African Journal of Agricultural Research Vol. 4 (5), pp. 511-517, May 2009
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2009 Academic Journals

Full Length Research Paper

Response of broiler chickens in terms of performance and meat quality to garlic (*Allium sativum*) supplementation

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Accepted 20 May, 2009

A study was conducted to assess the effect of dietary garlic (*Allium sativum*) supplementation on the performance and meat quality of broiler chickens using a total of 300 day old Shaver Starbo chicks allotted at 10 birds per replicate and 6 replicates per treatment over a period of 7 weeks. The basal starter and finisher diets contained 228.61 and 201.42 g/kg CP, respectively. The control diet was the basal diet without garlic supplementation. Diets 2 and 3 contained supplementary raw garlic powder at 500 and 5,000 mg/kg diet respectively, while diets 4 and 5 contained supplementary boiled garlic powder at 500 and 5,000 mg/kg diet respectively. 4 female birds per replicate were slaughtered at the end of the trial to evaluate carcass and muscle characteristics, garlic aroma and palatability scores of the meat and oxidative stability of refrigerated meat at 4°C for 6 days were determined. The average weight gain, average feed intake and feed conversion ratio of the birds were not significantly (P > 0.05) influenced by dietary treatments. Broiler chickens fed garlic supplemented diets had marginally higher weight gain than those fed the control diet and was higher at high level of garlic supplementation (39.18 ± 0.94, 40.42 ± 0.45, 42.39 ± 1.57, 39.72 ± 2.97 and 41.42 ± 2.60 g/bird/day for Diets 1, 2, 3, 4 and 5 respectively; P > 0.05). The carcass and organ characteristics of the chickens were not significantly affected (P>0.05) by dietary garlic supplementation but abdominal fat contents were numerically lowered due to supplementary garlic. Moisture contents of broiler chickens were not significantly (P > 0.05) influenced. Garlic aroma (P < 0.001) and palatability (P > 0.05) scores increased with increasing level of dietary garlic supplementation. Thigh muscle had the highest score for garlic aroma (2.60 ± 1.30), followed by drumstick (2.57 ± 1.14) and lowest for breast muscle (2.50 ± 1.17) (P > 0.05). Oxidation susceptibility of meat, measured as concentration of malondialdehyde (MDA), decreased with increasing level of supplementary garlic fed to the chickens (P < 0.01). Muscle MDA concentration was in order of thigh > drumstick > breast (P < 0.001). It was concluded that supplementation of chicken diets with garlic marginally improved weight gain and it was better at high level of supplementation (5,000 mg/kg diet). Boiled compared with raw garlic powder produced no beneficial effect. Dietary garlic supplementation improved meat quality by increasing meat palatability score and reducing the extent of oxidation of meat during refrigerated storage.

Key words: Broilers, performance, meat, garlic aroma, palatability, oxidative stability, garlic.

INTRODUCTION

More emphasis than ever before is now placed on global food security. Poultry meat offers considerable potential for bridging the gap between supply and demand for animal protein, especially in Africa. In this continent and other less developed nations, the low level of supply of animal protein is due to the poor performance of livestock (Aletor, 1986), which has been attributed to factors such

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as inadequate nutrition, high price and poor quality of feeds and inefficiency in production and distribution in the feed industry (Tewe, 1997). It also worth noting that several attempts have been made in this region to reduce feed cost while improving productivity of high-meat yielding exotic poultry like broiler chickens. These include the use of agro-industrial by-products (Aletor, 1986), maggot meal (Awoniyi et al., 2004), leafy vegetable protein concentrates (Agbede and Aletor, 2003) and herbaceous human haematinics (Adedapo et al., 2002; Nworgu et al., 2007).

