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Evaluating the effects of garlic (Allium sativum) as a feed additive on the growth performance and immune response in broiler chickens

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ABSTRACT

In a quest to find affordable, antibiotics-free and readily available means of increasing broiler meat productivity, a number of natural feed additives have been tested and suggested. Garlic (Allium sativum) has emerged as a preferable alternative to synthetic feed additives. The aim of this study was to assess the effect of garlic as a feed additive on feed intake, weight gain, feed conversion ratio, and immune response. 300-day-old chicks were acclimatized for 2 weeks and then randomly assigned to 5 treatments (0.00%, 0.25%, 0.50%, 0.75%, and 1.00% garlic inclusion levels) with replicates. Mean weekly feed intake, weight gain, feed conversion ratio, and differential leucocyte counts (lymphocytes, heterophils, basophils, eosinophils, and monocytes) were analyzed for treatment effects. There were significant differences among the means across all treatments for all dependent variables except mean weekly body weight gain at 2 weeks. Garlic supplementation significantly influenced body weight from three to six weeks of age, with the control group (0.00%) consistently exhibiting the lowest body weight. At six weeks, body weight was highest at 0.75%, followed by 1.00%, 0.50%, and 0.25% garlic inclusion levels, demonstrating the positive impact of dietary garlic on growth performance. It was also observed that garlic supplementation led to increases in the basophil and monocyte counts, suggesting a bolstered immune system.

KEYWORDS: *Broiler, garlic, growth promoter, immune system*

INTRODUCTION

Broiler production in Zambia has recorded rapid growth in the last two decades with high contribution by the smallholder producers whose main dependency is on the affordable and readily available conventional and non-conventional feed ingredients (Musaba and Mseteka, 2014). Despite this rapid growth, the demand for broiler meat remains unmatched, thereby creating a gap that will require an increase in broiler meat production and productivity. Commercial feeds are very expensive due to the escalating cost of feed ingredients and milling, which makes them out of the reach of many smallholder producers. Hence, there is a need to incorporate non-conventional feed ingredients and feed additives, including antibiotics and growth promoters. However, the use of antibiotics and other conventional feed additives as growth promoters has become a major concern due to the potential risk of antibiotic resistance emergence and other health-related risks in both animals and humans (Mastoi et al. 2023).

The shift away from antibiotic growth promoters due to concerns over antimicrobial resistance has heightened interest in phytogenic alternatives like garlic. Garlic has been recognized as a safe non-conventional way of improving broiler growth performance and stabilizing the immune system. Garlic is a herbaceous perennial plant that is grown for its underground bulb and used for culinary and numerous health benefits in Zambia (Maundu et al., 2009). Its popular health benefits have been reported to be associated mainly with the action of allicin compound which has antibacterial, antiviral, antiprotozoal, antifungal, antioxidant, anticancer, and anti-inflammatory properties (Chimbaka and Walubita, 2020; Makwana et al. 2015).

Similarly, a comprehensive review by Elwan et al. (2023) highlighted that garlic and its derivatives have been extensively used in poultry production systems. The dietary supplementation of broilers and layers with garlic induced improvements in production parameters, carcass quality, and intestinal integrity. This review consolidates findings from multiple studies, reinforcing the notion that garlic serves as an effective growth promoter in poultry diets. Several studies including Alrabadi et al. (2021) and Karangiya et al. (2016a) have investigated the impact of garlic on broiler chicken and rabbit growth performance and reported that the inclusion of garlic powder in broiler diets significantly (P<0.05) improved the weight gain and feed conversion ratio. Similarly, Faruk et al. (2023) found that garlic as a feed additive positively influenced body weight and mean weekly gain. According to Onu and Aja, (2011), garlic as a feed additive significantly improved (P<0.05) rabbit weight gain, feed conversion ratio, and haematological parameters. While the existing literature generally supports the beneficial effects of garlic as a feed additive, studies on optimal inclusion levels of garlic powder in broiler feed and its effects on broiler feed intake, weight gain, feed conversion ratio and immune response have not been comprehensively studied. Therefore, this study aims to investigate the effect of different levels of garlic powder as a feed additive on broiler growth performance and immune response.

