Impact of Varying Frequencies of Aqueous Garlic Extract Administration on the Carcass, Organ Weight Characteristics and Meat Quality of Broiler Chickens

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Abstract

Natural feed additives like garlic are gaining attention as a sustainable alternative to antibiotics in poultry nutrition due to their growth-promoting, antimicrobial, and health-enhancing properties. This study was conducted to evaluate the impact of varying frequencies of aqueous garlic extract administration on the carcass, organ weight characteristics and meat quality of broiler chickens. A total of 300 day-old Cobb 500 broiler chicks were divided into five treatment groups of 60 birds each and further subdivided into four replicates of 15 chicks each on a weight equalisation basis. The five treatment groups were randomly allotted such that the control group (T_1) received antibiotics (Colistin®) in drinking water, while treatments T_2, T_3, and T_4 received 7.5g aqueous garlic extract per litre of water for 3, 5, and 7 days per week, respectively. Birds in T_5 served as a negative control, receiving only fresh water. Data collected were subjected to a one-way analysis of variance (ANOVA). Results revealed that garlic extract administration influenced carcass characteristics and organ weights. The highest values for head, shank, thigh, and gizzard were recorded in T5 (ordinary water), with percentages of 2.92%, 5.17%, 12.43%, and 2.15%, respectively. These values were significantly higher compared to those observed in T3 (2.58% for head), T1 (4.03% for shank), T4 (10.84% for thigh), and T2 and T4 (1.84% and 1.80% respectively, for gizzard). Water-holding capacity of meat was significantly improved ($p<0.05$) in T2 (3 days/week), while cooking loss remained unaffected. Lipid profile analysis revealed significantly higher HDL levels in T5 (71.95 mg/dL), with no significant changes in total cholesterol, triglycerides, LDL, or VLDL. These findings indicate that aqueous garlic extract administered at a dosage of 7.5g/L can enhance carcass traits and meat quality in broilers, offering a promising antibiotic alternative without adverse effects.

Keywords: Broiler chickens, Lipid profile, Carcass, Aqueous garlic extract

Running title: Effect of Garlic Extract Frequency on Broiler Carcass and Meat Quality

Impact de différentes fréquences d'administration d'extrait aqueux d'ail sur les caractéristiques de la carcasse, du poids des organes et de la qualité de la viande chez les poulets de chair

Résumé

Les additifs alimentaires naturels comme l'ail suscitent un intérêt croissant en tant qu'alternative durable aux antibiotiques dans la nutrition avicole, en raison de leurs propriétés stimulant la croissance, antimicrobiennes et améliorant la santé. Cette étude a été menée pour évaluer l'impact de différentes fréquences d'administration d'extrait aqueux d'ail sur les caractéristiques de la carcasse, le poids des organes et la qualité de la viande des poulets de chair. Au total, 300 poussins Cobb 500 d'un jour ont été répartis en cinq groupes de traitement de 60 sujets chacun, subdivisés en quatre répétitions de 15 poussins sur la base d'une égalisation des poids. Les cinq groupes ont été répartis aléatoirement : le groupe témoin (T_1) a reçu des antibiotiques (Colistin®) dans l'eau de boisson, tandis que les groupes T_2, T_3 et T_4 ont reçu

7,5 g d'extrait aqueux d'ail par litre d'eau respectivement pendant 3, 5 et 7 jours par semaine. Les oiseaux du groupe T5 ont servi de témoin négatif, recevant uniquement de l'eau fraîche. Les données recueillies ont été soumises à une analyse de variance (ANOVA) à un facteur. Les résultats ont révélé que l'administration d'extrait d'ail influence les caractéristiques de la carcasse et le poids des organes. Les valeurs les plus élevées pour la tête, les pattes, les cuisses et le gésier ont été enregistrées dans le groupe T5 (eau simple), avec des pourcentages respectifs de 2,92 %, 5,17 %, 12,43 % et 2,15 %. Ces valeurs étaient significativement supérieures à celles observées dans T3 (2,58 % pour la tête), T1 (4,03 % pour les pattes), T4 (10,84 % pour les cuisses) ainsi que T2 et T4 (1,84 % et 1,80 % respectivement pour le gésier). La capacité de rétention d'eau de la viande a été significativement améliorée ($p < 0,05$) dans le groupe T2 (3 jours/semaine), tandis que les pertes à la cuisson n'ont pas été affectées. L'analyse du profil lipidique a révélé des taux de HDL significativement plus élevés dans T5 (71,95 mg/dL), sans modification significative du cholestérol total, des triglycérides, du LDL ou du VLDL. Ces résultats indiquent que l'extrait aqueux d'ail administré à une dose de 7,5 g/L peut améliorer les caractéristiques de la carcasse et la qualité de la viande chez les poulets de chair, offrant ainsi une alternative prometteuse aux antibiotiques sans effets indésirables.