Apart from the inadequate supply and consumption of animal protein, there has been a resurgence of interest in improving the physicochemical and sensory properties of meat, as well as its storage life. In pursuit of improved chicken healthiness and in order to fulfil consumer expectations in relation to food quality, poultry producers more and more commonly apply natural feeding supplements, mainly herbs (Gardzielewska et al., 2003). The positive effects of herbal supplements on broiler performance, carcass quality and quality traits of meat have been demonstrated (Schleicher et al., 1998). Onibi et al. (2000) reported the use of supplementary α-tocopheryl acetate in the diets of pigs which increased the concentration of vitamin E as well as the oxidative stability of meat. Thyme (*Thymus vulgaris*) addition to minced broiler chicken meat similarly retarded the rate of lipid peroxidation (Onibi, 2003). A variety of herbal supplements including garlic (*A. sativum)* have been widely used to maintain and improve health of humans (Freeman and Kodera, 1995). Garlic supplements in broiler chicken have been recognized for their strong stimulating effect on the immune system and the very rich aromatic oils enhance digestion of birds (Gardzielewska et al., 2003).

The key active ingredient in garlic is a powerful plant chemical called allicin which rapidly decomposes to several volatile organosulphur compounds with bioactivities (Chang and Cheong, 2008). Garlic is used both as condiment and medicament, anticoagulant, antioxidant, hypolipidaemic, antihypertensive, antiageing, antiplatelet and heavy metal detoxifier (Agarwal, 1996; Marilynn, 2001). The antioxidative influence of garlic in meat becomes more imperative in less developed nations, considering storage problems and increasing use of alternative feed resources without due consideration for meat quality (Onibi et al., 2007). Garlic is not widely used as human food because it gives a repulsive odour and the taste is pungent. Since monogastric animals are able to incurporate dietary components directly in their tissues (Scaife et al., 1994; Onibi et al., 2000), supplementary garlic for broilers could mediate in getting the bioactive compounds in garlic, through broiler meat into the human food chain, while avoiding the resentment due to its direct consumption. However, there is dearth of convincing studies on quantity and form of supplementary garlic in broiler nutrition. It is against these backgrounds that this study was conducted to evaluate the effect of feed supplementation with raw and boiled garlic (*A. sativum*) powder at 500 and 5,000 mg/kg diet on the growth performance and carcass characteristics, garlic aroma, palatability and oxidative stability of meat of broiler chickens.

MATERIALS AND METHODS

This study was conducted at the Department of Animal Production and Health of the Federal University of Technology, Akure, Nigeria. Raw garlic powder was prepared by cutting garlic bulbs into small pieces, followed by sun drying for 14 days and pulverization with Mortuno Victoria Grain Mill (Mecanicos Unidos® S.A.). Boiled garlic powder was prepared by putting raw garlic bulbs 190 - 200 g in watertight nylon and boiled for 30 min in boiling water. Thereafter, it was diced, sun-dried for 2 weeks and pulverized into powder.

A total of 400 day old Shaver Starbo broiler chicks were raised on wood shaving bedded floor pens, under similar managerial and hygienic conditions for 1 week pre-experimental period. At the beginning of the 8th day, 300 chicks were randomly distributed into the 5 treatment groups (TG) using the completely randomised experimental design (CRD). Each TG was allotted 10 birds per replicate (5 males and 5 females) and 6 replicates per treatment. The basal starter diet (228.61 g/kg CP and 3029.84 kcal/kg ME) and basal finisher diet (201.42 g/kg CP and 2949.69 kcal/kg ME) were fed without garlic supplementation (control diet); with supplementary raw garlic powder at 500 mg/kg diet (Diet 2), with supplementary raw garlic powder at 5,000 mg/kg diet (Diet 3); with supplementary boiled garlic powder at 500 mg/kg diet (Diet 4) and with supplementary boiled garlic powder at 5,000 mg/kg (Diet 5). The starter diets were supplied from 8th to 28th day while the finisher diets were supplied between 29th and end of trial at 56th day. The broiler starter and basal finisher diets were formulated to meet the NRC (1994) nutrient requirements for broilers. Feed and water were provided *ad libitum*.

During the experiment, weekly feed intake and live weight per replicate and mortality were recorded. At the end of the trial, the birds were weighed and 4 female broilers of similar body weights were selected from each replicate and subjected to a 12 h starvation. Thereafter, they were electrical stunned, manually slaughtered, eviscerated, cold-water washed and chilled at 4°C for 4 h prior to cut-up as described for turkey by Hahn and Spindler (2002). Parameters measured were carcass characteristics and organ weights. For logistic reasons, especially the problems of handling large number of treatment groups for organoleptic and oxidative stability studies, only meat samples from the control group and birds supplied the raw garlic supplementation were considered for meat quality analysis. Samples of breast, drumstick and thigh muscles without the skin from the left side were saved for oxidative study. Each of these muscle parts were divided into 2 parts, sepa-rately packed into polythene bags and one part frozen immediately at -18°C. The second part was refrigerated at 4°C for 6 days prior to frozen storage.