MATERIALS AND METHODS

Experimental Area Description

The experiment was conducted at the field station in the School of Agricultural Sciences at the University of Zambia, Great East Road campus, Lusaka, Zambia Lusaka, Zambia, with the following coordinates 28°20.278' E and 15°28.646' S during the months of July - August 2023. This was the cool and dry season, with the mean maximum and minimum temperature being 25°C in the daytime and 9°C at night.

Experimental design and treatments

Five treatments comprising the control, 0.25%, 0.50%, 0.75%, and 1.00% of garlic inclusion rates were set in a complete randomized design with two replicates resulting in ten (10) experimental units. Garlic was purchased from a nearby market as whole cloves. With the peeling off of the cloves' outer skin, the cloves were dried and milled to a fine powder and then sieved. The fine powder was stored in an airtight, clean bowl. The garlic was well mixed at the various inclusion rates with commercial broiler grower feed purchased from Novatek Animal Feeds Zambia and with the formulated broiler finisher feed.

Management of the chickens

A total of 300-day-old Cobb chicks purchased from Hybrid Poultry Farm Zambia were used for the study. Infra-red lamps were used in the brooding of the chicks for two weeks. Vaccinations against Newcastle disease and infectious bursal disease were done as recommended, clean fresh water and broiler starter feed were provided ad libitum. At the age of two weeks, 60 chicks were randomly assigned to each treatment (0.00%, 0.25%, 0.50%, 0.75%, and 1.00%) in the floor area of 4m2 per pen.

Data collection and analysis

The weekly feed intake was recorded by measuring the difference between the amount of feed supplied to the chickens for the week and the amount of feed remaining at the end of the week. Body weights were recorded weekly from the second to the sixth week of age. Weekly weight gains were computed by subtracting the body weights at the beginning of the week from the body weights at the end of the week. The feed conversion ratio was calculated by dividing the weekly feed intake by the weekly weight gain of the chickens. Blood samples for the analysis of differential blood cell counts were collected at the beginning and at the end of the experiment. Blood was taken from the wing veins of the sampled chickens using sterile needles and 1 ml syringes, then transferred to EDTA glass tubes and placed in a cooler box under ice. Blood analysis assay was carried out in the Microbiology laboratory at UNZA School of Veterinary Medicine during which cells were fixed and stained using Giemsa's staining method. Counts of white blood cells were carried out using a hemocytometer as described by Onyishi et al. (2017). The data collected was analyzed by using one-way ANOVA of the IBM SPSS Statistical Package, differences among treatments were tested for significance using Duncan's multiple comparison test.

RESULTS

Feed intake, body weight gain, and feed conversion ratio

Table 2 shows the mean weekly feed intake, body weight, weight gain and feed conversion ratio (FCR), at various ages. There is an increase in the mean weekly performances for all the traits with increasing levels of garlic supplementation except for FCR which has decreasing performance. There were significant differences observed among means at all ages for feed intake, body weight, weight gain and FCR except for weekly body weight at week two. Generally, the control group (0.00% garlic inclusion) exhibited the lowest mean performances for all the traits studied.

Differential white blood cell count

Table 3 shows the differential white blood cell counts at the beginning and at the end of the experimental period. There were significant differences in the mean basophils and monocytes counts between the initial and final period of study. The basophil and monocyte counts show significant decreasing counts for increasing levels of garlic inclusion at the initial and final periods.

DISCUSSION

There were observed differences in the feed intake for the different periods and across all garlic supplementation levels. The observed increase in feed intake may be attributed to the initial palatability or stimulatory effect of garlic at this concentration, as suggested by earlier studies that have shown garlic's potential to enhance feed intake in poultry diets (Karangiya et al. 2016b). In the subsequent weeks, a gradual increase in feed intake was observed as garlic supplementation increased, peaking at the 1.0% level during weeks 3-4, however, in weeks 4-5, feed intake was highest at 0.75% garlic inclusion level, followed by 1.0% garlic inclusion level. This decline at the highest supplementation level may be due to the development of an astringent taste of garlic associated with the excessiveness of garlic. The trend continued during weeks 5-6 with the highest feed intake being recorded at 0.75% garlic supplementation, further supporting the notion that excessive garlic supplementation may reduce feed intake (Yunwei et al. 2020). These findings compare favourably with the report of Chimbaka and Walubita, (2020) on rabbits which indicated that garlic inclusion in feed would initially stimulate an increase in feed intake but only to a certain point after which any more addition of garlic itself would negatively affect feed intake of broilers due its characteristic astringent flavour.

