



Effects of Fermented Garlic on Blood Lipid Profiles and Carcass Quality in Turkeys

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Abstract | The objective of this study is to investigate the impact of *Lactobacillus* spp.-fermented garlic (FG) on the carcass quality and lipid profile of turkey broilers. A completely randomized design was used for this study, which comprised of 90 turkeys aged 1 to 56 days. The study is composed of five different treatments, which are replicated three times. The allocation of treatments was balanced based on the sex of the broilers. The birds were provided with feed and water *ad libitum*. The experimental protocol involved the incorporation of an aqueous extract derived from fermented garlic (FG) into the animals' drinking water. The highest weights for carcass, breast, and thigh were observed in the 0.8% FG treatment, while the 0.6% FG treatment resulted in the highest weights for liver and small intestine ($p < 0.05$). There was no significant effect of FG on the carcass quality or blood lipid markers ($p > 0.05$). The addition of a 0.8% fermented grain (FG) improved the carcass quality of turkey broilers, without negatively affecting the blood parameters. The utilization of 0.6% and 0.8% FG shows potential for extensive implementation in poultry production.

Keywords | Fermented garlic, Carcass traits, Blood lipid profile, Turkey broiler

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INTRODUCTION

Recently, there has been a gradual expansion of turkey flocks, significantly contributing to the forward development of the poultry industry in Vietnam. This expansion has been driven by the growing demand for poultry meat in the country. However, the turkey industry faces notable challenges, particularly in encountering disease outbreaks, as it continues to expand.

The inclusion of medicinal additives, such as garlic, can be a potential dietary supplement that will enhance the growth performance and improve the carcass quality of avian species. Garlic is rich in essential nutrients and exhibits significant antibacterial properties. Moreover, its inclusion in animal diets has been shown to enhance digestive functions and

promote the growth of various livestock species, including chickens. The use of garlic has been reported to positively affect various health conditions such as inflammation, oxidative stress, hyperlipidaemia, and hypertension (Chen et al., 2021). Garlic is widely recognized in the field of alternative medicine for its extensive health benefits and is considered a remarkable pharmacological agent. It contains at least 33% sulfur-containing compounds, along with a diverse range of enzymes, amino acids, and minerals. The utilization of garlic as a notable dietary additive has been employed to augment the growth performance and many biochemical attributes of broiler chickens (Aarti and Khusro, 2020). Previous studies have demonstrated the advantageous impacts of aqueous garlic extract on the growth performance of poultry. The benefits observed were disease prevention, appetite stimulation, and enhancement

of beneficial bacteria in the intestinal tract, leading to improved digestive functions and ultimately the accelerated growth of the animals. According to [Karangiya et al. \(2016\)](#), it was observed that the inclusion of garlic powder in the feed of birds resulted in enhancements of villus height in the small intestines. Other previous researches conducted on the impact of garlic supplementation on the growth performance of chicken has demonstrated that the inclusion of functional garlic has yielded positive impacts on performance indicators and blood parameters. [Hossain et al. \(2014\)](#) found that meals with fermented garlic (FG) exhibited a deceleration in the process of meat lipid oxidation. Additionally, these diets were found to result in reduced levels of triglycerides and total serum cholesterol when compared to the non-supplemented diet. Similarly, [Borgohain et al. \(2017\)](#) reported that the inclusion of garlic supplements in commercial broiler meals resulted in the reduction of blood cholesterol levels, triglyceride levels, and fat deposition. Furthermore, the study of [Chen et al. \(2021\)](#) has documented the stimulatory properties and enhanced chemical composition of garlic following fermentation by *Lactobacillus*. According to studies conducted by [Lee et al. \(2016\)](#) and [Qui et al. \(2024\)](#), the inclusion of FG in the diet of broiler chickens resulted in the enhanced growth performance, especially during the early rearing phase. Additionally, FG supplementation was also found to have a positive impact on the intestinal morphology and has increased certain blood parameters, although this information is not extensively documented.

Nevertheless, the impact of supplementing dietary FG supplementation on the blood lipid profiles and carcass attributes of turkeys remains uncertain. Given the limited research on the garlic by *Lactobacillus* spp.-fermented, the objective of this study is to investigate the effects of the various quantity of fermented garlic on the carcass quality and blood parameters of turkeys.