Evaluation for oxidative stability was conducted using the aqueous extraction 2-thiobarbituric acid (TBA) method (Pikul et al., 1989; Onibi, 2005) within 2 weeks of frozen storage. The right side samples of breast, drumstick and thigh muscles with the skin were frozen for 3 weeks before sensory evaluation at the department of food science and technology of the aforementioned university. The meat samples were pooled together according to treatment group and muscle type, then 500 - 550 g sample was boiled at 85°C with 200 ml of water for 23 - 25 min. There was little broth formation

Table 1. Performance of broiler chickens fed diets containing supplementary garlic (8 - 56 days).

Parameters	Treatments				
	1	2	3	4	5
Supplementary garlic (mg/kg diet)	**0 (Control)**	**500 (raw)**	**5,000 (raw)**	**500 (boiled)**	**5,000 (boiled)**
Initial live weight (g/bird)	116.42 ± 6.17	115.83 ± 5.77	115.33 ± 5.28	116.03 ± 5.62	115.90 ± 6.61
Final live weight (g/bird)	2035.24 ± 51.60	2096.51 ± 20.53	2193.01 ± 81.70	2061.90 ± 139.73	2144.70 ± 133.69
Total weight gain (g/bird)	1919.80 ± 45.91	1980.72 ± 22.20	2077.11 ± 76.80	1946.13 ± 145.40	2029.70 ± 127.44
Total feed intake (g/bird)	5213.00 ± 248.00	5541.00 ± 320.00	5263.00 ± 303.00	5265.00 ± 305.00	5199.00 ± 250.00
Average weight gain (g/bird/day)	39.18 ± 0.94	40.42 ± 0.45	42.39 ± 1.57	39.72 ± 2.97	41.42 ± 2.60
Average feed intake (g/bird/day)	106.39 ± 5.07	113.08 ± 6.52	107.40 ± 6.18	107.45 ± 6.23	106.10 ± 5.10
Feed conversion ratio	2.72 ± 0.14	2.80 ± 0.15	2.54 ± 0.15	2.71 ± 0.19	2.56 ± 0.06
Mortality (%)	3.33	1.67	3.33	3.33	1.67

Mean ± Standard deviation.
No two treatment means are significantly different (P>0.05).

after the cooking. The cooked meat samples (without the skin and broth) were coded and evaluated by a 10 member trained panel using questionnaire containing a 5 point hedonic scale for garlic aroma (1 = no garlic aroma and 5 = very strong garlic aroma) and a 9 point hedonic scale for palatability (1 = dislike extremely and 9 = like extremely) as described by Larmond (1982). Fresh muscle samples were analysed for moisture and total lipids according to AOAC (1995) methods. All chemical analyses were carried out in quadruplicate.

The data collected were subjected to one-way analysis of variance (for performance and carcass characteristics) and factorial analysis (for meat quality). Where significant differences were found, the means were compared using Duncan's new multiple range test (DNMRT). The Minitab Statistic Package (v.10.2, Minitab Inc. USA) was used for the analysis.

RESULTS AND DISCUSSION

The performance parameters are presented in Table 1. Dietary garlic supplementation did not significantly (P > 0.05) influence the final live weight, feed intake, weight gain and feed conversion ratio of the broiler chickens. This observation agrees with the results of Ademola et al. (2004) which showed no significant difference (P > 0.05) in average live weight of broiler chickens fed garlic at 5,000 mg/kg diet. Higher, but statistically not significant final live weight (FLW) and average body weight gain (ABWG) values were recorded due to dietary garlic supplementation. The FLW and ABWG) were also numerically higher at high levels of inclusion garlic in the diets (5,000 mg compared with 500 mg/kg diet for both raw and boiled garlic). The relative growth-promoting effects of garlic in this study buttress earlier reports of Demir et al. (2003) and Lewis et al. (2003) and that body weight gain was improved in broiler chickens fed low concentrations of commercial garlic products. Feed to gain ratios were not affected by treatments and boiled garlic supplementation produced no improvement in performance characteristics compared with supplementary raw garlic. Percent mortality ranged between 1.67 and 3.33 but did not follow any trend in relation to treatment groups.