Chickens supplemented with garlic showed higher weight gain compared to the control group, with the highest mean weekly weight gain observed at 0.75% garlic. This suggests that low to moderate levels of garlic can positively impact growth, possibly due to its role as a natural growth promoter, enhancing gut health and nutrient absorption (Abd El-Ghany, 2024).

In weeks 3-4, mean weekly weight gain remained relatively stable across all treatment groups, with a slight decrease at 0.75% garlic. This may reflect a metabolic adjustment period as the chickens acclimatize to higher garlic levels, justified by the observations in weeks 4-5 and 5-6 during which 0.75% garlic inclusion was better than any other treatments in respective weeks. The observable improvement in mean weekly weight gain can be attributed to garlic's known antioxidant and antimicrobial properties, which enhance nutrient utilization and overall health (Jang et al. 2018), and the reduced mean weekly weight gain at 1.0% could be attributed to reduced palatability associated with high garlic intake (Patocka et al. 2023). Kairalla et al. (2022) reported that the chickens supplemented with 0.3% garlic powder significantly ($p < 0.05$) improved in terms of body weight gain, compared to other groups fed diets supplemented with 0%, 0.1%, and 0.2% garlic powder. Mirzaei-Aghsaghali (2012) showed that dietary inclusion of garlic powder at 0.5% significantly improved feed conversion ratio (FCR), body weight gain (BWG), and overall growth performance in broilers compared to control groups. Similarly, Ademola et al. (2009) reported improved weight gain and feed efficiency in broilers supplemented with garlic and ginger extracts, attributing these effects to the antimicrobial properties of garlic, which enhance gut health and nutrient uptake.

Contrary to the findings in this study Kairalla et al. (2022) found that the chickens provided food supplemented with 0.3% garlic powder significantly ($p < 0.05$) improved in terms of live body weight, compared to other groups fed diets supplemented with 0%, 0.1%, and 0.2% garlic powder. The findings reported by Kairalla et al. (2022) are consistent with previous studies that reported improved growth performance in broilers supplemented with garlic, attributed to its ability to enhance digestive efficiency and immune response (Elkatcha et al. 2017; Kewan et al. 2021 and Zare et al. 2021) During weeks 2-3 and 4-6, the FCR was slightly better (lower) in the 0.75% garlic-supplemented groups compared to the control and the rest of the treatments, indicating improved feed efficiency which might be due to the synergistic effects of garlic's bioactive compounds, which enhance nutrient absorption and metabolic efficiency. This aligns with the findings of (Ali et al. 2016 and Ghosh et al. 2010) who reported enhanced FCR with garlic supplementation in poultry. Contrary to the findings in this study whose best performing garlic inclusion level was 0.75%, (Patience, 2011 and Xu et al. 2020) indicated that the addition of 0.25% garlic and ginger to broiler finisher feed resulted in optimum feed efficiency and improved chicken growth rates.

Comprehensively, it is logically reasonable to infer that if garlic can mitigate oxidative activities, enhance digestive efficiency, and enhance gut health and nutrient absorption, then the feed efficiency of an animal is likely to be notably effective, as demonstrated in other studies. Kairalla et al. (2022) seemed to confirm this theory having observed that FCR improved significantly with increasing levels of garlic supplementation until 0.3% garlic powder.

Differential leucocyte counts as well as total white blood cell (WBC) among other hematological parameters are very important markers of chicken's immune status and ability to fight infections. Inflated levels of white blood cells could imply infection, inflammation, or stress, while low levels of white blood cells on the other hand may imply immunosuppression or problems with the bone marrow. Significant elevations in the counts of basophils and monocytes were observed in this study and only slight elevations in the counts of eosinophils were recorded which may have been due to various factors experienced by the chickens such as stress, allergies, and hypersensitivity (Tizard, 2013 and Wills, 1985).

