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Effect of Dietary Supplementation with Fish Oil with Selenium or Vitamin E on Oxidative Stability and Consumer Acceptability of Broilers Meat

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Abstract: In this experiment, the effect of dietary supplementation of fish oil with different antioxidant types and levels (selenium, α-tocopheryl acetate or the combination of both) on improving the oxidative stability and consumer acceptability of breast meat in male broilers were evaluated. 320 broiler cockerels (Ross 308) in 4 dietary treatments with four replicates were fed experimental diets. Diets with 3% fish oil (control) were supplemented with 0.3 mg/kg Se-enriched yeast (SY) or 50 mg/kg vitamin E (Vit. E) or with both SY and Vit.E in half of levels (0.15 + 25 mg/kg). The lipid peroxidation of breast meat in male broilers was decreased in diets supplemented with Se, vitamin E or both as compared with the control. Moreover, the consumer acceptability was improved. The inclusion of Vit.E in the dietary fish oil enhanced the oxidative stability more than SY alone or combination of SY and VE. These factors were expressed as reduced malondialdehyde (MDA) values in breast meat after 0, 5 and 10 days storage period in refrigerator at 4°C. The consumer acceptability of breast samples for treatment 4 (SY + VE) were higher than SY or VE supplemented groups alone after storage period. In conclusion, vitamin E In combination with dietary fish oil can increase oxidative stability and the VE /SY combination for improving consumer acceptability can be more effective in storage period.

Key words: Dietary fish oil · Selenium · Vitamin E · Broiler

INTRODUCTION

Nowadays, fish oil are used to enrich poultry and eggs with long chain n-3 polyunsaturated fatty acids (LC n-3 PUFA) such as C20:5 (eicosapentaenoic acid, EPA) and C22:6 (docosahexaenoic acid, DHA) because of their beneficial effects on health. However, a higher PUFA content of poultry meat increases the degree of unsaturation and, as a result, also increases the susceptibility to oxidation. This may then lead to off-flavors and off-odors and, consequently, lower consumer acceptability. The use of fish oils at concentrations above 2% in poultry diets may entail several sensory problems that compromise meat quality [1]. Supplementation with tocopherols or α-tocopheryl acetate (α-TA) increases the α-tocopherol content of chicken tissues [1 - 5]. Given the potential health effects described for α-tocopherol [7 - 9] enriched poultry meat could be considered a useful source of this vitamin in the human diet. Moreover, the antioxidant function of tocopherols in poultry meat prevents the formation of primary [10] and secondary [2, 4, 11] oxidation products and total volatiles [3].

On the other hand, the essential trace mineral, selenium, is of fundamental importance to human health [12]. Selenium is known to have important roles in reproductive functions and development, immunocompetence and ageing. Selenium is a component of the cell enzyme glutathione peroxidase. The amount of Se available for assimilation by the tissues is dependent on the form and concentration of the element, while organic selenium is deposited in the breast muscle more efficiently than inorganic selenium [13]. Inorganic and organic forms of Se (selenite, selenate, selenide, selenomethionine, selenium enriched yeast and selenium enriched alga) may be used as supplements. Selenocysteine is the predominant selenoamino acid in the tissue when inorganic selenium is given to animals. Se yeast is capable of increasing the activity of the selenoenzymes and its bioavailability was found to be

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higher than that of inorganic Se sources in all but one study [14]. Se-yeast is a product derived from the fermentation of specific strains of yeast incubated in high selenium levels during their growth phase. Being biochemically similar to sulphur, Se replaces the sulphur molecule in the normal biosynthetic pathways of the yeast cell and is absorbed actively across the intestine by the same amino acid carrier [14]. Selenium is an essential micronutrient required for normal growth and maintenance in poultry [15, 16].

Therefore, the present study was conducted to determine and to compare the better efficiency of either antioxidants (selenium in organic form and α-tocopheryl acetate, in combinational form or alone) in supplementing diet with 3% fish oil on improving the oxidative stability and consumer acceptability of breast meat in male broilers. Which can be more effective?.

MATERIALS AND METHODS

Diets and Husbandry: Six hundred 1 day-old ROSS-308 unsexed chicks obtained from a commercial hatchery were reared with commercial feed starter from 1-20 d. At 21st days, 320 male chickens were separated after sexing, individually weighed and randomly placed in 16 floor pens of 1.5 × 1.5 meters with 20 birds per pen. Up to 3 wk of age, chicks were fed the same starter diet. The grower diets were supplemented with 3% fish oil (control) supplemented with 0.3 mg/kg Se-enriched yeast (SY) or 50 mg/kg vitamin E (VE) and or with both SY and Vit. E in half levels (0.15 + 25 mg/kg) which were formulated in accordance with the NRC-1994 and were fed to birds during 21 days growth period. Vitamin E and Se-yeast supplements were included in the premix.