The selected carcass and organ characteristics measured (Table 2) showed no significant (P > 0.05) effect of garlic supplementation. Thus, supplementation of the diets with garlic promoted similar carcass development as the control diet. The relative weights of the abdominal fat were numerically lower for broilers fed supplementary garlic compared with those fed the control diet. This suggests that garlic supplementation could reduce fat deposition (Lydia, 2001).

Table 3 shows the moisture and lipid contents of meat from the experimental broiler chickens. Moisture contents of the meat were not significantly (P > 0.05) influenced by garlic supplementation, muscle type and interaction of the 2 factors. The value of the moisture contents of the meat did not follow any trend in relation to treatment groups or muscle type. Broiler chicken feed supplementation with Echinacea (*Echinacea purpurea*), garlic (*A. sativum*) and ginger (*Zingiber officinale*) was similarly reported by Gardzielewska et al. (2003) to produce no significant (P > 0.05) effect on dry matter content of the muscles. The moisture contents of the meat (731.33 - 766.04 g/kg fresh meat) were also similar to that reported for meat from broiler chickens on plant supplemented feed (747.02 - 750.29 g/kg fresh meat) (Gardzielewska et al., 2003). The lipid contents of the meat was significantly (P < 0.01) influenced by the muscle type but not by garlic supplementation or the interaction of garlic supplementation and

Table 2. Selected carcass and organ characteristics of broiler chickens fed diets containing supplementary garlic.

Parameters	Treatments				
	1	2	3	4	5
Supplementary garlic (mg/kg diet)	**0 (Control)**	**500 (raw)**	**5,000 (raw)**	**500 (boiled)**	**5,000 (boiled)**
Dressing percentage	93.24 ± 0.66	90.86 ± 0.83	94.54 ± 1.76	93.81 ± 1.26	92.52 ± 3.86
Eviscerated percentage	84.96 ± 2.26	82.31 ± 3.52	86.11 ± 2.42	88.36 ± 2.42	86.03 ± 2.16
Thigh (g/kg live weight)	102.61 ± 11.09	99.47 ± 8.71	102.48 ± 6.41	100.62 ± 12.86	112.35 ± 9.56
Drumstick(g/kg live weight)	96.24 ± 5.68	95.32 ± 8.52	96.74 ± 9.72	100.01 ± 6.06	91.08 ± 3.08
Breast (g/kg live weight)	206.56 ± 13.27	189.71 ± 14.76	196.10 ± 20.70	223.3 ± 19.20	209.90 ± 4.09
Back (g/kg live weight)	157.12 ± 17.10	158.34 ± 15.26	162.29 ± 8.59	165.30 ± 35.40	156.60 ±49.50
Abdominal fat (g/kg live weight)	16.27 ± 7.89	14.38 ± 2.50	15.60 ± 5.55	15.10 ± 4.41	14.97 ± 3.70
Heart (g/kg live weight)	4.76 ± 0.63	4.80 ± 0.93	4.78 ± 1.06	4.14 ± 0.49	4.28 ± 0.37
Liver (g/kg live weight)	18.94 ± 1.93	20.85 ± 1.95	20.35 ± 2.65	18.20 ± 0.72	19.34 ± 2.36
Gizzard (g/kg live weight)	19.35 ± 5.34	20.37 ± 1.72	18.67 ± 1.95	17.88 ± 4.65	17.60 ± 3.28

Mean ± Standard deviation.
No two treatment means are significantly different (P>0.05).

Table 3. Moisture and lipid contents (g/kg fresh meat) of meat from broiler chickens fed diets containing supplementary raw garlic.

