The effect of dietary antioxidant supplements on abdominal fat deposition in broilers

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Abstract: This study was done to evaluate the effects of several different dietary antioxidantsin broiler diets. The antioxidants tested in the study were organic selenium, vitamin E and garlic powder. Effects of antioxidants on broiler performance were measured according to parameters of abdominal fat deposition, liver lipid concentration and performance. The experiment was done in a completely randomized design with 192 day-old male chicks (Ross 308) randomly distributed in 4 groups of dietary treatments, each with 3 replicates and 16 chicks/pen. Diets tested on the chicks were as follows; a control diet, organic selenium (Sel-Plex®), vitamin E (Alpha-tocopherol acetate®) and garlic powder .Data on performance were recorded at the end of each week for each replicate pen. On day 42, three broilers from each pen were killed and dissected to evaluate abdominal fat deposits. Lipids were extracted from the liver using chloroform/methanol. The results indicated significant ($p<0.05$) reductions in abdominal fat deposition of chicken carcasses that were subjected to diets with garlic powder supplement. Vitamin E indicated significant ($p<0.05$) reduction in abdominal fat content and enhanced carcass mass of broilers but organic selenium had no significant effect on abdominal fat or broiler performance.

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Introduction

Today s commercial broiler is fast growing, making it the most efficient bird ever produced. This has been made possible by genetics and good management. Over the past few decades, the principle aim of poultry production in many countries has been to increase growth rates, but the effect of excessive fat deposition in the abdomen has been neglected (Sumei *et al*., 2007). Over the past 50 years of intensive selection for growth, chickens grown for meat now have a fast growth rate but this is accompanied by a number of negative consequences, including an increase in fat deposition (Griffin, 1996). One of the main problems encountered in the broiler industry today is that broilers often have excessive deposits of body fat. Abdominal fat is highly correlated with total carcass lipids and is used as the main criterion reflecting excess fat deposits in broilers (Chambers, 1990). Furthermore, fat constitutes the main source of waste in slaughter houses (Zerehdaran *et al.*, 2004). Excessive abdominal fat reduces both feed efficiency during rearing and lean meat yields after processing. Poultry with a high abdominal fat content have a low market value. In terms of marketing, economic viability and the recognition of consumers' aversion to excess fatty tissue deposits directs poultry scientists toward the development of new methods to reduce broiler body fat. Research by Havenstein *et al*. (2003) reported that fat in a broiler (at 43 d of age) accounted for as much as 10%- 15% of its total carcass weight. According to these figures there is great potential to make feed more efficient and to improve the quality of broiler carcass by further reducing fat deposition. Some nutrition strategies aiming to reduce costs of animal production have the potential to decrease fat accumulation in broiler carcass. Antioxidants are required for proper functioning of enzymes that destroy free radicals produced during normal metabolic activity. Antioxidant enzymes convert free radicals to relatively stable compounds and stop or prevent the chain reaction of free radical damage. Supplements of antioxidants in a diet increase the activity of glutathione peroxidase in plasma and decrease lipid peroxidation that act as a defense mechanism by its effect on liver cells. Liver is the main site for lipid transfer and biosynthesis in avian species. Organic Se, a natural form of selenium, has more beneficial effects in maintaining the antioxidative system than does its inorganic form (Pirsljin *et al.,* 2008). In poultry production, the main purpose of adding selenium to food is to prevent certain diseases, which is activated by its positive effect on the immune system (Mihailović *et al*., 1991; Jokić *et al.,* 2005; Pirsljin *et al*., 2008). There is a synergistic relationship between selenium and vitamin E, and research has suggested that this synergism may enhance the quality of meat (Surai and Dvorska, 2002). It has long been considered that antimicrobial and antioxidant properties of garlic (Allium sativum) have several beneficial effects for humans and animals (Konjufca *et al.*, 1997; Sivam, 2001). Other research has demonstrated that antimicrobial activity (Adimoradi *et al*, 2006), can effectively of lower lipid concentrations (Agarwal, 1996; Sharma and Dixit, 1996), lower serum and liver lipid levels (Qureshi *et al*., 1983) and improve the performance of broiler chicks in terms of productivity (Demir *et al*., 2003; Tollaba and Hassan, 2003). The aim of this experiment was to study the effects of different profiles of dietary antioxidants (organic selenium, vitamin E, garlic) on performance, abdominal fat deposition and liver lipid concentrationin broiler chickens.