MATERIALS AND METHODS

LOCATION AND ETHICAL APPROVAL

This research was conducted at the experimental farm of Tra Vinh University, situated in the southern region of Vietnam. The study was carried out from December 2022 to February 2023. The research was approved by the Committee of Education and Research at Tra Vinh University, under Approval No. 401/2022/HĐ.HĐKH&ĐT-ĐHTV. All procedures adhered to the animal welfare regulations set forth by the Vietnamese Government.

EXPERIMENTAL DESIGN

A total of 90 Turkey chicks from 1-8 weeks of age were used in the study. The study employed a completely randomized design with five treatments and three replications per treatment. Each experimental unit consisted of six turkey

chicks, with an equal distribution of males and females (1:1 sex ratio). All experimental units were equipped with feeds and drinkers that were made accessible without any restrictions. The chicks were given unlimited access to feed and water for the whole duration of the trial.

The five treatment groups were given these different concentrations of aqueous fermented garlic (FG) extract added to the drinking water: 0%, 0.2%, 0.4%, 0.6%, and 0.8% FG as in FG0, FG1, FG2, FG3 and FG4. The aqueous extract derived from garlic fermented by *Lactobacillus* spp. was used within a duration of 2-3 hours.

The avian specimens were confined in iron enclosures, with a surface area of roughly 1.5 square meters, and were netted to prevent escape. The cage floors were covered with husks and Balasa bio-yeast. To mitigate potential adverse effects and maintain sanitary conditions, each cage was cleaned weekly.

EXPERIMENTAL FEED

All ingredients were purchased from a nearby feed store located in Tra Vinh province. The chemical components were analysed prior to the formulation of the diets ([Table 1](#)). The chemical composition of the feed was analysed for dry matter, crude protein, organic matter, total minerals, calcium (Ca), and phosphorus (P), following the guidelines set by the Association of Official Analytical Chemists (AOAC, 1990). The formulation of the experimental feed was based on the growth phase ([NRC, 1994](#)), specifically for ages 1-28 days and 29-56 days of age. The feed formulation specifications are provided in [Table 1](#).

The initial administration of the Newcastle vaccine was given when the avian specimens reached the age of 3 days, followed by a booster dose at 14 days of age. The vaccine used was formulated with F strain virus, which is recognized as the more prevalent virus strain responsible for infecting poultry in Vietnam. Furthermore, the Gumboro vaccine and highly pathogenic avian influenza vaccine were administered on the seventh and sixteenth day, respectively.

FG PREPARATION

The preparation of fermented garlic (FG) followed the method described by [Qui et al. \(2024\)](#). 1 kilogram of fresh garlic was meticulously peeled and precisely sliced. The chopped garlic was treated with alcohol. Subsequently, the aforementioned blend was mixed with molasses and meticulously homogenized. Molasses serves as an integral element in the fermentation procedure, acting as a suitable substrate for the growth and proliferation of lactic acid bacteria. The mixture will be incubated for a duration of 10 minutes at ambient temperature, after which it was subjected to additional stirring. Vinegar (1 liter) will then be added to accelerate the fermentation process and establish an

Table 1: The chemical compositions of ingredients in the diets.

Ingredients	CP	ME	EE	NFE	CF	Ca	P	OM	DM
Corn	7.15	3699	1.8	88.2	1.24	0.004	0.140	98.4	87.2
Broken rice	7.98	3488	0.91	90.7	0.10	0.020	0.100	99.7	86.2
Rice bran	13.2	2608	8.25	63.6	7.60	0.030	2.030	92.6	88.7
Soybean	45.5	2661	1.73	43.3	3.7	0.250	0.640	94.2	87.2
Fish meal	50	3223	10	25.4	0.40	3.300	2.430	85.8	91.6
Stone meal	-	-	-	-	-	37.9	0.01	-	100
Limestone	-	-	-	-	-	39.7	0.01	-	100
Lysine	-	-	-	-	-	-	-	-	97.4
Methionine	-	-	-	-	-	-	-	-	99.3
Mineral-Premix	-	-	-	-	-	-	-	-	100

CP: crude protein; DM: dry matter; EE: Ether extract; CF: Crude fat; Ca: Calcium; OM: organic matter; P: Phosphate; ME; Metabolizable energy.

Table 2: The experimental diets' ingredient compositions.

