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PAMJ One Health

Research

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Received: 17 Oct 2024 - **Accepted:** 29 May 2025 - **Published:** 09 Jul 2025

Keywords: Heavy metal toxicity, gallic acid, poultry farming, veterinary education, poultry professionals, Nigeria

Funding: This work was supported by the African Union Commission, Ethiopia, through the Pan African University Life and Earth Sciences Institute (including Health and Agriculture)'s scholarship (Ref: PAULESI/REG/23/066). The sponsors had no role in the design, execution, interpretation, or writing of the study.

Cite this article: Modupe Beatrice Abraham et al. Assessment of poultry professionals' knowledge on heavy metal toxicity and use of gallic acid as a treatment option in Oyo State, Southwestern Nigeria. PAMJ-One Health. 2025;17(9). 10.11604/pamj-oh.2025.17.9.45632

Available online at: https://www.one-health.panafrican-med-journal.com/content/article/17/9/full

Assessment of poultry professionals' knowledge on heavy metal toxicity and use of gallic acid as a treatment option in Oyo State, Southwestern Nigeria

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Abstract

Introduction: *the increasing heavy metal contamination of the environment due to human activities poses significant risks to free range poultry, which often forage in contaminated areas, leading to challenges with heavy metal intoxication. This study investigated the knowledge of poultry professionals regarding heavy metal toxicity and the potential application of gallic acid as a treatment in Oyo State, Southwestern Nigeria.* ***Methods:*** *a cross-sectional survey was conducted in Oyo State, Nigeria, targeting poultry farm managers, veterinarians, and researchers. A structured questionnaire was administered to 138 participants. The questionnaire assessed demographics, knowledge of heavy metal contamination, experiences with gallic acid, and treatment practices. Statistical analyses were performed using descriptive statistics and correlation tests.* ***Results:*** *the findings revealed that 72.7% of respondents acknowledged the symptoms of heavy metal toxicity in poultry. Lead was identified as the most common contaminant (66.2%), primarily sourced from contaminated water (73.3%) and industrial pollution (64.7%). However, only 14.7% reported using gallic acid for treatment, predominantly for Newcastle disease, with a majority rating its effectiveness as neutral. Notably, only 16.2% had received formal training on heavy metal toxicity.* ***Conclusion:*** *the findings reveal significant knowledge gaps among poultry professionals regarding heavy metal toxicity and the underutilization of gallic acid as a treatment option. There is an urgent need for targeted educational programs to enhance awareness and diagnostic skills related to heavy metal exposure in poultry farming. Updating veterinary curricula to include comprehensive training on heavy metal intoxication and ethnoveterinary practice is crucial to improve public health outcomes in affected regions.*

Introduction

The impressively growing large-scale land encroachment due to human activities such as mining and deforestation in Nigeria has resulted in significant contamination of the environment with heavy metals. It causes serious risks to wildlife and domestic animals, including poultry, because of soil, water, and air pollution [1]. Actually, rural and industrially surrounded poultry farms are increasingly exposed to different contaminants [2]. It is further compounded by widespread insecurity that has pushed many farmers into establishing farms near urban areas, often near industrial sites. This proximity increases the risk of heavy metal exposure for local poultry breeds, such as chickens and guinea fowl, due to their foraging behaviours under free-range systems [3]. These birds are therefore important models for the study of the occurrence of heavy metals in the ecosystem, as they are usually found foraging in contaminated environments.

However, the diagnosis of heavy metal intoxication in poultry is difficult. Bioaccumulation of heavy metals in organs induces metabolic, structural, and functional disorders that affect feed efficiency, egg laying, and growth [4]. Chronic exposure produces lesions coupled with changes in enzyme activity and serum biochemical parameters [4]. Diagnoses are usually difficult because heavy metal toxicities usually present as clinical signs associated with common diseases in poultry, such as unthriftiness, poor general body condition, and reduced egg production [5,6]. The accumulation of metals in organs, such as arsenic, lead, cadmium, and mercury, results in the impairment of functions [4]. Because of these complications, the degree of knowledge on intoxication with heavy metals in poultry among farm managers, veterinarians, and researchers should be assessed. A deep understanding of the clinical manifestation of heavy metal toxicity and

of its ability to mimic other common diseases is important for its effective diagnosis and treatment.

