 fatty acid inside the body. Omega-3 PUFA plays an important role in human nutrition by reducing the susceptibility towards coronary artery diseases, hypertension and diabetes (Simopoulos 2000).

Flax or linseed (*Linum usitatissimum L.*), the richest source of omega-3 fatty acid, contains a cyanogenic glucoside, linamarin, which limits its use in poultry feed. Along with omega-3 fatty acid, selenium is also an essential trace mineral which has a profound effect on growth performance and productivity. It plays a major role in maintaining cell membrane integrity and prevents the damage from free radicals as it is component of enzyme glutathione peroxidase (GSH-Px).The aim of this investigation was to study the effect of different levels of selenomethionine and omega-3 fatty acid on performance, oxidative stability and fatty acid composition of meat in broiler chickens.

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MATERIALS AND METHODS

Experimental design and housing: This study was a 2 × 3 factorial arrangement of 2 levels of selenomethionine (0 and 0.3 ppm) and 3 levels of omega-3 fatty acids (0, 0.5 and 1% of diet). Day-old broiler chicks (180), belonging to a single hatch were wing banded, weighed and were randomly assigned into the 6 treatment groups of 30 chicks in each (3 replicates of 10 birds in each treatment). The trial lasted for 42 days. Birds were raised under deep liter system. Broiler starter, grower and finisher rations were offered to the birds in mash form. The brooding temperature was maintained close to the requirement. Vaccination of birds was done time to time.

Treatments and additives: Nutrient composition of diets for chicks at 0 to 42 days old was based on the National Research Council (NRC 1994) recommendations. Ingredient and proximate composition of broiler's diet are shown in Table 1. Treatment groups were as follows: group 1, control; groups 2, 3, 4, 5 and 6 were supplemented with 0.5% omega-3 fatty acid, 1% omega-3 fatty acid, 0.3 ppm selenomethionine, 0.3 ppm selenomethionine with 0.5% omega-3 fatty acid and 0.3 ppm selenomethionine with 1% omega-3 fatty acid, respectively. Linseed oil was used as

Table 1. Ingredient and proximate composition of broiler starter, grower and finisher diet (on % DM basis)

Feed ingredients	Ingredient composition		
	Broiler starter	Broiler grower	Broiler finisher
Yellow maize	53	56.40	59.70
Soya DOC	36.40	33.40	26.30
Deoiled rice bran	2.40	-	-
Fish meal	2	2	5
Soyabean oil	2.50	4.60	5.5
Dicalcium phosphate	1.70	1.60	1.30
Limestone powder	0.70	0.70	0.70
DL-methionine	0.28	0.26	0.22
Lysine	0.02	-	0.17
Soda-bi-carb	0.17	0.16	0.23
Salt	0.28	0.33	0.26
Premix*	0.56	0.58	0.63
Proximate composition			
Crude protein	22.90	21.40	19.65
Crude fibre	3.72	3.33	3.25
Ether extract	5.39	7.41	8.48
Total ash	7.32	6.68	6.63
Acid insoluble ash	1.66	1.78	1.39
Nitrogen free extract**	60.67	61.18	61.99
Calcium	0.94	0.85	0.95
Phosphorus	0.75	0.70	0.74
ME (kcal/kg)**	2970	3050	3123

* Trace mineral premix mg/kg diet: Mg 300, Mn 55, Fe 56, Zn 30, Cu 4; vitamin premix per kg diet: vit. A 8250IU, vit. K 1mg, vit. E 26.84 mg, vit. B_1 2 mg, vit. B_2 4 mg, vit. B_{12} 100mg, Niacin 60 mg, pantothenic acid 10 mg; choline 500 mg and 30 ppm salinomycin (Coxistac 12%), 55 ppm bacitracin methylene di salicyclate (BMD110),**Calculated value.

the source of omega-3 fatty acid while selplex was used for selenomethionine supplementation.

Measurements: Feed intake and body weight were measured and then feed conversion ratio (FCR) was calculated weekly. At 42 days of age, 3 birds of identical body weight from each replicate were sacrificed. The birds were fasted overnight, bled, defeathered and eviscerated with sufficient care. Different carcass parameters were recorded and presented as the percentages of live body weight. Selenium content in meat was determined by using atomic absorption spectrophotometer.

Antioxidant assay: Blood was analyzed for determination of glutathione peroxidase (Gpx) as per Paglia and Valentine (1967). Thiobarbituric acid (TBA) value in muscle was determined according to Strange *et al*. (1977).

Antibody titer: Humoral immune response was assessed by haemagglutination inhibition test against Newcastle disease virus (NCDV). Ranikhet vaccination was done on 7th and 28th day. The blood samples were collected on 21 and 42 day. The serum was separated for the evaluation of HI titer against NCDV. The HA unit of NCDV was determined according to Allan and Gough (1974).