Feed ingredients	Growing period	
	1-4 weeks of old	5-8 weeks of old
Rice bran	29.0	28.3
Corn	24.2	30.2
Soybean meal	22.8	18.0
Broken rice	13.0	12.7
Fish meal	8.1	7.7
Limestone	2.00	2.20
Salt	0.3	0.3
Vitamin-Mineral Premix*	0.30	0.30
Lysine	0.20	0.20
Methionine	0.10	0.10
Total	100.0	100.0
ME (Kcal/kg)	2,959	3,010
CP (%)	21.0	19.0
Calcium	1.28	1.34
Lysine	1.28	1.18
Phosphate	0.60	0.65
Methionine	0.55	0.52

*: Vitamin- mineral premix was mixed according to growing phases of chickens.

acidic milieu within the combination, primarily through the presence of acetic acid. At this stage, *Lactobacillus* species will be introduced. *Lactobacillus* species (*Lactobacillus* spp. a comercial product, GGP Pharma company, Ho Chi Minh city, Vietnam) were then introduced at a concentration of 5×10^5 colony-forming units. A quantity of freshwater will be added into a container to achieve the final volume of 20 litters. Subsequently, the container will be subjected to an incubation period lasting from 7 to 14 days, during which it was kept at ambient temperature and shielded from direct exposure to sunlight. According to the study conducted by (Lee et al., 2016), the garlic to water ratio was reported should be 1:8. The abundance of *Lactobacillus*

spp. was evaluated, and the pH of the combination was documented on a weekly basis. The amount of *Lactobacillus* should be at least 5×10^5 . The mixture with decreased count of *Lactobacillus* spp. and/or with pH level exceeding 4.0, will be discarded.

MEAT QUALITY

On the final day of the experiment, the birds were chosen randomly and slaughtered (one female and one male bird from each replicate). To assess carcass quality, internal organ sizes, and meat quality, the carcasses were physically plucked and eviscerated on the day of slaughter. The weights of the whole carcass, as well as the cuts (thigh and breast), internal organs (the gizzard and liver), and immunological organs (spleen, thymus and bursa of Fabricius) were recorded using a digital scale. Using a digital pH meter (pH/ORP/Temperature Laboratory Bench Meter Mi 151, USA) with a spear-shaped electrode, the pH of the thigh and breast meat was assessed after the birds were slaughtered. The pH meter was cleaned and calibrated using manufacturer-provided standard solutions.

Cooking loss was determined by weighing thigh meat and breast meat samples of each experimental unit before and after cooking. The samples were cooked for 5 minutes in clean, fresh water and then were weighed again to calculate cooking loss (final weight subtracted from initial weight). Cooking loss will be calculated as the difference between the initial and final weights.

BLOOD PROFILE

Blood samples (approximately 2 mL) were collected from two randomly selected birds of each experimental unit using 23-gauge needles using 5 mL disposable syringes at the end of the experiment. Blood samples were immediately transferred to haematological tubes containing the anticoagulant EDTA for haematological analysis.

Table 4: The effects of fermented garlic on carcass traits of turkey chickens at 56 days old.

Criteria	Treatments					SEM	p-value
	CTR	FG1	FG2	FG3	FG4		
Live weight, g/bird	878.3 ^c	901.0 ^c	981.7 ^b	1027 ^{ab}	1064 ^a	15.48	0.001
Carcass quality							
Carcass weight, g/bird	546.1 ^b	561.6 ^b	611.8 ^{ab}	639.2 ^a	668.5 ^a	14.25	0.001
Carcass percentage, %	62.17	62.37	62.32	62.19	62.82	1.337	0.997
Weight of breast, g/bird	104.6 ^c	107.4 ^c	111.4 ^{bc}	120.4 ^{ab}	122.6 ^a	1.989	0.001
Breast percentage, %	19.18	19.17	18.21	18.86	18.35	0.483	0.504
Weight of thigh, g/bird	101.1 ^b	106.0 ^{ab}	112.5 ^{ab}	115.5 ^{ab}	121.6 ^a	3.942	0.031
Thigh percentage, %	18.49	18.91	18.38	18.08	18.18	0.565	0.852
Organ weights, g/bird							
Weight of liver	21.70 ^b	22.77 ^b	23.77 ^{ab}	26.60 ^a	24.70 ^{ab}	0.754	0.009
Weight of heart	5.10	4.80	4.97	5.50	5.77	0.344	0.323
Weight of gizzard	56.10 ^b	58.77 ^{ab}	65.30 ^a	58.63 ^{ab}	57.67 ^b	1.555	0.016
Intestine weight, g							
Small intestine	32.97 ^c	41.17 ^b	45.33 ^{ab}	49.60 ^a	47.13 ^{ab}	1.300	0.001
Large intestine	4.80 ^d	6.07 ^{cd}	7.53 ^{bc}	9.00 ^b	11.80 ^a	0.497	0.001

SEM: standard error of the mean. a, b, c means within a row with different superscripts are significantly different at $p < 0.05$.