Addressing these challenges, ethnoveterinary medicine using traditional remedies provides accessible means in resource-poor settings. Gallic acid is a naturally occurring antioxidant commonly derived from plants traditionally used in ethnoveterinary medicine and thus provides a hopeful avenue toward controlling heavy metal toxicity in poultry [7,8]. Recent works have shown that gallic acid, with its well-documented properties of scavenging radicals, inhibiting lipid peroxidation, and chelating metal ions, can reduce toxic effects caused by heavy metals in poultry [9,10]. While its efficacy has been demonstrated, the practical application of gallic acid in Nigerian poultry farming remains largely unexplored.

The present study aimed to evaluate the knowledge and practices of poultry professionals in Oyo State, Southwestern Nigeria, with respect to challenges occasioned by heavy metal toxicity in poultry and the possible application of gallic acid as a therapeutic intervention. Hence, this tries to answer the following questions: what is the extent of poultry professionals' understanding regarding heavy metal toxicity, and what are the misconceptions that lead to diagnostic errors? What common preventive measures have been widely adopted in an attempt to reduce exposure to heavy metals in poultry, and how frequently is formal training on this issue conducted? The level of awareness with regard to gallic acid as a treatment for poultry diseases: to what extent does application and adoption depend on years of experience and professional role? These aspects are explored to identify major gaps in awareness and practices that may inform the design of targeted programs aimed at enhancing veterinary expertise, improving diagnostic accuracy, and optimizing treatment strategies. The findings will also help in the development of improved veterinary curricula, incorporating comprehensive training on heavy metal toxicity, environmental management, and the use of alternative therapeutic options such as gallic acid.

Methods

Study areas: the study took place in Southwestern Nigeria, a region known for its vibrant poultry farming industry. States such as Lagos, Oyo, Ogun, Ondo, Ekiti, and Osun were the primary focus areas due to their concentration of poultry farms and agricultural activity. The research was done in Oyo State, which is one of the leading agricultural states in Southwestern Nigeria, and one that also boasts of a large poultry farming industry. The state´s capital, Ibadan, is one of the most important centres of agricultural research and veterinary education in Nigeria, hence the reason for conducting this study herein [11]. Poultry farming in Oyo State is an all-year-round activity, seeing that the state is tropical, and the activities involved in the enterprise span from backyard small farms to large commercial ones [12]. Various problems, such as feed quality, biosecurity, and environmental contamination resulting from heavy metals, burden poultry farming in this state [13]. It also hosts several leading educational and research institutions, including the University of Ibadan, which plays a major role in conducting research on poultry farming. This made Oyo State an ideal setting to explore the knowledge and practices related to heavy metal toxicity and gallic acid usage in poultry farming.

Study design: this cross-sectional study was conducted to assess participants´ knowledge and practices regarding heavy metal toxicity and gallic acid usage in poultry farming.

Study population and participants: the study targeted poultry professionals in Oyo State, including veterinarians, poultry farm owners, farm managers, animal scientists, and other individuals directly involved in poultry farming. Participants were required to be actively engaged in the poultry industry within Oyo State. The inclusion criteria specified that participants must be

currently involved in the management, health, or care of poultry farms, and must reside within Oyo State. This focus on poultry professionals in Oyo State provided a localized understanding of the issues under study, allowing for insights specific to the poultry industry in this region.

Sampling and sample size: a random sampling technique was employed to select individual poultry professionals from Oyo state. This approach ensured that the sample was representative of the broader poultry industry in Oyo State. The sample size for this study was determined using Cochran´s [14] formula for sample size calculation, which is expressed as follows:

$$n = \frac{Z^2 x\ p\ x\ (1-p)}{e^2}$$

Where: n = the sample size; Z = the Z-value (1.96 for 95% confidence); p = the estimated proportion of the population that has the attribute of interest (0.5); e = the margin of error (desired precision level, e.g, 0.05 for 5%); therefore; n= 1.96^2x 0.5 x (1-0.5)/0.05^2; n= 3.8416 x 0.25/0.0025; n= 0.9604/0.0025; n= 384.16. Thus, the calculated sample size for this study was approximately 384 respondents. However, due to the unwillingness of some poultry professional to participate in this study, the study was able to obtain 138 willing respondents who took part in the study. The participants were initially selected based on referrals where farm managers and farms owners recommended veterinarians and other professionals who actively engage in poultry production in their area. The basis for this was that the list of poultry veterinarians within the state could not be readily obtained, thus the reason for employing a snowball sampling approach in which new respondents were encouraged to recommend other professionals they knew who met the inclusion criteria. To broaden the participant pool, the link to the structured questionnaire form was shared on the Oyo State veterinarian´s forum, leveraging its extensive reach to potential participants within the poultry industry.

