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Original article

EFFECTS OF DIETARY GARLIC (*ALLIUM SATIVUM*) MEAL ON SKIN THICKNESS AND FAT DEPOSITION IN COMMERCIAL BROILER CHICKENS

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Summary

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Excessive deposition of fat in the skin of commercial chickens has major implications on human health. Garlic (*Allium sativum*) has been reported to have hypolipidaemic effect in animals. The effect of garlic on fat deposition in the skin of commercial broilers was therefore investigated. One hundred and sixty day-old Arbor acres broilers of different sexes were randomly separated into four groups. Group A was fed a plain ration; group B had 0.125% garlic meal (GM) in feed continuously, group C – 0.125% GM at pulse inclusion (on for 2 weeks and off for 2 weeks) and group D – 0.25% GM continuously. At 4 and 8 weeks of age, five broilers per group were randomly selected, euthanised and back cape skin sections were harvested and processed for histology. Epidermal as well as dermal-hypodermal thicknesses were measured. Data were statistically analysed using Duncan's multiple range test and Student's *t*-test at $P<0.05$. The epidermis in the control group (Group A) was significantly different vs the other groups at 8 weeks of age. Dermal-hypodermal thickness of group C (15296.1±965.7 μm) was significantly higher vs other groups at 4 weeks of age. Fat globules were relatively more abundant in the hypodermis of group A at 4 and 8 weeks of age, while collagen fibres in the dermis were relatively denser in the GM-supplemented groups. It was concluded that garlic inclusion in feed of commercial broilers resulted in thinner epidermis and denser collagen fibres in the dermis causing thicker dermis-hypodermis, as well as decreased fat deposits in the hypodermis.

Key words: broiler chickens, garlic, fat deposition, skin thickness

INTRODUCTION

Increased growth rate and low feed conversion ratio through genetic selection in broiler chicken has been attributed to increased body fat deposition, high mortality and high incidence of metabolic diseases and skeletal disorders (Zubair & Leeson, 1996). Excessive fat (abdominal and subcutaneous) in carcasses of broiler

chickens is a waste product in slaughterhouses since it reduces carcass yield and feed efficiency (Lippens, 2003; Jennen, 2004), causes meat rejection by the consumers (Kessler *et al.,* 2000), as well as brings about significant economic losses (Havenstein *et al*., 2003; Nikolova *et al*., 2007). Also, consumer awareness of the relationship between consumption of certain fat and cardiovascular diseases has resulted in preference for leaner meat (Cable & Waldroup, 1990), thus stimulating interest in reducing body fat deposition in broiler production. Nonetheless, a minimum quantity of carcass fat is necessary for an optimal sensory quality because of its positive influence on succulence and taste (Lippens, 2003; Zerhdaran *et al*., 2004; Zerhdaran, 2005).

Garlic (*Allium sativum*) is regarded as a therapeutic agent in the traditions of many cultures (Amagase *et al*., 2001). The active component of garlic has some beneficial effects for livestock, having hypocholesterolaemic effects, growth promoting and antioxidant activities (Lewis *et al*., 2003; Oladele *et al*., 2012). It has been reported to decrease the concentration of triglycerides and cholesterol in blood (Gorunovic, 2001), and to possess anticholesterolaemic and anti-lipidaemic actions proven experimentally in rabbits and rats (Sovová & Sova, 2004). Feeding garlic powder results in lower plasma cholesterol as well as breast and thigh muscles cholesterol in broilers (Konjufca *et al.*, 1997). Garlic supplementation can be valuable in the production of quality broiler meat as suggested by Sklan *et al*. (1992). It is known to improve the activity of enzymes which are involved in the conversion of cholesterol to bile acids (Raeesi *et al.*, 2010), thus, it could be valuable in the reduction of lipids in body tissues. The biochemically active constituent of garlic is allicin (thio-2-propene-1-sulfinic acid S-allyl ester) which is produced from an odourless precursor alliin, catalysed by the enzyme alliinase or alliin lyase and is responsible for its smell (Murad & Baseer, 1997). Barhagallo *et al*. (1998) reported that chronic exposure to small amounts of tellurium found in garlic may reduce endogenous cholesterol production through inhibition of hepatic squalene epoxidase.