Blood sample tubes were placed in a cooling bag, and blood samples were analysed within 48 h of collection. The samples were sent to an animal hospital for blood biochemical analysis using a Cobas 6000 analyser (Roche, Switzerland). The analysis included the determination (mg/dL) of albumin, total cholesterol, total protein, glucose, triglycerides, low-density lipoprotein cholesterol (LDL-c), globulin and high-density lipoprotein cholesterol (HDL-c).

DATA ANALYSES

The data were initially processed using Microsoft Excel 365 and then analysed using a general linear model (GLM) with analysis of variance (ANOVA) in Minitab software 2016. The Tukey’s test was used to compare the means across different treatments with a confidence level of 95%. The statistical significance level is commonly represented as $p < 0.05$.

RESULTS AND DISCUSSION

CARCASS QUALITY

FG treatment improved the carcass quality (Table 4). Carcass weight was significantly higher in the treatments with 0.6% and 0.8% FG ($p < 0.05$). The breast and thigh weights were the highest in the treatment with 0.8% FG ($p < 0.05$). However, there were no significant differences in carcass, breast, and thigh percentage. For internal organs, liver weight was significantly higher in the treatment with 0.6% FG ($p < 0.05$), while gizzard weight was the greatest in the treatment with 0.4% FG, and no differences

observed in heart weight. The FG supplementation significantly increased intestinal weights, with the highest small intestine weight observed in the treatments with 0.6% FG and the highest large intestine weight in the 0.8% FG treatment.

CARCASS QUALITY

No significant effect of FG on carcass quality was observed, including the pH of breast and thigh meat and water-holding capacity (Table 5). Although the pH in the FG supplementation treatments appeared to be higher than that in the control treatment, the difference was not statistically significant ($p > 0.05$). After cooking, breast meat and thigh meat of the FG supplementation treatments retained more water than the meat from the control treatment.

THE EFFECTS OF FG ON BLOOD PROFILES OF TURKEYS AT 56 DAYS OLD

At 56 days of age, blood samples were collected from the birds to determine their profiles (Table 6). No significant differences between treatments were observed in any factor, including total protein, globulin, albumin, cholesterol, glucose, triglycerides, HDL- and LDL-cholesterol ($p > 0.05$). Although higher globulin and lower cholesterol levels were recorded, these differences were not statistically significant.

An increase in growth performance along with the preservation of carcass quality and internal organs, was recorded in this study. This can be attributed to the effects of

FG in this experiment. As mentioned above, fermentation of garlic enhances the abundance of chemical compounds, the nutritional value of garlic, and intestinal activities (Fadlalla et al., 2010; Sasi et al., 2021), thereby increasing the synthesis of protein in muscle and carcass weights. This finding was similar to the results of a previous study where 0.125%-1.25% garlic powder was added to starter broiler diets, which resulted to improved carcass and organ weights (Javandel et al., 2008).

Table 5: The effects of fermented garlic on carcass quality at 56 days old.

Criteria	Treatments					SEM	p value
	FG0	FG1	FG2	FG3	FG4		
pH							
Breast	6.170	6.300	6.140	6.247	6.293	0.096	0.693
Thigh	6.443	6.897	6.910	6.730	6.950	0.130	0.100
Before cooking							
Breast	5.400	5.533	5.533	5.467	5.200	0.082	0.081
Thigh	5.300	5.333	5.233	5.333	5.267	0.145	0.983
After cooking							
Breast	3.633	3.833	3.833	4.067	3.733	0.161	0.450
Thigh	3.700	3.900	3.767	3.900	4.000	0.079	0.132
Cooking loss (%)							
Breast	32.72	30.78	30.76	25.57	28.28	2.482	0.356
Thigh	30.08	26.79	28.02	26.67	23.95	2.384	0.512

SEM: standard error of the mean.