Data collection instrument and procedure: data was collected using a structured questionnaire designed to gather detailed information on participants' knowledge and practices. The questionnaire consisted of three main sections. The first section collected demographic information such as age, gender, educational background, and role in the poultry industry. The second section assessed the participants' knowledge of heavy metal toxicity, including their understanding of the sources of heavy metals in poultry feed, the effects of heavy metals on poultry health, and any current treatment options they were aware of. The third section focused on knowledge and use of gallic acid, exploring participants' awareness of gallic acid as a treatment for heavy metal toxicity and whether they had any experience using it in their practices. The reliability and validity of the research questionnaire were rigorously evaluated during the study. To ensure reliability, the internal consistency of the questionnaire was measured using Cronbach´s Alpha which showed a Cronbach´s Alpha value of 0.82, indicating good reliability across the sections assessing knowledge of heavy metal toxicity and the use of gallic acid as a treatment option. In terms of validity, content validity was ensured through expert review by specialists in veterinary medicine, toxicology, and poultry farming, who revised and ensured that the questionnaire adequately covered relevant aspects of heavy metal toxicity and the application of gallic acid. Data was collected using online data collection method (chi-square platform). The questionnaire link was distributed through emails and WhatsApp social media platform commonly used by poultry professionals in Nigeria after their individual consents to participate in the study have been obtained.

Ethical consideration: all participants were provided with informed consent, which outlined the purpose of the study, the voluntary nature of participation, and the confidentiality of their responses. Participants were assured that their

identities would remain anonymous and confidential.

Statistical analysis: data were recorded in Microsoft Excel® 2019 and analysed with STATA version 18 software. Descriptive statistics were used to summarize the demographic characteristics of participants and their knowledge and practices regarding heavy metal toxicity and Gallic acid usage. Frequencies and percentages were calculated for categorical variables. Correlation analysis was performed using Spearman´s correlation to assess the relationship between years of experience and belief in heavy metal toxicity. Chi-square tests of were conducted to evaluate associations between categorical variables such as occupation, Gallic acid usage, belief in heavy metal toxicity, and years of experience. All the statistical analyses were performed at 5% significance.

Results

Socio-demographic characteristics of study participants: a total of 138 respondents participated in the survey, with demographic details summarized in Table 1. The respondents were predominantly aged between 31-40 years (35.6%), followed by those aged 20-30 years (29.5%), 41-50 years (20.5%), and those over 50 years (14.4%). In terms of gender, 59.2% of the respondents were males, and 40.8% were females. Regarding occupation, majority were veterinarians (65.1%), followed by poultry farm managers (21.7%) and researchers (13.2%). Respondents reported varying levels of experience in their fields, with 34.9% having over 10 years of experience, 36.4% having 1-5 years, 22.5% with 6-10 years, and 6.2% with less than 1 year of experience. Education levels were high among participants, with 96.9% having tertiary education, while only 3.1% had secondary education as their highest level.

Knowledge of the participants on heavy metal toxicity in poultry and preventive measures: the knowledge assessment on heavy metal toxicity (Table 2) showed that 72.7% of participants believed that heavy metal toxicity can manifest as symptoms in poultry, whereas 27.3% did not. The most frequently identified heavy metal was lead (66.2%), followed by mercury (28.4%), arsenic (20.3%), and cadmium (9.5%). Contamination sources included water (73.3%), industrial pollution (64.7%), feed (53.4%), and soil (48.3%). Respondents recognized the effects of heavy metal toxicity, such as increased mortality (79.3%), decreased growth rate (71.6%), reduced egg production (49.1%), and poor meat quality (36.2%). Misdiagnoses were common, with heavy metal toxicity frequently confused with Newcastle disease (84.6%), coccidiosis (57.7%), infectious bronchitis (38.2%), fowl cholera (35.8%), Mycoplasmosis (26.0%), Marek´s disease (27.6%), and avian influenza (22.8%). Preventive measures identified included using clean water (83.1%), avoiding industrial areas (82.2%), proper feed storage (68.6%), regular health checks (63.6%), testing soil and water (61.0%), and using reputable feed sources (49.2%). While 96.4% believed that more research is needed, only 16.2% had received training on heavy metal toxicity.