Consistent with this study, beyond growth performance, garlic supplementation has been associated with enhanced immune responses in broiler chickens. Kairalla et al. (2022) observed that garlic supplementation led to increases in monocyte and lymphocyte counts, indicating a bolstered immune system and this is in agreement with the findings of this study. However, the findings of this study are also suggestive that the age of chickens could have an important influence on the differential white blood cell counts as reported by (Talebi et al. 2005). The basophil and monocyte counts were higher in the 6th week compared to the 2nd week even for the chickens under control thus suggesting that age might have also influenced or confounded the basophil and monocyte counts though not entirely conclusive as the evidenced elevated numbers may also imply infections or inflammations. There were however decreasing levels of the basophils and monocytes with increasing levels of garlic inclusion in the feed. This is indicative that the decrease in the differential leucocyte counts were as a direct result of the garlic inclusion in the broiler diets. The optimal inclusion rate was not determined but appears to lie between 03 and 0.75% of the broiler diet.

CONCLUSION

Incorporation of garlic as a feed additive in broiler diets has been shown to improve feed intake, body weight, feed conversion ratio, growth performance, and enhance immune responses. The optimal inclusion level in the diet appears not to be definite in order to balance efficacy and cost-effectiveness. The multifaceted benefits of garlic, including antimicrobial, antioxidant, and lipid-lowering effects, make it a promising natural alternative to antibiotic growth promoters in poultry production.

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Author contribution
JM, IMC and JN were responsible for the study design, while MBM participated in the statistical analysis; IKO, SJH and FK participated in the manuscript preparation.

Data availability
The datasets analyzed are not publicly available but can be accessed from the author upon reasonable request.

Code availability.

Not applicable

Declarations
Ethics approval: Not applicable.
Consent to participate: Not applicable.
Consent for publication: Not applicable.
Conflict of interest
The author declares no competing interests.
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APPENDICES
Appendix A. Tables

Appendix A.1

Table 1: Table 1 Nutrient composition of broiler feed

Sample name	Analysis	Results
Broiler Starter	Protein	20%
	Moisture	12%
	Ether	5%
	Phosphorus	6g/ Kg
	Calcium	6g / Kg-10g/Kg
	Lysine	12.3g/Kg
	Methionine	5g/Kg
Broiler grower	Protein	18%
	Moisture	12%
	Fibre	5%
	Phosphorus	5g/Kg
	Calcium	5g/Kg-10g/Kg
	Lysine	10.2g/Kg
	Methionine	4.2g/Kg
Broiler finisher feed	Crude protein	20.32%
	Crude fibre	6.20%
	Crude oil	8.10%
	Ash	7.60%
	Sodium chloride	0.95%
	Calcium	1.40%
	Phosphorus	1.90%
	Moisture	9.85%
	Dry matter	90.15%
	Metabolisable energy	3299kcal/kg

Appendix A.2

Table 2: Table 2: Mean weekly performances of feed intake, weight gain, body weight and FCR of broiler chickens fed different inclusion levels of garlic powder.