The present study was therefore carried out to determine the effect of dietary garlic supplementation on subcutaneous fat deposition in chicken in order to improve carcass quality and consumer acceptance.

MATERIALS AND METHODS

Experimental chickens and maintenance

One hundred and sixty Arbor acres day-old broilers of different sexes were purchased from a commercial hatchery in Ibadan, Nigeria. The chicks were reared at the Experimental Animal Unit of the Department of Veterinary Medicine, University of Ibadan (N 07.27121, E 003.50661). The altitude was 815 metres above sea level with relative humidity ranging from 50–80%, having a rainfall of approximately 70 inches per annum and temperatures ranges between 28 ^{o}C and 34 ^{o}C.

They were randomly separated into 4 treatment groups (A, B, C and D) of forty birds each and reared in different cages for 8 weeks. The chicks were fed *ad libitum* with broiler starter ration (from day-old to 4 weeks of age) and broiler finisher ration (from 5 to 8 weeks of age) supplemented with varying levels of garlic meal (GM, Patent No. NG/2012/285). The broilers were administered multivitamins in drinking water between 1–5 days of age and prophylactic dose of doxycycline hyc-

late and gentamicin sulphate (Gendox®, Pantex Holland Veterinary pharmaceutical company) from 6–11 days of age. Newcastle disease (ND) vaccine, HB_1 strain was administered on day 1 and LaSota strain at 21 days of age, while infectious bursal disease vaccine was administered at 8 and 17 days of age.

Experimental procedure

Broilers in Group A were fed plain ration, those in Group B were fed ration containing 0.125% GM continuously, those in Group C were fed ration containing 0.125% GM for 2 weeks on and 2 weeks off (pulse dosing), while those in Group D were fed ration with 0.25% GM continuously, till 8 weeks of age. At 4 and 8 weeks of age, five broilers per group were randomly selected and euthanised in CO_2 chamber. Sections of skin at the region of the back cape were cut, and fixed in labelled sample bottles containing 10% formalin.

Histological sections were processed and stained with haematoxylin & eosin stain. From each section, increase in the thickness of collagen fibres was microscopically visualised while epidermal and dermal-hypodermal thicknesses as well as hypodermal and adipocytes layer thicknesses were measured with a micro-meter using the motic image scale under the microscope with a graduated eye piece of ×100 objective lens. The percent ratios of the adipocytes layer to the total thickness of the hypodermis and of adipocytes layer to the total thickness of dermal+hypodermal layers were calculated.

Statistical analysis

Mean and standard error of mean values were calculated for each group and comparisons between and within groups for significant differences were made using analysis of variance, Duncan's multiple range test and Student's *t*-test.

RESULTS

The epidermal thickness in group A (control group) was significantly ($P<0.05$) higher in 8-week-old birds compared to all other groups (Table 1). The epidermal thickness decreased significantly ($P<0.05$) in group C at 4 weeks of age vs the same group at 8 weeks of age (Table 1). Similarly, the epidermal thickness decreased significantly ($P<0.05$) in birds from group D at 4 weeks to birds in the same group at 8 weeks of age (Table 1). The dermal-

Table 1. Epidermal thickness and dermal-hypodermal thickness (mean ± SEM; n=5) in commercial broilers at 4 and 8 weeks of age fed varying levels of garlic meal (GM): Group A – plain ration, Group B – 0.125% GM continuously, Group C – 0.125% GM for 2 weeks on and 2 weeks off (pulse dosing), Group D – 0.25% GM continuously