		Parameters	
		Moisture	**Lipids**
Supplementary garlic effect			
0 mg/kg diet (Control)		750.56 ± 23.51	64.93 ± 15.71
500 mg/kg diet		742.22 ± 18.24	67.44 ± 14.39
5,000 mg/kg diet		755.18 ± 15.23	66.72 ± 18.52
Muscle type effect			
Breast		749.54 ± 15.21	49.08 ± 4.22^{c}
Drumstick		748.89 ± 17.23	66.90 ± 7.58^{b}
Thigh		749.54 ± 26.09	82.94 ± 9.21^{a}
Interaction			
Supplementary garlic	**Muscle type**		
0 mg/kg diet (Control)	Breast	749.68 ± 20.90	48.73 ± 3.11
	Drumstick	750.73 ± 17.18	63.04 ± 6.14
	Thigh	751.27 ± 38.30	83.04 ± 7.03
500 mg/kg diet	Breast	742.61 ± 9.54	51.33 ± 5.89
	Drumstick	752.69 ± 26.89	68.72 ± 4.51
	Thigh	731.33 ± 12.60	82.33 ± 7.44
5,000 mg/kg diet	Breast	756.44 ± 16.01	47.43 ± 3.80
	Drumstick	743.28 ± 9.69	69.52 ± 11.61
	Thigh	766.04 ± 13.84	83.31 ± 15.34
Statistical significance			
Supplementary garlic		NS	NS
Muscle type		NS	***
Interaction		NS	NS

Mean ± Standard deviation NS = Not significant (P>0.05) *** = P<0.001
Means with different superscripts within the same column and for the same parameter are significant (P < 0.05).

muscle type. Thus, supplementary garlic did not reduced the lipid contents of meat which did not confirm the results of study by Gardzielewska et al. (2003) that intramuscular fat content of broilers offered garlic decreased

Table 4. Garlic aroma and palatability of meat from broiler chickens fed diets containing supplementary raw garlic.

		Parameters	
		Garlic aroma	**Palatability**
Supplementary garlic effect			
0 mg/kg diet (Control)		2.03 ± 0.96[a]	6.70 ± 0.95
500 mg/kg diet		2.63 ± 1.16[b]	6.77 ± 1.04
5,000 mg/kg diet		3.00 ± 1.26[c]	7.17 ± 1.26
Muscle type effect			
Breast		2.50 ± 1.17	6.73 ± 1.29
Drumstick		2.57 ± 1.14	7.17 ± 1.10
Thigh		2.60 ± 1.30	6.73 ± 0.91
Interaction			
Supplementary garlic	**Muscle type**		
0 mg/kg diet (Control)	Breast	2.10 ± 0.99	6.40 ± 0.84
	Drumstick	2.40 ± 1.08	7.00 ± 1.24
	Thigh	1.60 ± 0.70	6.70 ± 0.68
500 mg/kg diet	Breast	2.90 ± 1.45	6.40 ± 1.51
	Drumstick	2.30 ± 1.06	7.10 ± 0.74
	Thigh	2.70 ± 0.95	6.80 ± 0.63
5,000 mg/kg diet	Breast	2.50 ± 0.97	7.40 ± 1.27
	Drumstick	3.00 ± 1.25	7.40 ± 1.20
	Thigh	3.50 ± 1.43	6.70 ± 1.34
Statistical significance			
Supplementary garlic		**	NS
Muscle type		NS	NS
Interaction		NS	NS

Mean ± Standard deviation NS = Not significant ($P > 0.05$) ** = $P<0.01$
Means with different superscripts within the same column and for the same parameter are significant ($P<0.05$).

by 43% compared with the control group . The thigh muscle had the highest lipid content (82.94 ± 9.21 g/kg), followed by drumstick muscle (66.90 ± 7.58 g/kg) and lowest for breast muscle (49.08 ± 4.22 g/kg) ($P < 0.05$). Similarly, fat deposition has been reported to be higher in thigh than drumstick and lowest for breast muscle (Ikeme, 1990; Onibi, 2006).