The chicks were maintained on a 24-h constant lighting schedule and diets and fresh water were offered *ad libitum* until slaughter at 42 d of age. Ingredient composition and nutrient calculation for diets are shown in Table 1. The results of the analysis of the experimental diets and breast muscle for Se and α-tocopherol are shown in Table 2. At the end of trial on 42nd day, eight birds (2 males per pen) from each treatment were slaughtered after 12 hour food deprivation, in order to eliminate the influence of outside factors on weight ratios. After evisceration of birds, they were apportioned by hand into commercial cuts and total breasts and thighs, with the skin on, were placed in plastics bags and were chilled during transport to the laboratory. The breast) and thigh muscles were ground and divided into several same parts for the determination of selenium, α-tocopherol and lipid oxidation during storage period for at 4°C before the determination of malondialdehyde and some taste tests for assess consumer acceptability of meat.

Table 1: Composition and calculated nutrient content of diets fed to chicks

Ingredients (%)	Starter diet [1]	Experimental diet [3]
Maize	62.50	31.00
Wheat	-	33.00
Soybean meal	30.50	30.00
Fish meal	4.00	--
Fish oil [3]	-	3.00
Oyster shell	1.20	1.20
Monocalcium phosphate	0.80	-
Dicalcium phosphate	-	1.00
DL-Methionine	0.30	0.10
Sodium chloride	0.20	0.20
Vitamin/mineral premix[4]	0.50	0.50
Total	100.00	100.00
Vitamin E (mg kg $^{-1}$)	--	(T1=0, T2=0, T3=50 and T4=25)
Se (se-yeast) (mg kg $^{-1}$)[2]	--	(T1=0, T2=0.3, T3=0 and T4=0.15)
Calculated nutrient content		
ME (kcal/kg)	2,950	3,085
Crude protein (%)	21.20	20.15
Calcium (%)	0.32	0.10
Available P (%)	0.32	0.19
Methionine (%)	0.37	0.23
Methionine+cystine (%)	0.65	0.57
Lysine (%)	1.22	1.27

[1]starter diet fed to birds from 0 to 20 days. [2]1% basal premix was made with the selenium products for mixing of dietary Treatments in experimental phase. Se-enriched yeast (SY) provided per kg of diets: selenium 0.3 mg, calcium 0.75 mg, phosphorus 2.33 mg, sulphur 1.21 mg, potassium 3 mg, magnesium 0.94 mg, iron 0.074 mg, manganese 0.034 mg, copper 0.015 mg, zinc 0.107 mg. [3]Treatments: T1= control diet; T2 = 0.3 SY; T3 = 50 vit. E and T4 = 0.15 SY + 25 vit. E of mg/kg

[4]Provides per kilogram of diet: vitamin A, 9,000 IU; vitamin D3, 2,000, IU; vitamin E, 18 IU; vitamin B1, 1.8 mg; vitamin B2, 6.6 mg; vitamin B3, 10 mg; vitamin B5, 30 mg; vitamin B6, 3.0 mg; vitamin B9, 1 mg; vitamin B12, 1.5 mg; vitamin K3, 2 mg; vitamin H2, 0.01 mg; folic acid, 0.21 mg; nicotinic acid, 0.65 mg; biotin, 0.14 mg; choline chloride, 500 mg; Fe, 50 mg; Mn, 100 mg; Cu, 10 mg; Zn, 85 mg; I, 1 mg; Se, 0.2 mg

Table 2: Concentration of selenium and á-tocopherol in diets (mg/kg) and breast muscles[1]

	Experimental diets[2]				
Parameter	T1	T2	T3	T4	SE
P[3] Diet Selenium	0.03^{c}	0.32^{a}	0.01^{c}	0.16^{b}	0.021***
α-tocopherol	0.04^{c}	0.08^{c}	50.2^{a}	25.6^{b}	0.311***
Breast muscle[3] Selenium	Nd^{c}	1.24^{a}	Nd^{c}	0.37^{b}	0.035***
α-tocopherol	Nd^{c}	Nd^{c}	38.53^{a}	22.0^{b}	0.462***

^{a,b,c,d} Averages with different superscripts differ at $P < 0.05$. [1]Values are means of eight observations per treatment and their standard errors. [2]Treatments: T1= control diet; T2 = 0.3 SY; T3 = 50 vit. E and T4 = 0.15 SY + 25 vit. E of mg/kg. [3] The amounts are in 0 day storage. [3] NS= P>0.05; *= P<0.05; **= P<0.01