	Group A	Group B	Group C	Group D
Epidermal thickness (μm)				
4 weeks	1675.9±199.9^{a}	1538.4±163.6^{a}	1279.7±173.4^{a}	1368.7±209.2^{a}
8 weeks	1566.7±354^{a}	1241.4±225.7^{ab}	851.5±101.7^{b}	989.1±87.4^{ab}
Dermal-hypodermal thickness (μm)				
4 weeks	9927.1±1285.6^{b}	13603.2±1754.9^{ab}	15296.1±965.7^{a}	11194.3±936.4^{b}
8 weeks	11700.4±1600.6^{a}	14512.2±1252.6^{a}	14430.7±912.6^{a}	14159.5±2132.7^{a}

Values in the same row with different superscript are significantly different ($P<0.05$).

Table 2. Adipocyte layer and hypodermal layer thickness (mean ± SEM; n=5) in commercial broilers at 4 and 8 weeks of age fed varying levels of garlic meal (GM): Group A – plain ration, Group B – 0.125% GM continuously, Group C – 0.125% GM for 2 weeks on and 2 weeks off (pulse dosing), Group D – 0.25% GM continuously

	Group A	Group B	Group C	Group D
Adipocyte layer, µm 4 weeks of age	4808.4±1046.1	4016.2±551.5	2574.1±454.9	4978.1±469.7
Hypodermal layer, µm 4 weeks of age	1824.5±350.7	1603.4±409.2	1742.2±376.2	2248.4±433
Adipocyte layer, µm 8 weeks of age	3492.8±496.6	3246.6±1228.3	2353.3±356.2	3677.5±344.3
Hypodermal layer, µm 8 weeks of age	2253.7±298.7	1673.1±310.6	1429.2±240.3	2208.0±671.1

Table 3. Percent ratios of adipocytes to total of hypodermal and dermal hypodermal thicknesses (mean ± SEM; n=5) in commercial broilers at 4 and 8 weeks of age fed varying levels of garlic meal (GM): Group A– plain ration, Group B –0.125% GM continuously, Group C – 0.125% GM for 2 weeks on and 2 weeks off (pulse dosing), Group D–0.25% GM continuously

	Group A	Group B	Group C	Group D
Adipocytes layer/hypodermis thickness percentage, 4 weeks of age	325.4±104.7[a]	274.2±30.1[a]	190.8±50[a]	292.2±101.7[a]
Adipocytes layer/hypodermis+ dermis thickness percentage, 4 weeks of age	47.3±7.2[b]	29.7±1.6[a]	16.7±2.5[a]	46.2±6.9[b]
Adipocytes layer/hypodermis thickness percentage, 8 weeks of age	170±33.1[a] *	199.9±72.5[a]	174.9±30.9[a]	237.8±80.7[a]
Adipocytes layer/hypodermis+ dermis thickness percentage, 8 weeks of age	31±4.9[a]	22.2±8[a]	16±1.7[a]	34.2±3.3[a]

Values in the same row with different superscript are significantly different (P<0.05); *significantly lower than value for 4 weeks-old birds.

hypodermal thickness in group C was significantly higher (P<0.05) than the respective value in group A at 4 weeks of age (Table 1).

No significant differences were found out with respect to adipocyte and hypodermal layer thicknesses (Table 2).

The percentage of adipocytes to the total dermal-hypodermal thickness was significantly lower (P<0.05) in Groups B and C (fed 1.25 g/kg GM) than the value in controls (A) at 4 weeks of age (Table 3).

Histological examination of skin sections showed thinner epidermis in all garlic meal fed groups B, C and D (Fig. 1) compared with control Group A (Fig. 2). The dermis-hypodermis of garlic meal fed groups was thicker than those of control Group A which had more abundant fat globules (Fig. 2). Also, thicker collagen fibres were observed in GM groups (Fig. 1) unlike the scanty appearance in control group A (Fig. 2).