Materials and Methods

The experiment was done using a total of 192 day-old male broiler chicks (Ross 308). Birds were randomly allotted to one of four treatments (three replicates of sixteen chicks per pen) according to body weight in a completely randomized design. Broilers were housed in controlled pens (length 180 cm × width 100 cm). Chicks were maintained on a 24 h constant-light schedule. Feed and water were provided ad libitum and diets were given as mash. Diets were formulated to meet or exceed the nutrient requirements of broilers (NRC, 1994). Composition of the corn-SBM basal diet is shown in Table 1.

Diets assigned to the groups of broilers were as follows; a commercial basal diet which contained no additives was used as a control diet (diet 1); diet 2 was formulated by supplementing the control diet with 0.3 g/kg organic Se(Sel-Plex, it is a selenized yeast product);diet 3 was supplemented with 2 g/kg of vitamin E (Alpha-tocopherol acetate) anddiet 4 was formulated by the control diet plus 15 g/kg of garlic powder(the garlic powder contained 14.22% crude protein, 34.5% crude fiber and 2.6% total ash on dry matter basis). Performance data (weight gain, feed intake and feed conversion ratio) of each replicate pen were recorded at the end of each week. On day 42 of the trial, 12 broilers from each pen were selected according to an average body weight within the pen following a fasting period of 12-h, they were weighed individually, killed then bled and dissected immediately to evaluate carcass fat deposits. Other organs such as heart, spleen, liver and bursa of fabricius were weighed to the nearest time and presented as relative to body weight (g/100 g BW). Fat around the cloaca, bursa of fabricius, proventriculus, and muscles adjacent to the abdomen were considered as abdominal fat deposits (Cahaner *et al*. 1986), which were collected, weighed, and expressed as a proportion of carcass weight without the head and feet. The liver lipids were extracted by chloroform/methanol (Folch *et al.*, 1957).

Table 1: Ingredient composition (dry matter (%)) and calculated analysis of the basal diets

Ingredient	Starter (0-14)	Grower (14-28)	Finisher (28-42)
Corn	59	62	65
Soybean meal	37.45	34.18	31.45
Plant oil	1	1.5	1.5
DCP	1.34	1.25	1.13
Salt	0.5	0.4	0.3
Vitamin premix*	0.25	0.25	0.25
Mineral premix*	0.25	0.25	0.25
DL-Methionine	0.11	0.08	0.04
L-lysine	0.1	0.09	0.08
Nutrient content			
ME (kcal/ kg)	2850	2900	2950
Crude protein (%)	20.9	19.3	18.44
Crude fiber (%)	4.21	4.12	3.9

*Vitamin and mineral provided/kilogram of diet: Vitamin A, 360000IU; Vitamin D_3, 800000 IU; Vitamin E, 7200IU; Vitamin K_3, 800mg; Vitamin B1, 720mg; vitamin B2, 2640mg; vitamin B6, 1200mg; vitamin B12, 6mg; Choline, 200000 mg; Manganese, 40000 mg; Iron, 20000 mg; Zinc, 40000 mg; Copper, 4000 mg; Iodin, 400mg; Selenium, 80mg .

Table 2: Effect of antioxidant supplementation in diet on performance of broiler chickens

performance	Treatments				SEM
	Control	Garlic	Organic Se	Vitamin E	
Body weight	2018.73^{ab}	2136.42^{a}	1977.95^{b}	2047.75^{ab}	54.18
Weight gain	1892.99^{b}	2083.38^{a}	1921.39^{b}	2010.15^{a}	37.11
Feed intake	4714.81^{ab}	4901.17^{a}	4509.02^{b}	4583.14^{b}	63.17
FCR	2.49	2.3	2.34	2.28	0.27

^{ab}values in the same row with no common superscript differ significantly(P≤0.0
Control = commercial basal diet which contained any feed additive
Garlic = Control diet Plus garlic fed at 15 g/kg
Organic Se = Control diet Plus organic selenium (Sel-Plex) fed at 0.30 g/kg
Vitamin E = Control diet Plus vitamin E (Alpha-tocopherol acetate) fed at 2 g/kg

Table 3: The effect of antioxidants supplementation in diet on organs weight (In 100g BW).