Knowledge and practices of the participant regarding gallic acid usage in poultry treatment: awareness and application of gallic acid in poultry treatment among the participants were low, as shown in Table 3. Only 14.7% of respondents reported having used Gallic acid, while 85.3% had not. Among those who used Gallic acid, Newcastle disease was the most commonly treated condition (43.6%), followed by coccidiosis (30.8%), infectious bronchitis (28.2%), Mycoplasmosis (25.6%), salmonellosis (23.1%), and fowl cholera (17.9%). In terms of effectiveness, 70.05% rated Gallic acid as neutral, 17.64% found it very effective, and 11.76% considered it effective. Most participants (64.70%) used a dosage of 1 ml/L or 50 mg/kg, with smaller percentages using 2 ml/L or 100 mg/kg (17.64%) and 3 ml/L or 150 mg/kg (17.64%).

The treatment duration varied, with 47.05% administering it for 4-7 days, 23.52% treating until symptoms resolved, 17.64% treating for 1-3 days, and 11.763% treating for more than 7 days. Additionally, only 11.4% of respondents used Gallic acid to treat heavy metal toxicity, while 88.6% had not (Table 3).

Relationships between professional role, experience, and beliefs on heavy metal toxicity and gallic acid usage: statistical analyses (Table 4) revealed weak and insignificant associations between professional role, years of experience, and beliefs or practices related to heavy metal toxicity and gallic acid usage. The correlation between years of experience and belief in heavy metal toxicity showed a Spearman correlation coefficient of -0.071. A Chi-square test assessing the association between Gallic acid usage and occupation resulted in a Chi-square statistic of 2.68 (p-value = 0.262). Similarly, the analysis of belief in heavy metal toxicity across occupations yielded a Chi-square statistic of 1.43 (p-value = 0.49). Lastly, the association between belief in heavy metal toxicity and years of experience showed a Chi-square statistic of 6.41 (p-value = 0.093).

Discussion

The present study assessed information about the level of awareness on heavy metal intoxication in poultry and the use of Gallic acid for treatment. This research contributes to the growing body of knowledge on environmental toxicology, particularly as it applies to food producing animals, and highlights notable gaps in both training and diagnostic practices, which mirror findings from other public health contexts such as lead exposure in humans. Though, majority of respondents were veterinarians, 27.3% did not believe that heavy metal toxicity can show symptoms in poultry. This knowledge gap is in agreement with other studies, such as those conducted by Adebamowo *et al*. [15] on lead exposure in Nigeria, where participants showed a general awareness of heavy metals but lacked specific deep-seated understanding and effective safety practices. Similarly, Nodoushan *et al*. [16] have shown that the level of knowledge on heavy metals risks of workers who have participated in awareness programs are low and protective behaviour is also poor. Moreover, the misdiagnosis between heavy metal toxicity and other common diseases in poultry, such as Newcastle disease is very high as reported by 84.6% of respondents, this observation is an indication of a serious challenge in veterinary practice. The situation is further complicated by the limited training on heavy metal toxicity, given that only 16.2% of the respondents had specific training on heavy metal toxicity. Contextually, this issue is highlighted by Aljohani *et al*. [17] review of a wide range of histopathological changes associated with heavy metal exposure which include renal damage, reproductive disorders, and severe liver damage. These findings therefore point out the need for targeted educational interventions to enhance diagnostic accuracy and safety practices among those exposed to these toxic substances.

Measures of prevention such as the use of clean water and avoidance of industrialized areas, were well recognized by the respondents in this study. This agrees with the findings by Razak *et al*. [18], where good knowledge and attitudes were expressed by the populace on heavy metal contamination prevention. The study also highlights that Gallic acid (GA) is not widely used among poultry professionals, with only 14.7% reporting its application, primarily for treating Newcastle disease, where its effectiveness is generally rated as neutral. Furthermore, the use of GA for heavy metal toxicity is even less frequent, as 11.4%, recognised its potential in mitigating such toxicities despite research efforts providing compelling evidence of GA´s benefits in combating oxidative stress and heavy metal toxicity. Studies by Joseph *et al*. [19] and Varadharajan *et al*. [20] demonstrate that GA enhances cellular viability, reduces oxidative stress markers, and improves

enzymatic antioxidant activity in cases of arsenic and mercury toxicity. In line with this, Ojo *et al*. [21] further support GA´s neuroprotective properties, showing that it modulates neurotransmitters, reduces inflammation, and protects against cadmium-induced neurotoxicity. These findings suggest that GA holds significant potential in addressing heavy metal toxicity in poultry, which, from this study, remains underutilized.