The intestinal weights increased with the supplementation treatment, partly suggests that birds consumed and digested more feed than the control treatments. Sunu et al. (2021) showed that carcass weights, liver weight, and intestinal length increased when FG was added to the diet. The stronger effect of garlic on reducing the fatty acid synthetase enzyme may also explain this improvement (Bawish et al., 2018).

However, this study found that FG did not affect meat

quality, including pH and cooking loss. These findings were consistent with Ao et al. (2011), who demonstrated that the mean cooking loss did not differ among treatments, but the pH of breast meat decreased with increased levels of FG. In addition, cooking loss tended to decrease with increasing levels of FG in this study (non-significant). This shows that adding FG is beneficial to meet the quality requirements of turkey meat since the juiciness of meat decreases as cooking loss increases.

The mixture fermented by *Lactobacillus* spp. in the current study likely contributed to the effects recorded in this study. Previous studies have indicated the potential impact of *Lactobacillus* as a probiotic on meat quality (Zhang et al., 2017). The mechanisms of action of probiotics (particularly *Lactobacillus*) on meat quality (fat content and water content) remain unknown, although some researchers have linked the effects of probiotics on meat quality to the activity of bacteriocins or extracts.

In the current study, we observed a reduction in cholesterol levels in the FG supplementation treatments, although with no significant difference. Garlic has been shown to provide several health benefits, including hypocholesterolemic, hypolipidaemic, and antioxidant properties in humans and animals (Kothari et al., 2019). Steroidal saponins may be responsible for these effects; these compounds may prevent the absorption of cholesterol in the intestine, leading to reduced total cholesterol levels in the blood (Hossain et al., 2014). However, this study did not show the effects of garlic fermented by *Lactobacillus*. This could be due to the influence of numerous factors that can partly affect blood parameters, including season, age, rearing conditions, nutrition, and the type and amount of feed additives used.

In a study conducted by Prasad et al. (2009), it was observed that the inclusion of garlic powder in the feed led to a significant reduction in total cholesterol, LDL, and triglyceride levels in broilers. Additionally, the supplementation of garlic powder was found to raise the levels of HDL in these birds. The recorded results can be

Table 6: The effects of FG on blood lipid profiles.

Criteria	Treatments					SEM	p-value
	FG0	FG1	FG2	FG3	FG4		
Total protein, mg/dL	3940	4077	3993	4027	4013	238.7	0.996
Albumin, mg/dL	1243	1324	1249	1314	1278	53.61	0.753
Globulin, mg/dL	2697	2753	2743	2710	2737	199.5	0.999
Glucose, mg/dL	1804	1744	1689	1692	1715	60.26	0.657
Total cholesterol, mg/dL	32.34	38.28	28.62	29.94	28.74	4.811	0.608
Triglycerides, mg/dL	89.28	91.02	75.72	67.92	75.06	5.668	0.068
LDL-cholesterol, mg/dL	44.76	48.24	34.50	30.90	35.10	4.992	0.142
HDL-cholesterol, mg/dL	22.92	25.38	28.20	23.40	26.88	3.943	0.855

SEM: standard error of the mean; HDL: high-density lipoprotein; LDL: low-density lipoprotein.

attributed to the hypocholesterolemic and hypolipidemic modes of action exhibited by garlic. Consequently, these innate characteristic of garlic reduced the hepatic activities of enzymes involved in cholesterol and lipid synthesis, including malic enzyme, fatty acid synthase, and glucose-6-phosphate dehydrogenase (Kairalla et al., 2022).

CONCLUSIONS AND RECOMMENDATIONS

The supplementation of 0.8% garlic fermented by *Lactobacillus* spp. in the drinking water of turkeys resulted in the improved carcass weights and increased liver, gizzard, and intestinal weights. However, it did not affect the thigh and breast meat carcass percentages. It did not also affect the overall meat quality. Furthermore, this study did not observe any significant difference in the blood profiles of turkeys at 56 days of age.

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NOVELTY STATEMENT

Most previous studies have focused on the supplementation of garlic and garlic powder on the growth performance of chickens, mainly broilers. However, our study is novel in that it only focuses on the effects of fermented garlic on the carcass quality of turkeys and blood parameters when supplemented in drinking water.

AUTHOR'S CONTRIBUTION

Qui NH and Linh NT: Research design; Linh NT: Data analysis; Qui NH: Methodology; Qui NH: Validation; Linh NT: Investigation; Qui NH and Linh NT: Writing—original draft preparation; Qui NT and Linh NT: Writing—review and editing. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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