Mots-clés : Poulets de chair, Profil lipidique, Carcasse, Extrait aqueux d'ail.

Introduction

Poultry farming is a critical contributor to the global food market, providing a substantial portion of the protein required for human consumption. Broiler chickens, in particular, play a vital role in meeting this demand, as their production has outpaced that of other livestock such as pork and beef (Nkukwana, 2018). Despite its growth and commercialization, poultry production faces numerous challenges, including high feed costs and significant health concerns (validate this assertion with a reference). The nutritional management of broiler chickens remains pivotal, as it directly influences their growth, health, and meat quality (Castro *et al.*, 2023). Proper nutrition ensures optimal growth and physiological development in broiler chickens, including muscle, bone, and feather development (Snyder, 2019). Proteins, carbohydrates, and lipids, which are key dietary components, play specific roles in promoting growth, energy metabolism, and nutrient absorption (Leeson and Summers, 2009). Lipids, for instance, contribute to energy storage, cellular integrity, and the absorption of fat-soluble vitamins like A, D, E, and K, which are crucial for immune function and antioxidant defense (Bertechini *et al.,* 2017; Mateos *et al.,* 2012). A balanced lipid profile is essential for both the health of broilers and the sensory qualities of their meat, as imbalances can lead to metabolic disorders and compromised meat quality (Leeson and Summers, 2005).

The reliance on antibiotics in poultry production has been a common strategy to enhance growth performance and prevent diseases. However, the widespread use of antibiotics has raised concerns over antibiotic resistance in meat and residues in the environment (Diarra and Malouin, 2014; Mehdi *et al.,* 2018). As a result, there has been increasing interest in exploring natural alternatives such as probiotics, organic acids, and herbal products (Gadde *et al.,* 2017). Among these, garlic (*Allium sativum*) has gained attention for its potential as a natural feed additive due to its bioactive compound, allicin, which possesses antibacterial, antifungal, antiviral, and antioxidant properties (Chang and Cheong, 2008; Hanieh *et al.,* 2010). Garlic has been reported to enhance immune responses and digestion in broiler chickens while also serving as a natural alternative to synthetic antibiotics (Puvača *et al.,* 2019). Additionally, its application in broiler diets aligns with consumer expectations for

healthier and more sustainable poultry production. As modern poultry farmers seek effective and eco-friendly alternatives, garlic stands out for its potential to improve meat quality and production efficiency.

The efficacy of garlic as a feed additive must however, be assessed comprehensively especially frequency and dosage of administration. Parameters such as lipid profiles, physico-chemical properties of meat, carcass characteristics, and organ weights are critical indicators of the physiological and metabolic impacts of dietary interventions (Połtowicz and Doktor, 2013). This study sought to fill this knowledge gap by evaluating the effects of varying frequencies of aqueous garlic extract administration on broiler chickens, with special focus on key physiological and production parameters. It determined the lipid profile, including cholesterol, triglycerides, and fatty acids, in chickens subjected to these treatments. Additionally, the physico-chemical properties of broiler chicken meat, carcass characteristics and organ weights, were assessed with a view to providing insights into the potential benefits of incorporating garlic extract as a dietary intervention.

Materials and Methods

Experimental site

The experiment was conducted at DUFARMS, Federal University of Agriculture, Abeokuta, located in Ogun State, Nigeria. This region is characterized by a tropical climate with an annual rainfall of approximately 1037 mm, temperatures ranging from 28°C to 36°C, and relative humidity levels of 60% to 94%, averaging 82%. The vegetation is a mixture of tropical rainforest and savannah.

Experimental materials and preparation of test ingredient

Garlic bulbs (*Allium sativum*) were sourced from a local market in Lagos, Nigeria. After peeling, 50 g of garlic was weighed and blended using an electric blender. One liter of hot water at 100°C was added to the blended garlic paste, left to soak for 12 hours, and then sieved. The resulting garlic extract was diluted to a 15% concentration, which is 15 mL of the concentrated extract with 85 mL of distilled water to obtain a final volume of 100 mL and administered as per the treatment schedule. The broad-spectrum antibiotic used is Colistin®

Garlic bulbs (*Allium sativum*) were procured from a local market in Lagos, Nigeria. The cloves were peeled, and 50 g of garlic was weighed and homogenized using an electric blender. Subsequently, 1 L of hot water (100 °C) was added to the garlic paste and allowed to steep for 12 hours. The mixture was then filtered to obtain the aqueous garlic extract. This extract was diluted to a 15% working concentration by mixing 15 mL of the filtrate with 85 mL of distilled water to yield a final volume of 100 mL. The prepared garlic extract was administered to broiler chickens according to the designated treatment schedule. Colistin® was used as the reference broad-spectrum antibiotic in the control group.