		Treatment				
Traits	Age	Control	0.25%	0.50%	0.75%	1.00%
Mean weekly feed intake (g/chicken)	Week 2 - 3	737.8^{d} ±165.2	746.9^{b} ±157.5	741.3^{c} ±161.7	741.3^{c} ±163.1	763.7^{a} ±169.4
	Week 3 - 4	924.4^{c} ±214.2	895.3^{d} ±208.6	963.9^{b} ±219.1	956.9^{b} ±212.8	982.8^{a} ±225.4
	Week 4 - 5	1269.8^{b} ±283.5	1273.3^{b} ±281.4	1265.6^{b} ±280.0	1326.5^{a} ±291.2	1233.4^{c} ±278.6
	Week 5 - 6	1306.2^{b} ±284.2	1305.5^{b} ±279.3	1329.3^{a} ±287.7	1358.7^{a} ±289.8	1267.0^{c} ±280.7
Mean weekly gain (g/chicken)	Week 2-3	417.2^{c} ±95.9	465.5^{b} ±102.2	468.3^{b} ±101.5	476.7^{a} ±104.3	466.2^{b} ±102.9
	Week 3-4	550.9^{a} ±116.7	543.2^{b} ±115.5	559.3^{a} ±119.0	513.8^{c} ±110.6	550.2^{a} ±116.2
	Week 4-5	431.2^{b} ±91.7	441.7^{b} ±89.6	489.3^{b} ±98.7	525.0^{a} ±105.7	469.7^{b} ±90.3
	Week 5-6	564.2^{d} ±119.7	609.0^{c} ±131.6	608.3^{c} ±128.1	660.8^{a} ±137.9	644.7^{b} ±70.7
Mean weekly body weight (g/chicken)	Week 2	387.4 ±89.4	389.5 ±89.6	388.9 ±88.6	380.0 ±88.1	391.2 ±91.8
	Week 3	804.3^{b} ±220.1	854.7^{a} ±219.7	857.8^{a} ±217.2	856.6^{a} ±200.4	857.5^{a} ±211.1
	Week 4	1355.0^{c} ±356.1	1398.0^{ab} ±348.4	1417.3^{a} ±362.9	1370.0^{bc} ±340.5	1407.9^{a} ±350.1
	Week 5	1786.4^{b} ±458.2	1839.5^{ab} ±469.1	1906.7^{a} ±490.2	1895.1^{a} ±481.4	1877.3^{a} ±450.2
	Week 6	2351.4^{b}±609.2	2448.1^{ab} ±670.4	2514.6^{a} ±687.4	2555.6^{a} ±699.1	2522.3^{a} ±645.1
Mean Weekly FCR	Week 2 - 3	11.9^{a} ±1.4	11.2^{b} ±0.7	11.2^{b} ±1.4	11.2^{b} ±1.4	11.2^{b} ±0.7
	Week 3 - 4	11.2^{c} ±1.4	12.6^{b} ±0.7	11.9^{c} ±1.4	13.3^{a} ±2.1	12.6^{b} ±1.4
	Week 4 - 5	21.0^{a} ±2.8	20.3^{a} ±3.5	18.9^{b} ±3.5	16.1^{c} ±2.8	18.2^{b} ±4.2
	Week 5 - 6	16.1^{a} ±2.8	15.4^{b} ±0.4	15.4^{b} ±3.5	13.3^{c} ±2.1	14.0^{b} ±1.4

*Different superscript across the rows means significant differences (P<0.05), and the same superscript means no significant differences (P>0.05) across the rows, mean and Standard error of the mean (SEM)

Appendix A.3

Table 3: Table 3: Differential White Blood Cell Counts (cells/µL) of broiler chickens fed different inclusion levels of garlic powder

WBC Components		Control	0.25%	0.50%	0.75%	1.00%	Mean Counts
Lymphocytes	Initial	54.0 ±13.7	58.8 ±14.1	52.6 ±14.6	57.8 ±14.9	58.4 ±13.8	56.3±14.2
	Final	34.8 ±8.4	52.2 ±10.2	47.6 ±9.7	44.4 ±8.9	52.6 ±10.6	46.3±9.6
Heterophils	Initial	26.8 ±7.1	22.6 ±5.3	27.8 ±7.3	24.6 ±7.1	24.4 ±6.7	25.2±6.7
	Final	27.4 ±7.1	9.8 ±3.6	11.0 ±2.2	24.1 ±6.1	17.8 ±3.9	18.0±4.6
Basophils	Initial	5.2^{b} ±1.3	3.2^{d} ±1.1	4.6^{c} ±1.2	6.1^{a} ±1.8	4.8^{bc} ±1.3	4.8±1.3
	Final	17.4^{a} ±3.9	14.8^{c} ±3.1	12.6^{d} ±2.8	15.0^{bc} ±3.8	15.6^{b} ±4.1	15.1±3.5
Eosinophils	Initial	7.2 ±1.8	7.8 ±1.7	8.0 ± 2.1	7.4 ±1.9	7.2 ±2.0	7.5±1.9
	Final	7.6 ±2.2	8.6 ±3.1	8.2 ±2.9	5.6 ±1.9	3.8 ±1.1	6.8±2.2
Monocytes	Initial	6.8^{b} ±1.5	7.6^{a} ±1.9	7.1^{ab} ±2.1	4.2^{d} ±1.4	5.2^{c} ±1.4	6.2±1.7
	Final	12.8^{c} ±2.9	14.6^{b} ±3.7	20.6^{a} ±4.5	11.0^{d} ±2.1	10.2^{e} ±1.7	13.8±2.9

Treatments: Control, 0.25%, 0.50%, 0.75%, 1.00%

*Different superscripts across the rows means significant differences (P<0.05); the same superscript or no superscript means no significant differences (P>0.05) across the rows.