Sensory Analysis: Two consumer panel tests were carried out, in 1 week and 1 month of storage in refrigerator at 4°C that for doing sensory tests whole breasts, with the skin on were cooked. Fifteen consumer panelists were used in both tests. They were selected from department and all had experience in poultry meat sensory analysis. Criteria for selection were: age between 20 to 50 years, not allergic to chicken, consumption of chicken at least once per week and willingness to evaluate meat from chickens fed experimental diets. Vacuum-packed cooked chicken meats were served to the panelists in a professional taste panel including normal smell, flavor, juiciness (water-holding capacity) and tenderness of meat using a 5-point scale ranking following Chekani-Azar, *et al.* [17]. Samples were identified by random 4-digit numbers and all dietary treatments were presented to the consumer panelists in one session. They were also, asked to rank the total acceptability of the product using 4 total scale (very good, good, acceptable, bad).

Determination of TBA Values: Lipid peroxidation in breast and thigh muscles was measured by the thiobarbituric acid method through a third derivative spectrophotometry method after acid aqueous extraction [10].

Statistical Analysis: Data were analyzed using SAS software [18] by the ANOVA test which were appropriate for a randomized complete block design and When significant differences ($P < 0.05$) were detected, means were compared post-hoc using the Duncan multiple range test. The results are expressed as means and their Standard Error (SE).

RESULTS

Table 2 shows data on selenium and α-tocopherol contents of diets and breast tissues samples. The Source of the dietary lipid supplement did significantly influence in the SY and Vit. E amounts. The better results in SY and Vit. E transfer efficiency from diet to meat was related to Treatment 4 (0.15 SY + 25 Vit. E).

The lipid peroxidation as MDA formation in the breast meat of male broilers was decreased in dietary fish oil supplemented with Se, vitamin E or both compared to the control (Figure 1). Moreover, the consumer acceptability was improved. The inclusion of Vit. E in the dietary fish oil could better enhanced the oxidative stability of meat as compared to samples of birds fed diet supplemented by SY (T2) or SY and Vit. E (T4) as reduced malondialdehyde (MDA) values in breast meat after

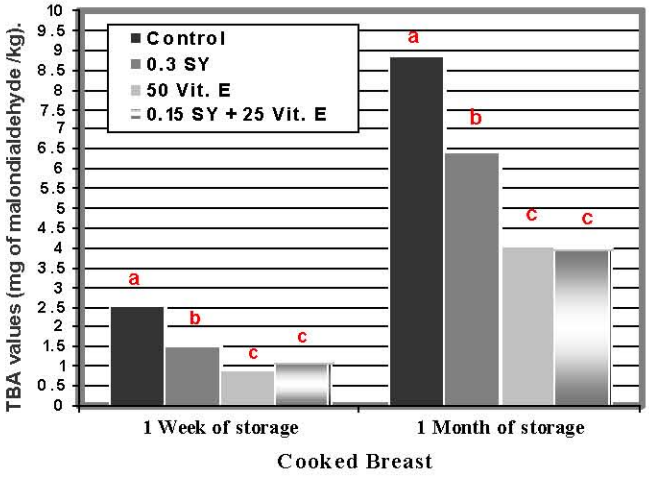

Fig. 1: Effect of adding selenium and Vit. E to dietary fish oil on TBA values of cooked breast chicken meat after 1 wk and 1 month of storage at - 4°C

Table 3: Effect of adding selenium and vitamin E to dietary fish oil on consumer panelists and acceptability scores and TBA values (mg of malondialdehyde /kg) of cooked breast chicken meat after 1 wk and 1 month of storage at -4°C

	Experimental diets[2]					
Item[2]	T1	T2	T3	T4	SE	P[3]
1 Week of storage						
Flavour	2.93^{c}	3.63^{b}	4.13^{a}	4.13^{a}	0.152	***
Normal smell	2.66^{c}	3.32^{b}	3.86^{a}	3.40^{b}	0.146	***
Juiciness	3.53^{b}	3.73^{ba}	3.93^{ba}	4.20^{a}	0.161	*
Tenderness	3.60	3.70	3.73	3.86	0.174	NS
Acceptability[4]	4.40^{b}	5.60^{b}	7.20^{a}	7.80^{b}	0.447	***
TBA values	2.54^{a}	1.53^{b}	0.92^{c}	1.12^{c}	0.073	***
1 Month of storage						
Flavour	2.13^{c}	2.63^{b}	3.27^{a}	3.40^{a}	0.142	***
Normal smell	2.10^{b}	2.46^{b}	3.33^{a}	3.40^{a}	0.161	***
Juiciness	2.73^{c}	3.00^{bc}	3.53^{a}	4.40^{ba}	0.155	**
Tenderness	3.06^{c}	3.86^{ba}	4.33^{a}	3.53^{bc}	0.175	***
Acceptability[4]	3.60^{b}	4.40^{b}	6.80^{a}	6.20^{a}	0.387	***
TBA values	8.81^{a}	6.43^{b}	4.06^{c}	4.01^{c}	0.249	***