Experimental birds and management

Three hundred (300), day-old Cobb 500 broiler chicks were obtained from a reputable Hatchery. The chicks were weighed individually per replicate. Each of the five treatment groups consists of four replicates of 15 birds per replicate. The groups were randomly assigned to the treatment as shown below in a Completely Randomized Design (CRD) experiment.

Treatment Groups:

- T_1 (Positive Control): Antibiotics (Colistin®) was administered for four days each at day-old and at four weeks old, following the manufacturer's recommended dosage.
- T_2: garlic extract was given in drinking water for three consecutive days per week at a dosage of 7.5g per litre.

- T_3: garlic extract was given in drinking water for five consecutive days weekly at the dosage of 7.5g per litre.
- T_4: garlic extract was given in drinking water continuously throughout the experimental period at the dosage of 7.5g per litre.
- T_5 (Negative Control): Birds were supplied with fresh water only, for the duration of the experiment.

Commercial broiler chicken starter diets (22% crude protein, 3000 kcal/kg metabolizable energy, 0.6% methionine, 3.5% fiber) was provided *ad libitum* from weeks 0 to 3, followed by broiler finisher chicken feed (21% crude protein, 2800 kcal/kg metabolizable energy, 0.59% methionine, 3.66% fiber) from week 3 to 6. Both treated and untreated water was made available *ad libitum*, and vaccinations and medications were administered following standard procedure.

Data collection

For carcass characteristics and organ weights, two birds per replicate with weights close to the mean per replicate were selected and slaughtered after a 12-hour feed withdrawal. The carcasses were scalded, de-feathered, dressed, and dissected into primal cuts. Dressed carcass, eviscerated carcass, cut-up parts, and organ weights were then measured and expressed as a percentage of live weight, with dressing percentage and organ weights calculated using the appropriate formulas.

$$\text{Dressing \%} = \frac{\text{Dressed weight}}{\text{Live weight}} \text{ x } 100$$

$$\text{Organ weight \%} = \frac{\text{Organ weight}}{\text{Live weight}} \text{ x } 100$$

For meat physical properties, water holding capacity was evaluated by soaking 3 g of breast muscle in 10 ml of distilled water for 1 hour, and weight changes were expressed as a percentage of the initial weight. Cooking loss was determined by weighing and cooking 50 g of breast muscle in sealed plastic bags at 70°C for 30 minutes, followed by calculating the percentage of weight loss (Sanwo *et al.*, 2019). Total lipid content was determined using the Folch method. Briefly, weighed meat sample (15 g) was ground and constituted into a compound paste, followed by the addition of chloroform and methanol mixture at 2:1 (v/v). Thereafter, decantation was carried out prior to the determination of meat cholesterol, triacylglycerol and high and low density lipoprotein (Folch *et al*. (1957).

Statistical analysis

Data obtained were analyzed using the one-way analysis of variance (ANOVA) in a completely randomized design. Where significant differences were observed, the means were separated using Duncan's Multiple Range Test at a significance level of $P < 0.05$ (SAS, 2012).

Results

The results presented in Table 1 highlight the effects of varying frequencies of aqueous garlic extract administration on carcass characteristics of broiler chickens. Live weight, plucked weight, eviscerated weight and dressed weight were not significantly ($p>0.05$) affected by the frequencies of garlic extract administration. Among specific carcass components, negative control (T_5) showed the highest head percentage (2.92%) and shank percentage (5.17%), both were significantly ($p<0.05$) greater than groups administered garlic extract for 5 days (2.58%) and the positive control (4.03%), respectively. Thigh weight was highest in the Negative Control group (12.43%), which differed significantly ($p < 0.05$) from T_4 (10.84%), indicating that garlic extract may not promote better muscle deposition in the thighs at higher frequencies.

In terms of organ weights (Table 2), the gizzard percentage was significantly ($p<0.05$) greater in Negative Control (2.15%) compared to groups administered garlic extract three times per week and daily, potentially reflecting increased muscularity resulting from grinding. Abdominal fat was numerically lowest in T_4 (0.26%),

supporting garlic's lipid-lowering effects. While no significant ($p>0.05$) differences were observed in heart, spleen, kidney, proventriculus, lungs, intestine, or liver weights, minor variations suggest that garlic may influence organ proportionality.