Organs	Treatment				SEM
	Control	Garlic	Organic Se	Vitamin E	
Spleen	0.092^{b}	0.095^{ab}	0.096^{ab}	0.104^{a}	0.05
bursa	0.102	0.1	0.098	0.102	0.07
Heart	0.457	0.496	0.491	0.466	0.26
liver	2.286^{a}	2.183^{ab}	2.083^{b}	2.110^{b}	0.71

^{ab}values in the same row with no common superscript differ significantly(P≤0.05)
Control = commercial basal diet which contained any feed additive
Garlic = Control diet Plus garlic fed at 15 g/kg
Organic Se = Control diet Plus organic selenium (Sel-Plex) fed at 0.30 g/kg
Vitamin E = Control diet Plus vitamin E (Alpha-tocopherol acetate) fed at 2 g/kg

Data were statistically analyzed by ANOVA using the GLM procedure of SAS (SAS Institute, 1989) for a randomized complete design. Differences among all treatments were separated by Duncan's multiple range tests. Mean values and standard error of means (SEM) are reported. Probability values of less than 0.05 were considered as significant.

Results

Results of this study for performance parameters at 0-3 weeks of age showed no significant difference (P>0.05) between the diet treatments. Body weights of birds from 3 to 6 weeks of age were significantly higher in those that were subjected to diets with garlic supplement(P<0.05). Test diets did not have any significant affect on feed conversion ratio at any age (Table 2)**.** Diet had no effect on heart and bursa of fabricius weights (Table 3), but in vitamin E and organic Se diets, spleen and liver weights were highest and lowest respectively in comparison with the control (P<0.05). Abdominal fat pad deposits increased in birds on the control diet and were significantly less in groups fed on diets with garlic and vitamin E supplements(P<0.05)**.** Abdominal fat represented 2.35% of carcass weight in broiler chickens fed on the control diet and chickens fed on garlic and vitamin E diets had fat/carcass weight levels of 1.94 and 1.95%, respectively(Table 4).Vitamin E and organic Se reduced the percentage of fat in broiler liver (Table 4), but there was no significant difference (P>0.05). Broilers fed with garlic powder had faster growth rates compared with broilers fed with the control diet and this difference was more noticeable after the tertiary week (Figure 1). In addition, these results indicated a significant reduction in abdominal fat pad contents of chicken carcasses due to the influence of garlic powder as a dietary supplement and this group had the highest record for body weight(p<0.05).

Discussion

The best increase body weight of chicks receiving diets supplemented with garlic was obtained at 3-6 weeks and 0-6 weeks. The effect of garlic dietary supplementation in diets compared to other groups on growth performance of broiler chicks can be explained by its effect on the histological structure of the small intestine; it is proposed that it serves to provide a greater surface area for absorption of nutrients (Adibmoradi*et al*., 2006). Also, theantimicrobial and antioxidant attributes of garlic may facilitate be enhanced growth performance of broilers.

Table 4: Abdominal fat (In 100g BW) and liver fat (percent on dry matter) measured for the broiler chickens fed antioxidant supplementation in diet.

	Treatment				
Fat percent	Control	Garlic	Organic Se	Vitamin E	SEM
Abdominal fat	2.35[a]	1.94[b]	2.27[a]	1.95[b]	0.12
Liver fat	24.95	27.47	20.42	19.95	6.07

[ab]values in the same row with no common superscript differ significantly($P \leq 0.05$)
Control = commercial basal diet which contained any feed additive
Garlic = Control diet Plus garlic fed at 15 g/kg
Organic Se = Control diet Plus organic selenium (Sel-Plex) fed at 0.30 g/kg
Vitamin E = Control diet Plus vitamin E (Alpha-tocopherol acetate) fed at 2 g/kg

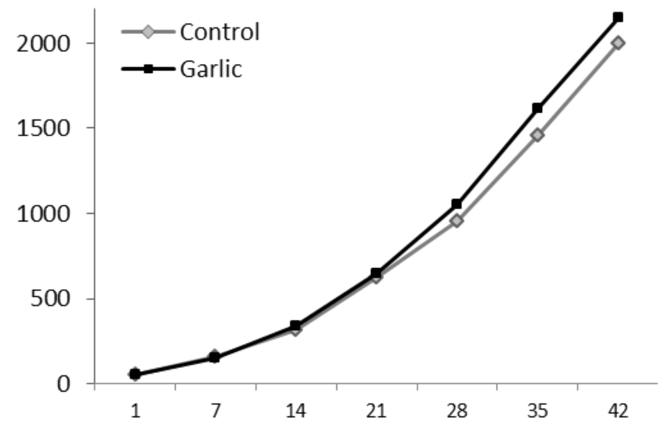

Figure 1. Weight gain measured for the broiler chickens fed garlic diet in comparison with control diet group
Control = commercial basal diet which contained any fee
Garlic = Control diet Plus garlic fed at 15 g/kg