^{a,b,c,d} Values in the same row and variable with no common superscript differ significantly. [1]Values are means of fifteen (for professional taste panel and acceptability) and eight (for TBA) o bservations per treatment and their standard errors. [2] The consumers ranked either flavor, normal smell, juiciness and tenderness of meat using a 5-point scale and the acceptability of the meats using a 9-point scale (1 = bad; 3= acceptable; 6= good; 9 = very good). [3] Juiciness = Water-holding capacity. Proportion of area of liquid in relation to the area of meat. [4]Treatments: T1= control diet; T2 = 0.3 SY; T3 = 50 vit. E and T4 = 0.15 SY + 25 vit. E of mg/kg. [5]At 1 mo of storage a freshly cooked commercial chicken meat sample stored for 1 d at -20°C (vacuum-packed) was added to the consumer test as a blind control. [5] NS= P>0.05; *= P<0.05; **= P<0.01

1 week and 1 month storage in refrigerator at 4°C. The consumer's acceptability of breast samples of treatment 4 were higher than SY alone or Vit. E alone groups after 1 wk or 1 month under chilled storage.

Table 3 shows the objective quality meat parameters as flavor, normal smell, juiciness and tenderness of the breast samples of broiler chickens fed diet supplemented with various concentrations of selenium and vitamin E. The breast meat of T3 (50 mg/kg Vit. E) birds had high values in normal smell (P<0/01) and flavour after 1 week and 1 month of storage. The birds that fed diets T3 and T4 had significantly (p<0.01) more juiciness in first week and month and tenderness in first week (p>0.05) and after 1 month of storage (p<0.01).

DISCUSSION

The results of selenium and α-tocopherol concentrations of diets and breast samples showed that SY and Vit. E transfer efficiency from diets including the 3% fish oil to breast muscles were significantly reduced due to their usages to prevent lipid oxidation. On the other hand, omega-3 source such as fish oil are highly unsaturated and elongated (eicosapentaenoic acid, EPA, C20:5 and docosahexaenoic acid, DHA, C22:6) and susceptible to peroxidation when excessive supplemented in diet without added sufficient antioxidants [19]. However, it is well known that the protective effect of selenium and vitamin E for cell membranes which are vulnerable to $O2^{-}$ injury can be boost when those react with these free radicals, notably peroxyl radicals and with singlet molecular oxygen (O^{2-}). Therefore, the quality characteristics, nutritional value of meat and consumer acceptability can be improved with decreasing oxidative deterioration and especially, deleterious biological effects [7, 17].

Grau, *et al.* [20] reported that the antioxidant function of tocopherols in poultry meat prevents the formation of primaryand secondary oxidation products and total volatiles. On the other hand, the essential trace mineral, selenium, is of fundamental importance to human health [12]. Miller and Huang [21] also reported that breast and thigh α-tocopherol content was reduced by 1 or 2% dietary fish oil, compared with 1% soya oil, when diets were supplemented with α-TA at 250 or 450 mg/kg but not when supplemented with α-TA at 50 mg/kg.

Results of the consumer panel tests from cooked breast meats showed that the best values were related to T3 and T4 that are in agreement with results of Lopez Ferrer, *et al.* [22]. Bou, *et al.* [23] studied consumer acceptability of meat of female broiler chicks fed dietary fish oil, supplemented with α-tocopheryl acetate and zinc and they observed no significant differences between dietary treatments after 5mo of storage at -20°C or with respect to a freshly cooked commercial sample used as a blind control.

Despite this, the highest difference in acceptability in control samples as compared with other groups indicates that not only fish oil, but SY and Vit. E doses, especially in combination are probably major contributors to acceptability scores.

In conclusion, both SY and Vit. E supplements decreased TBA values, especially, after a month of chilled storage and improved consumer acceptability scores, thus both supplements can be said to give similar protection against oxidation.

Vitamin E in combination with dietary fish oil can increase oxidative stability and the VE /SY combination for improving consumer acceptability can be more effective in storage period.

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