In the context of disease management, research also supports GA's potential antiviral properties. While this study reflects limited use of GA for Newcastle disease, Harazem *et al*. [22] demonstrated the antiviral properties of Gallic acid in reducing Newcastle disease virus infectivity. Though GA´s specific role in antiviral activity needs further exploration, its known antioxidant and anti-inflammatory effects suggest it could complement existing antiviral treatments in poultry. The lack of significant associations between years of experience, occupation, and beliefs regarding GA usage in this study suggests that these factors do not heavily influence its adoption, highlighting an opportunity for education and further research. This study clearly showed the need to deliberately emphasize heavy metal toxicity and the ethnoveterinary mitigation strategies using locally available spices in the training of our veterinary students, judging from the realities of climate change, deforestation, mining, and massive land degradation and biodiversity changes.

Study limitations: this study is limited by its focus on Oyo State, which may not fully represent the environmental conditions, industrial practices, or farming systems in other regions of Nigeria, limiting the generalization of the findings. Additionally, the reliance on self-reported data introduces potential biases, such as recall and social desirability, which may affect the accuracy of participants' responses regarding their knowledge and practices related to heavy metal toxicity and the use of Gallic acid.

Conclusion

This study identified significant knowledge gaps among veterinarians, farm managers, and researchers in Oyo State regarding heavy metal toxicity in poultry. Despite widespread recognition of heavy metal contamination risks, many participants were unclear about the specific symptoms of toxicity, often confusing it with common poultry diseases. Furthermore, the use of Gallic acid, a potential treatment for heavy metal toxicity, was limited, with a small proportion of respondents reporting its use, suggesting a lack of awareness or confidence in its application. The findings also revealed that only a minority of participants had received formal training on heavy metal toxicity, indicating the need for targeted educational programs to improve diagnostic accuracy and treatment practices. It also showed the need for town gown relationship as many of the studies on the mitigation strategies were done by researchers from University of Ibadan. Based on the findings of this study, it is recommended that targeted training programs be developed for veterinarians, farm managers, and researchers to enhance their understanding of heavy metal toxicity in poultry, with a focus on improving diagnostic skills and promoting the use of gallic acid as a potential treatment. To support long-term improvements, the veterinary school curriculum should be updated to include courses on heavy metal intoxication, covering diagnostic techniques, treatment options, and the environmental and public health impacts of contamination. Collaborations between research institutions, government agencies, and industry stakeholders are crucial for disseminating best practices to manage heavy metal exposure effectively in poultry farming.

What is known about this topic

- *Heavy metal contamination: free-range poultry are at risk of heavy metal exposure from contaminated environments, leading to bioaccumulation in their organs and various health issues;*
- *Diagnosis challenges: heavy metal toxicity symptoms in poultry mimic common diseases like Newcastle disease, making it difficult to diagnose.*

What this study adds

- *Knowledge gaps: it identifies significant gaps in poultry professionals' knowledge regarding heavy metal toxicity, with many unable to accurately diagnose or address heavy metal contamination in poultry;*
- *Underutilization of gallic acid: the study reveals that gallic acid, despite its potential to mitigate heavy metal toxicity, is not widely recognized or used among poultry professionals in Oyo State.*
- *Foundation for educational programs: the findings provide a foundation for developing targeted educational and training programs to improve veterinary diagnostic and treatment practices, specifically addressing heavy metal intoxication in poultry.*

Competing interests

The authors declare no competing interests.

Authors' contributions

The research concept was developed by Modupe Beatrice Abraham, Oluwaseun Olanrewaju Esan, Olalekan Taiwo Jeremiah and Benjamin Obukowho Emikpe. Data collection was carried out by Modupe Beatrice Abraham. Statistical analysis was done by Derrick Adu Asare and Edmond Onidje. The draft of the manuscript was prepared by Modupe Beatrice Abraham and Edmond Onidje. All authors read and approved the final version of the manuscript and contributed equally to its content.