Fatty acid analysis: Omega -3 fatty acid composition of thigh muscle was determined by gas chromatography. In muscle, lipid extraction was performed according to Folch *et al.* (1957), on 1 g of thigh muscle tissue. The lipids were resolved in heptane, and methylated, using both sodium methoxide and methanolic HCl 3N. Subsequently, the fatty acid methyl esters were analyzed using a gas chromatograph with a 100 m capillary column. Omega-3 fatty acid peaks determined by gas chromatograph were then used to calculate the amount of fatty acids (g/100 g fat) by theoretical response factors. Standard omega-3 fatty acids of known composition were run to identify the fatty acids in the samples. Muscle control samples were extracted, methylated and analysed by every 10th sample.

Statistical analysis: The data obtained were subjected to statistical analysis by the software (SPSS, 1997) following 2×3 factorial design. Levels of significance were calculated as per Duncan (1955) whenever any effect was found significant.

RESULTS AND DISCUSSION

The body weight, feed intake and FCR of broilers fed varying levels of dietary selenomethionine and omega-3 fatty acid are given in Table 2. The final body weight, feed intake and FCR of the birds were significantly influenced by dietary supplementation. As the concentration of selenomethionine and omega-3 fatty acid increased in the diet, final body weight of broilers significantly ($P<0.05$) increased whereas, feed intake decreased in comparison with control. Highest body weight was recorded in 0.3 ppm selenomethionine and 0.5% omega-3 fatty acid supplemented birds which was 8.1% more than control group. Similarly efficient conversion of feed improved 13% on same treatment group as compared to control. Significant ($P<0.05$) interaction observed between fat source and selenium which significantly improved broiler performance. The present study showed that feeding selenomethionine and omega-3 fatty acid improved broilers performance due to increased body weight and decreased feed intake. Similar to this experiment, many authors described the influence of selenium supplement on body weight (Skrivan *et al*. 2008a, Dlouha *et al*. 2008, Jiang *et al*. 2009). In contrast other authors (Choct *et al*. 2004, Yoon *et al*. 2007) did not observe any significant effect of selenium supplementation on final body weight of chickens. However Zuidhof *et al*. (2009) observed that as the concentration of dietary fat increased, feed consumption significantly decreased, which is in agreement with the current study. Findings also corroborated with Saleh (2013) who reported that n-3 lipid in broilers diet was beneficial in terms of net profit, which might be due to better feed conversion efficiency. But, Bou and Guardiola (2005) concluded that dietary selenium and supplemented fat did affect feed intake, body weight and FCR.

Selenomethionine and omega-3 fatty acid in the diet significantly influenced the dressing percentage and various carcass cuts yield (Table 3). Highest dressing percentage was recorded in 0.3 ppm selenomethionine and 0.5% omega-3 fatty acid dietary treatment and was 8.04% more

Table 2. Effect of selenomethionine and omega-3 fatty acid on performance of broiler chicken (mean±SE)

Particulars	Selenomethionine (0 ppm)			Selenomethionine (0.3 ppm)			Significance		
	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Seleno-methionine	Omega-3 fatty acid	Seleno-methionine x Omega-3 fatty acid
Body weight (g)	2008.12 ±1.21 ^{ay}	2120.8 ±8.32 ^{by}	2140.68 ±15.65 ^{c}	2115.48 ±41.80 ^{az}	2185.67 ±7.54 ^{cz}	2152.68 ±6.92 ^{b}	P<0.05	P<0.05	P<0.05
Feed intake (g/day)	3801.31 ±16.28 ^{cy}	3651.01 ±49.08 ^{by}	3613.20 ±31.94 ^{ay}	3719.38 ±22.08 ^{az}	3599.53 ±17.74 ^{cz}	3655.85 ±41.24 ^{bz}	P<0.05	P<0.01	P<0.05
FCR (feed/gain)	1.93 ±0.04 ^{cz}	1.76 ±0.02 ^{bz}	1.72 ±0.05 ^{a}	1.79 ±0.01 ^{cy}	1.68 ±0.03 ^{ay}	1.71 ±0.02 ^{b}	P<0.05	P<0.01	P<0.05

Means with in row with different superscripts abc (omega-3 fatty acid) and superscripts yz (selenomethionine) differ significantly. NS shows nonsignificance.