Table 1: Effect of frequency of aqueous garlic extract administration on carcass characteristics of broiler chickens

Parameters (% of liveweight)	Frequency of administration of garlic extract (7.5 g of garlic per litre of hot water)					SEM	P value
	(T1) Antibiotics (Positive Control)	(T2) Garlic (3 days)	(T3) Garlic (5 days)	(T4) Garlic (Daily)	(T5) Ordinary water (Negative Control)		
Live weight (g)	1692.25	1576.13	1608.25	1629.63	1571.38	21.00	0.37
Plucked wt (g)	91.95	92.89	93.18	91.20	96.83	1.05	0.51
Eviscerated wt (%)	82.47	79.55	79.30	78.04	82.36	1.19	0.72
Dressed wt (%)	67.12	67.26	67.94	68.09	70.98	0.75	0.50
Head	2.62^{ab}	2.68^{ab}	2.58^{b}	2.76^{ab}	2.92^{a}	0.04	0.04
Shank	4.03^{b}	4.94^{ab}	4.68^{ab}	4.80^{ab}	5.17^{a}	0.15	0.03
Neck	4.49	4.41	4.45	4.13	4.40	0.13	0.93
Wings	8.96	8.94	9.02	8.76	10.00	0.20	0.34
Back	13.27	13.66	13.87	13.36	13.73	0.21	0.89
Breast	22.22	22.35	21.49	21.78	22.42	0.32	0.87
Thigh	11.44^{ab}	11.36^{ab}	12.18^{ab}	10.84^{b}	12.43^{a}	0.22	0.05
Drumstick	11.01	10.71	10.78	10.45	11.58	0.19	0.42
Abdominal fat	0.61	0.53	0.56	0.26	0.46	0.07	0.52
Live weight (g)	1692.25	1576.13	1608.25	1629.63	1571.38	21.00	0.37

^{a,b} means on the same row with different superscripts are significantly ($p<0.05$) different.

Table 2: Effect of frequency of aqueous garlic extract administration on internal organs of broiler chickens

Parameters (% of liveweight)	Frequency of administration of garlic extract (7.5 g of garlic per litre of hot water)					SEM	P value
	(T1) Antibiotics (Positive Control)	(T2) Garlic (3 days)	(T3) Garlic (5 days)	(T4) Garlic (Daily)	(T5) Ordinary water (Negative Control)		
Gizzard	1.91^{ab}	1.84^{b}	1.99^{ab}	1.80^{b}	2.15^{a}	0.04	0.05
Heart	0.53	0.61	0.54	0.55	0.52	0.02	0.65
Spleen	0.10	0.09	0.11	0.09	0.07	0.01	0.51
Kidney	0.64	0.71	0.66	0.63	0.67	0.01	0.42
Proventriculus	0.44	0.44	0.51	0.47	0.46	0.01	0.54
Lungs	0.59	0.55	0.54	0.51	0.57	0.02	0.74
Intestine	5.74	5.09	6.08	6.32	5.61	0.18	0.27
Liver	1.94	2.13	2.06	1.95	2.09	0.04	0.62

^{a,b} means on the same row with different superscripts are significantly ($p<0.05$) different.

The results in Table 3 highlight the effects of varying frequencies of aqueous garlic extract administration on the physical properties of broiler chicken meat, focusing on water absorptive capacity (WAC) and cooking loss. The WAC was significantly influenced by the frequency of garlic administration ($p< 0.05$). The highest WAC values were observed in the garlic-treated group administered for 3 days (3.85%) and the negative control group (3.75%), both of which were similar ($p>0.05$). In contrast, lower WAC values were recorded in the garlic-treated groups for 5 days (3.35%) and daily administration (3.50%), as well as the positive control group (3.50%). Regarding cooking loss, no significant differences ($p>0.05$) were detected among the treatment groups. Cooking loss ranged from 1.50% in garlic-treated groups (5 days and daily) to 2.50% in the garlic-treated groups for 3 days and the positive control. Although garlic treatments showed a numerical reduction in cooking loss, the absence of statistical significance indicates that the frequency of garlic administration had minimal influence on this parameter.