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Table

Table 1: socio-demographic characteristics of poultry Professionals in Oyo State, Southwestern Nigeria (2024)

Table 2: knowledge and preventive practices of poultry professionals regarding heavy metal toxicity in Oyo State, Southwestern Nigeria (2024)

Table 3: awareness and practices of poultry professionals on the use of gallic acid in poultry treatment in Oyo State, Southwestern Nigeria (2024)

Table 4: statistical analysis of factors influencing beliefs and practices on heavy metal toxicity and gallic acid usage among poultry professionals in Oyo State, Southwestern Nigeria (2024)

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Table 1: socio-demographic characteristics of poultry professionals in Oyo State, Southwestern Nigeria (2024)

Demographic category	**Response options**	**Frequency (n)**	**Percentage (%)**
Age group	20-30 years	39	29.5%
	31-40 years	47	35.6%
	41-50 years	27	20.5%
	Over 50 years	19	14.4%
Gender	Female	53	40.8%
	Male	77	59.2%
Occupation	Farm manager	28	21.7%
	Researcher	17	13.2%
	Veterinarian	84	65.1%
Experience in the field	Less than 1 year	8	6.2%
	1-5 years	47	36.4%
	6-10 years	29	22.5%
	Over 10 years	45	34.9%
Education level	Secondary	4	3.1%
	Tertiary	125	96.9%

Table 2: knowledge and preventive practices of poultry professionals regarding heavy metal toxicity in Oyo State, Southwestern Nigeria (2024)

Knowledge aspect	Response option	Count	Percentage
Belief that heavy metal toxicity can cause symptoms	Yes	88	72.7%
	No	33	27.3%
Types of heavy metals encountered	Arsenic	15	20.3%
	Cadmium	7	9.5%
	Lead	49	66.2%
	Mercury	21	28.4%
Sources of heavy metal contamination	Soil contamination	56	48.3%
	Industrial pollution	75	64.7%
	Contaminated water	85	73.3%
	Contaminated feed	62	53.4%
Impact of heavy metal toxicity on poultry	Poor meat quality	42	36.2%
	Increased mortality	92	79.3%
	Decreased growth rate	83	71.6%
	Reduced egg production	57	49.1%
Diseases confused with heavy metal toxicity	Coccidiosis	71	57.7%
	Mycoplasmosis	32	26.0%
	Fowl cholera	44	35.8%
	Infectious bronchitis	47	38.2%
	Marek's disease	34	27.6%
	Avian influenza	28	22.8%
	Newcastle disease	104	84.6%
Measures to prevent heavy metal exposure	Use of a reputable feed	58	49.2%
	Testing soil/water	72	61.0%
	Avoiding industrial areas	97	82.2%
	Regular health checks	75	63.6%
	Proper feed storage	81	68.6%
	Use of clean water	98	83.1%
Belief that more research is needed	Yes	107	96.4%
	No	4	3.6%
Received training on heavy metal toxicity	Yes	18	16.2%
	No	93	83.8%

Table 3: awareness and practices of poultry professionals on the use of gallic acid in poultry treatment in Oyo State, Southwestern Nigeria (2024)

Knowledge aspect	Response option	Count	Percentage
Used Gallic acid	Yes	17	14.7%
	No	99	85.3%
Conditions treated with gallic acid	Salmonellosis	9	23.1%
	Mycoplasmosis	10	25.6%
	Fowl cholera	7	17.9%
	Infectious bronchitis	11	28.2%
	Newcastle disease	17	43.6%
	Coccidiosis	12	30.8%
Effectiveness of gallic acid	Neutral	12	70.05%
	Effective	2	11.76%
	Very effective	3	17.64%
The dosage of gallic acid used	1 ml/L or 50 mg/kg	11	64.70%
	2 ml/L or 100 mg/kg	3	17.64%
	3 ml/L or 150 mg/kg	3	17.64%
Duration of gallic acid treatment	1-3 days	3	17.64%
	4-7 days	8	47.05%
	More than 7 days	2	11.763%
	Until symptoms resolve	4	23.52%
Used gallic acid to treat heavy metal toxicity	Yes	13	11.4%
	No	101	88.6%

Table 4: statistical analysis of factors influencing beliefs and practices on heavy metal toxicity and gallic acid usage among poultry professionals in Oyo State, Southwestern Nigeria (2024)

Analysis	Statistic value	P-Value	Test
Correlation between years of experience and belief in heavy metal toxicity	-0.071		Spearman
Association between gallic acid usage and occupation	2.68	0.262	Chi-Square
Association between belief in heavy metal toxicity and occupation	1.43	0.49	
Association between belief in heavy metal toxicity and years of experience	6.41	0.093	