Table 3. Effect of selenomethionine and omega-3 fatty acid on carcass characteristics and antioxidant status of broiler chicken at 42 day (mean±SE)

Particulars	Selenomethionine (0 ppm)			Selenomethionine (0.3 ppm)			Significance		
	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Seleno-methionine	Omega-3 fatty acid	Seleno-methionine x Omega-3 fatty acid
Dressing (%)	72.15 ±1.18 ^{ay}	76.49 ±1.05 ^{by}	78.03 ±0.94 ^{cy}	76.25 ±1.11 ^{az}	78.46 ±1.26 ^{bz}	77.47 ±0.88 ^{by}	P<0.05	P<0.05	P<0.05
Fat (%)	1.07 ±0.04 ^{bz}	0.73 ±0.08 ^{ay}	1.19 ±1.02 ^{bz}	0.98 ±0.01 ^{cz}	1.15 ±1.15 ^{cz}	0.94 ±0.09 ^{cz}	P<0.05	P<0.05	P<0.05
Thigh (%)	19.38 ±0.96 ^{a}	19.32 ±0.81 ^{a}	19.47 ±0.44 ^{a}	20.31 ±0.29 ^{a}	20.46 ±0.62 ^{a}	18.66 ±0.36 ^{b}	NS	P<0.05	P<0.05
Breast (%)	9.18 ±0.25 ^{ay}	10.34 ±0.61 ^{by}	10.29 ±0.08 ^{by}	10.62 ±0.49 ^{az}	11.04 ±0.19 ^{az}	10.02 ±0.43^{az}	P<0.05	P<0.05	NS
Back and neck (%)	12.43 ±0.43 ^{ay}	14.62 ±0.32 ^{cy}	13.82 ±0.24 ^{by}	13.58 ±0.57 ^{az}	14.72 ±0.20 ^{bz}	14.63 ±0.39 ^{bz}	P<0.05	P<0.05	P<0.05
Giblet (%)	4.75 ±0.16 ^{az}	4.64 ±0.03 ^{az}	4.14 ±0.11 ^{az}	4.33 ±0.19 ^{ay}	4.37 ±0.14 ^{ay}	4.21 ±0.47 ^{ay}	P<0.05	NS	NS
Se (mg/kg muscle)	0.28 ±0.01 ^{ay}	0.29 ±0.02 ^{ay}	0.29 ±0.02 ^{ay}	0.34 ±0.01 ^{az}	0.39 ±0.01 ^{bz}	0.38 ±0.02 ^{bz}	P<0.05	NS	P<0.01
GPx (U/ml)	11.40 ±0.33 ^{ay}	11.50 ±0.09 ^{ay}	11.50 ±0.12 ^{ay}	12.5 ±0.10 ^{az}	12.6 ±0.10 ^{az}	12.5 ±0.16 ^{az}	P<0.05	NS	NS
TBA (µg/kg muscle)	0.31 ±0.05 ^{ay}	0.40 ±0.03 ^{b}	0.41 ±0.04 ^{b}	0.30 ±0.04 ^{ay}	0.32 ±0.01 ^{a}	0.32 ±0.01 ^{a}	NS	P<0.01	NS

Means with in row with different superscripts abc (omega-3 fatty acid) and superscripts yz (selenomethionine) differ significantly. NS shows nonsignificance.

than control group. Similarly, thigh, breast, back and neck and giblet percentages were recorded maximum in same treatment group. The minimum abdominal fat was recorded in 0.5% omega-3 fatty acid supplemented broilers. The selenomethionine in the diet significantly (P<0.05) increased the selenium content of meat. The product of fat source and selenium showed interaction (P<0.01) between the dietary treatments. The GPx activity and TBA value were affected by selenium and fat source alone, respectively, whereas its interaction was nonsignificant. PUFA reduced the hepatic lipogenesis (Shang *et al.* 2004) and also caused higher fat oxidation (Crespo and Esteve-Garcia 2002). The inclusion of organic selenium in the diet improved eviscerated weight and breast yield of broilers (Naylor *et al*. 2000). Edens (2001) observed a significant increase in total carcass yield and cut up parts with dietary organic selenium. The principal function of selenium in body is to destroy free radicals and also to be involved in several enzyme mediated systems i.e. energy and essential fatty acid metabolism, synthesis of prostaglandin and immune response in animals (McDowell 1992). The fatty acid profile of the body fat is dependent on the composition of the fat

Table 4. Effect of selenomethionine and omega-3 fatty acid on fatty acid composition (%) of broiler meat at 42 day (mean±SE)

Particulars	Selenomethionine (0 ppm)			Selenomethionine (0.3 ppm)			Significance		
	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Seleno-methionine	Omega-3 fatty acid	Seleno-methionine × Omega-3 fatty acid
C 18: 3 Linolenic acid	1.49 ±0.12 ^{a}	2.27 ±0.19 ^{b}	2.74 ±0.09 ^{c}	1.53 ±0.10 ^{a}	2.33 ±0.14 ^{b}	2.62 ±0.17 ^{c}	NS	P<0.05	P<0.01
C 20: 5 Eicosa pentanoic acid	0.40 ±0.07 ^{ay}	0.79 ±0.10 ^{b}	0.90 ±0.08 ^{c}	0.52 ±0.12 ^{az}	0.81 ±0.12 ^{b}	0.89 ±0.16 ^{c}	P<0.05	P<0.05	P<0.05
C 22: 6 Docosa hexanoic acid	0.31 ±0.05 ^{ay}	0.42 ±0.09 ^{by}	0.50 ±0.09 ^{c}	0.44 ±0.07 ^{az}	0.49 ±0.12 ^{bz}	0.48 ±0.10 ^{b}	P<0.05	P<0.05	P<0.05

Means within row with different superscripts abc (omega-3 fatty acid) and superscripts yz (selenomethionine) differ significantly. NS, nonsignificant.