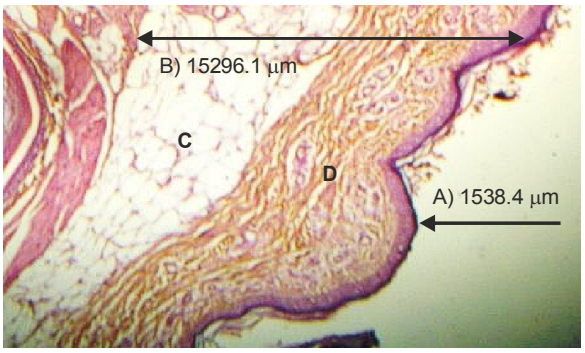

Fig. 1. Photomicrograph of the skin of broilers from Group C (1.25 g/kg garlic inclusion at pulse dose) at 4 weeks of age showing (A) thinner epidermis; (B) thicker dermal-hypodermal layer with fat globules (C); (D) collagen fibres (H&E) ×100.

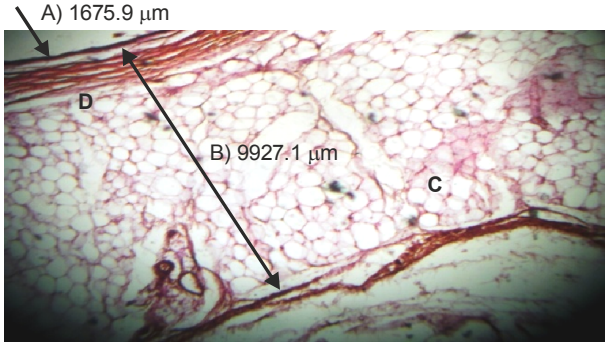

Fig. 2. Photomicrograph of the skin of broilers from Group A (control) at 4 weeks of age showing (A) thicker epidermis; (B) thinner dermal-hypodermal thickness with fat globules (C); (D) collagen fibres (H&E) ×100.

DISCUSSION

This study was conducted to determine the skin thickness and fat deposition in garlic inclusion and non-inclusion commercial broilers. Thicker epidermis as recorded for control group A at 4 and 8 weeks of age compared with the garlic meal groups (B, C and D) was probably due to a very thick surface layer of dead cells in the epidermis which was absent in garlic groups due to exfoliation. Furthermore, the thicker dermis-hypodermis layer of the skin largely recorded for the garlic groups at both 4 and 8 weeks of age was a result of the thicker collagen present in their dermis compared to that of the control group. Lisa (2014) reported that sulfur containing amino acids i.e. methionine and cysteine (both of which are present in garlic) build up collagen and prevent damage to it. Collagen, which is the main structural protein in the skin, provides the structural scaffolding for cells, tissues, and organs (Draelos, 2015). It gives the skin its strength, durability and is also responsible for the replacement of dead skin cells (Mcintosh, 2014). Moon (2006) also reported that collagen is the major component of intramuscular connective tissue associated with meat tenderness, while meat tenderness is a very important

trait of meat quality and consumer acceptance, and this is dependent on textural characteristics and composition of the meat (Nhat Thu, 2006). Furthermore, Muir *et al.* (2000) and Monson *et al.* (2005) argued that meat tenderness is a relationship between the collagen content, heat stability and the myofibrillar structure of muscle. As reported by Young & Braggins (1993), sensory tenderness and shear force of meat are functions of total collagen content. The shear force is an indicator of the easy cut measure of the meat and inidicating its tenderness (Platter *et al*., 2003). Likewise, the observed reduction in fat in the skin of broilers in the garlic groups confirms the lipolytic effect of garlic (Keefer, 2013).

This study has shown that garlic inclusion in feed particularly at a dose of 0.125% given either continuously or by pulse-dosing has the ability to bring about thinner epidermis, thicker collagen in the dermis and decreased fat deposits in the hypodermis resulting from thicker dermis-hypodermis.

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