The garlic aroma of the meat samples were not influenced ($P > 0.05$) by muscle type and interaction of garlic supplementation and muscle type (Table 4). However, there was a significant ($P < 0.001$) effect of garlic supplementation with 5,000 mg/kg diet garlic supplementation having the highest garlic aroma score. The garlic aroma score, though lowest, recorded for meat from chickens fed the control diet is attributable to the residual effect of the garlic aroma of meat from chickens on the other treatment groups. Thigh muscle had the highest numerical score for garlic aroma (2.60 ± 1.30), followed by drumstick (2.57 ± 1.14) and lowest for breast muscle (2.50 ± 1.17). This could be attributed to the lipid contents of these muscles (thigh > drumstick > breast). Although not significant, the preference for the taste (palatability) of meat samples of chickens increased with increased levels of supplementary garlic, similar to results that meat of birds fed on garlic-supplemented diet achieved the highest sensory score (Schleicher et al., 1996).

The results of oxidation, measured as the concentration of malondialdehyde (MDA) in meat during refrigerated storage are presented in Table 5. There were significant differences due to the diets on the MDA concentration at day 1 ($P < 0.05$) and day 6 ($P < 0.001$) of refrigerated storage. Generally, MDA concentrations in meat decreased with increasing level of supplementary garlic. Muscle type also had significant effect ($P < 0.001$) on MDA concentration at day 6 of storage. The highest MDA concentration was in thigh (3.06 ± 0.20 mg/kg fresh meat), followed by drumstick (2.90 ± 0.22 mg/kg fresh meat) and lowest in breast muscle (2.64 ± 0.37 mg/kg fresh meat). These results agree with other reports (Apte and

Table 5. Oxidative stability (mg MDA/kg meat) of refrigerated meat from broiler chickens fed diets containing supplementary raw garlic.

		Storage length at 4ºC (days)	
		0	6
Supplementary garlic effect			
0 mg/kg diet (Control)		0.92 ±0.12[a]	3.01 ± 0.34[a]
500 mg/kg diet		0.77 ± 0.07[b]	2.92 ± 0.27[b]
5,000 mg/kg diet		0.72 ± 0.09[c]	2.67 ± 0.27[c]
Muscle type effect			
Breast		0.80 ± 0.10	2.64 ± 0.37[c]
Drumstick		0.77 ± 0.14	2.90 ± 0.22[b]
Thigh		0.83 ± 0.15	3.06 ± 0.20[a]
Interaction			
Supplementary garlic	**Muscle type**		
0 mg/kg diet (Control)	Breast	0.86 ± 0.11	2.73 ± 0.45
	Drumstick	0.89 ± 0.17	3.06 ± 0.08
	Thigh	1.00 ± 0.07	3.25 ± 0.20
500 mg/kg diet	Breast	0.75 ± 0.07	2.75 ± 0.43
	Drumstick	0.77 ± 0.05	2.96 ± 0.16
	Thigh	0.78 ± 0.10	3.04 ± 0.07
5,000 mg/kg diet	Breast	0.79 ± 0.10	2.44 ± 0.27
	Drumstick	0.65 ± 0.06	2.68 ± 0.21
	Thigh	0.71 ± 0.08	2.88 ± 0.13
Statistical significance			
Supplementary garlic		*	***
Muscle type		NS	***
Interaction		NS	NS

Mean ± Standard deviation NS = Not significant (P > 0.05) ** = P < 0.001
Means with different superscripts within the same column and for the same parameter are significant (P<0.05).

Morrissey, 1987Onibi, 2006) that breast muscle with lowest lipid content had the lowest MDA concentration and thigh muscle which had the highest lipid content, oxidized most.

Conclusions and Recommendations

Garlic supplementation of broiler chicken diets marginally improved weight gain (P > 0.05) and it was better at higher level of supplementation (5,000 vs. 500 mg/kg diet).

No consistent effect was derived from boiled garlic compared with raw garlic powder dietary supplementation in term of performance of birds.

Supplementary garlic in the diets of broilers did not influence significantly (P > 0.05) carcass and organ characteristics but the weights of the abdominal fat were numerically lowered.

Dietary supplementation with garlic non-significantly (P>0.05) enhanced palatability scores and significantly (P < 0.05) increased garlic aroma scores.

Oxidative stability of refrigerated broiler chicken meat was improved by supplementary garlic in the diets and it was better at higher level of supplementation.

The extent of deposition of the active compounds in garlic, which are of medicinal value, in meat, may be investigated in further research.

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