Amagase *et al.*, 2001 suggested that these functions were mainly attributed to the bioactive components of garlic, which include sulphur-containing compounds, such as alliin, diallylsulphides and allicin. Many studies have indicated that allicin is the potentially active component of garlic, and that it serves to inhibit the growth of pathogenic bacteria (Samanta and Dey, 1991). When a clove of garlic crushed, alliin, which is of the cyclo-oxygenase and lipoxygenase group of enzymes, is converted to its anti-microbial active form of allicin(Metwally, 2009). Allicin is a sulphur containing compound (thio-2-propene-1-sulfinic acid S-allyl ester) and its production from an odorless precursor alliin, is catalyzed by an enzyme, alliinase or alliin lyase and is responsible for the characteristic smell of garlic (Yeh and Liu, 2001). Garlic's antioxidant properties can be attributed in part tothe compound alliin (Metwally, 2009). Selenium is part of the antioxidant defense system required for proper functioning of glutathione peroxidase enzymes. It defends the cellular system from oxidative damage (Aydemir *et al.*, 2000). Dietary organic Se supplementation has a positive effect on the antioxidant system during the fattening period in chickens (Pirsljin *et al*., 2008). Marković (2007) reported that additions of organic Se and vitamin E have a positive effect on carcass mass and broiler meat yield. Similar conclusions wereReached in research by Naylor *et al.* (2000) and Payneand Southerm(2005).Researchhas indicated that the inclusion of organic Se in chicken food for fattening chickens results in increased carcass mass and proportions of breast meat in the mass of a processed carcass. However, in this experiment, Sel-Plex did not have a significant effect on broiler performance.

Body weight is positively correlated with total abdominal fat,therefore this evaluation should have been highest in chicken produced from a garlic enriched diet, results showed that it had excellent body weight, but data showed significantly lower levels of abdominal fat in the group that were fed garlic.This indicates that garlic may have had an affect on lipogenesis and triglyceride synthesis in chickenlivers. Little research has been done to determine that dietary garlic supplements regulate hepatic lipid metabolism in chickens. The organosulfur content of garlic is primarily that of alliin derivatives, which are reported to be the cause of its low effect onlipids. Ademola *et al.*, 2009 reported that garlic in a diet decreased production of abdominal fat pads, serum cholesterol and triacylglycerol of broiler chickens. Research has demonstrated that garlic supplements fed to broilers affectlipid and cholesterol metabolism that reduce plasma cholesterol and triacylglycerols (Konjufca *et al.*, 1997). Studies in animal models indicate that dietary garlic supplement depresses the hepatic activities of lipogenic and fatty acid syntheses (Qureshi *et al*,. 1983). Studies in human and animal models and *in vitro* results provided satisfactory evidence that garlic lowers serum lipid and cholesterol (Lau *et al*. 1987; Silagy and Neil 1994). The results of another trial comparing garlic with a commercial lipid-lowering drug (benzafibrate, a fibric acid derivate) reported a statistically significant effect of decreasing lipids (Holzgartner *et al*. 1992). Garlic depresses the hepatic activities of lipogenic and cholesterogenic enzymes, including malic enzyme, fatty acid syntheses and glucose-6 phosphate dehydrogenase (Qureshi *et al.*, 1983). Development of adipose tissue depends on the availability of plasma triglycerides. Activity of the hepatic malic enzyme is positively correlated with the rate of fatty acid synthesis, percentages of body fat and abdominal fat in chicks(Sumei *et al*,. 2007). Ain Baziz *et al*., (1996) demonstrated that in broilers, lipids deposited in adipose tissue are almost exclusively synthesized in the liver and taken up through Lipoprotein lipase (LPL) activity. LPL is an adipocyte enzyme that cleaves fatty acids from circulating lipoproteins, and fatty acids enter the cell to be oxidized or esterified into triacylglycerol (Mersmann, 1998). Lu*et al.*,(2006) showed that LPL can hydrolyze triglycerides of chylomicrons and low-density lipoproteins to free fatty acids and glycerols, which go into adipose tissue and are esterified into triglycerides. Research demonstrated that percentages of abdominal fat could be reduced by decreasing LPL activity in abdominal fat and reported that the key factor in maintaining adiposity was toincrease garlic in broiler diets in order toreduce percentages of abdominal fat deposition in these birds. However, inhibitition activity of LPL directly or indirectly by garlic is still unknown and no information is available regarding the effect of dietary garlic supplement on LPL activities in abdominal fat of broilers.Further experiments can be carried out to elucidate whether garlic has an affect on LPL activity in deposition of abdominal fat in broilers.

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