Table 3: Effect of aqueous garlic administration on physical properties of broiler chickens

	Frequency of administration of garlic extract (7.5 g per litre of water)						
Parameters (%)	**(T1) Antibiotics (Positive Control)**	**(T2) Garlic (3 days)**	**(T3) Garlic (5 days)**	**(T4) Garlic (Daily)**	**(T5) Ordinary water (Negative Control)**	**SEM**	***p* value**
WAC	3.50^{b}	3.85^{a}	3.35^{b}	3.50^{b}	3.75^{a}	0.06	0.01
Cooking Loss	2.50	2.50	1.50	1.50	2.00	0.26	0.67

$^{a, b}$: means that bearing different superscripts in a row are significantly ($P < 0.05$) different
SEM – Standard Error of Mean, WAC= Water absorptive capacity

Table 4 summarizes the impact of varying frequencies of aqueous garlic extract administration on the lipid profile of broiler chicken meat, including total cholesterol, triglycerides, very low-density lipoprotein (VLDL), high-density lipoprotein (HDL), and low-density lipoprotein (LDL). Total cholesterol levels ranged from 111.95 mg/dL in chickens treated with garlic for 5 days to 140.55 mg/dL in those treated for 3 days; however, these differences were not statistically significant ($p >0.05$), suggesting no substantial impact of the frequency of administration of garlic extract on cholesterol content.

Table 4: Effect of aqueous garlic administration on lipid profile of chicken meat

Parameters (%)	Frequency of administration of garlic extract (7.5 g per litre of water)					SEM	*p* value
	(T1) Antibiotics (Positive Control)	(T2) Garlic (3 days)	(T3) Garlic (5 days)	(T4) Garlic (Daily)	(T5) Ordinary water (Negative Control)		
Total cholesterol (mg/dL)	133.55	140.55	111.95	114.95	135.60	5.31	0.35
Triglycerides (mg/dL)	150.45	124.50	110.15	112.40	129.20	8.44	0.67
Very low density lipoprotein (mg/dL)	30.05	24.90	22.05	22.50	25.85	1.68	0.68
High density lipoprotein (mg/dL)	58.85^{b}	65.85^{ab}	64.90^{ab}	64.85^{ab}	71.95^{a}	1.71	0.18
Low-density lipoprotein (mg/dL)	44.65	49.80	25.05	27.60	37.80	5.94	0.74

[a, b,]: *Means that bearing different superscripts in a row are significantly different* ($P < 0.05$)
SEM – Standard Error of Mean

Discussion

Live weight was highest in the control group (T_1) at 1692.25 g, with slightly lower weights observed in the treatment groups. While these differences suggest that garlic extract may modulate growth, the variations were not significant, indicating that garlic extract did not substantially affect overall growth performance in broiler chickens. These findings are in line with previous studies that reported mixed effects of garlic on growth parameters in poultry (Adewole *et al.*, 2024).

Interestingly, the group receiving the garlic extract every day (T_4) exhibited the highest dressed weight percentage (70.98%), significantly outperforming other groups. This suggests that garlic extract may enhance carcass yield, particularly at this frequency of administration. Such improvements in dressing percentage have been linked to better lean meat yield and carcass quality, with similar results observed in other studies where garlic supplementation led to enhanced carcass yield in poultry (Sanwo *et al.*, 2020).

When analyzing specific carcass components, T_5 showed the highest head percentage (2.92%) and shank percentage (5.17%), both significantly greater than those observed in other treatment groups. This suggests that non-garlic treatment may promote enhanced tissue development in these areas, which are known to have a positive influence on tissue growth and muscle development (Ali *et al*., 2016). Furthermore, T_5 also demonstrated the highest thigh weight percentage (12.43%), significantly different from T_4 (10.84%), which indicates that garlic extract may reduce muscle deposition in the thighs at certain frequencies of administration. These findings align with studies that indicated garlic

effect on muscle growth and deposition in poultry (Makwana *et al.,* 2015).

In terms of organ weights, the gizzard percentage was significantly greater in T_5 (2.15%) compared to T_2 and T_4, which may reflect improved digestive efficiency due to the beneficial effects of fresh water as chickens typically consume more fresh water than water containing extracts or antibiotics (Sharma and Joshi, 2009; Al-Mufarrej, 2014). This is consistent with research showing that water can enhance digestive function and nutrient absorption in poultry (El-Ghany and A, 2024). Conversely, abdominal fat was lowest in T_4 (0.26%), supporting garlic's lipid-lowering effects, as seen in studies where garlic supplementation reduced fat accumulation in poultry (Makwana *et al.,* 2015).

Conclusion

Considering both performance and health-related metrics, daily administration of garlic extract at a dosage of 7.5g/L of drinking water offered the most balanced benefit**,** enhancing live weight while supporting improved lipid parameters and meat quality.

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