Table 5. Effect of selenomethionine and omega-3 fatty acid on HI titer against Newcastle disease of broiler chicken

Particulars	Selenomethionine (0 ppm)			Selenomethionine (0.3 ppm)			Significance		
	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Seleno-methionine	Omega-3 fatty acid	Seleno-methionine × Omega-3 fatty acid
28 day	3.78±0.15 ^{ay}	4.38±0.04 ^{by}	4.86±0.12 ^{cy}	4.85±0.08 ^{az}	5.41±0.17 ^{bz}	5.49±0.20 ^{bz}	P<0.05	P<0.05	P<0.05
42 day	4.29±0.09 ^{ay}	5.64±0.11 ^{by}	6.24±0.08 ^{cy}	5.93±0.19 ^{az}	7.06±0.20 ^{bz}	7.24±0.06 ^{bz}	P<0.05	P<0.05	P<0.05

Means within row with different superscripts abc (omega-3 fatty acid) and superscripts yz (selenomethionine) differ significantly. NS, nonsignificant.

Table 6. Effect of selenomethionine and omega-3 fatty acid on average lymphoid organ weight (g) at 42 day of broiler chicken

Particulars	Selenomethionine (0 ppm)			Selenomethionine (0.3 ppm)			Significance		
	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Omega-3 fatty acid (0%)	Omega-3 fatty acid (0.5%)	Omega-3 fatty acid (1%)	Seleno-methionine	Omega-3 fatty acid	Seleno-methionine × Omega-3 fatty acid
Bursa of Fabricius	5.26±0.06 ^{a}	6.90±0.54 ^{b}	5.10±0.44 ^{a}	5.20±0.71 ^{a}	7.10±0.68 ^{b}	5.50±0.19 ^{a}	NS	P<0.05	P<0.01
Spleen	1.83±0.03 ^{ay}	2.80±0.24 ^{c}	2.20±0.27 ^{b}	2.70±0.12 ^{bz}	3.00±0.09 ^{c}	2.40±0.06 ^{a}	P<0.05	P<0.05	P<0.05
Thymus	5.90±0.02 ^{ay}	8.20±0.79 ^{cy}	7.30±0.67 ^{by}	6.70±0.21 ^{az}	9.40±0.75 ^{cz}	8.40±0.26 ^{bz}	P<0.05	P<0.05	P<0.05

Means within row with different superscripts abc (omega-3 fatty acid) and superscripts yz (selenomethionine) differ significantly. NS, nonsignificant.

present in the broilers feed (Gonzalez-Esquerra and Leeson 2000). Increased concentration of linseed in feeds helps to fulfill the requirements of essential fatty acids (Lopez-Ferrer *et al*. 2001).

The omega-3 fatty acid (linolenic acid, EPA and DHA) concentration of meat increased in the treatment groups than control due to fat source alone or fat source and selenium interaction (Table 4). However selenomethionine alone did not affect the linolenic acid concentration of meat but increased the levels of EPA and DHA.

Serum antibody titer against Newcastle disease virus increased significantly (P<0.05) on day 28 and 42 in treatment groups than control due to increased concentration of selenomethionine and omega-3 fatty acid (Table 5). The interaction between these 2 supplements was also significant (P<0.05). Weights of bursa of Fabricius, spleen and thymus also increased due to supplementation of selenium or fat source alone or in combination, although the weight of bursa due to selenium was not found affected (Table 6). Selenium supplementation enhanced the ability of immune system to respond against various disease challenges. Recently, E-series of resolvins and docosatrienes was identified which is formed from long-chain omega-3 fatty acid and exerts potent anti-inflammatory effects (Serhan *et al*. 2004).

This study adds data on selenium and omega-3 fatty acid enrichment of animal products. The results confirmed the

identical effect of selenium and omega-3 fatty acid in broiler chickens. Furthermore, the organic selenium supplement and omega-3 fatty acid were effectively absorbed into muscles of chickens. Thus it may be speculated that selenomethionine and omega-3 fatty acid enriched broilers diet improved performance, antioxidant status and meat composition. Consumption of such enriched broiler meat may be beneficial for human health also.

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