Veterinary and Animal Science 28 (2025) 100448

Contents lists available at ScienceDirect

Veterinary and Animal Science

journal homepage: www.elsevier.com/locate/vas

Antibiotic use and residue detection in guinea fowl eggs in rural Togo: An assessment of practices and risks

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ARTICLE INFO

Keywords:
Antibiotics
Guinea fowl
Antibiotic residues
Savannah region
Sub-therapeutic
Withdrawal period

ABSTRACT

Various classes of antibiotics are used to treat guinea fowl diseases in rural Togo. The aim of this study was to assess antibiotic treatment practices and detect the presence of antibiotic residues in eggs from guinea fowl farms in the Savannah region of Togo. The study involved direct interviews using a questionnaire administered to 87 farmers in the Oti, Tone and Tandjoare prefectures, using the Kobocollect tool. Qualitative analysis of the presence of antibiotic residues in guinea fowl eggs was carried out using the Premi®Test collected from farmers. Data were presented as relative frequencies using Excel software and logistic regression analysis and Chi-square test were performed to ascertain positive associations. The minority of farmers (1.15 %) were under the care of a veterinarian, while 87.36 % practiced self-medication and did not respect the prescribed doses of antibiotics, and 11.49 % had no supervision. All the farmers surveyed use plants for therapeutic purposes, without any real knowledge of the correct dosage. Additionally, 56.66 % of farmers did not respect the withdrawal period before guinea fowl eggs are consumed or placed on the market. Furthermore, 49.43 % (Chi-square statistic = 14.92; dof = 2; P = 0.00058) of guinea fowl egg samples analyzed contained antibiotic residues. Biosecurity and confinement were positively associated with the presence of antibiotic residues in eggs. The study reveals inappropriate use of antibiotics by guinea fowl farmers in the Savannah region of Togo, leading to the presence of antibiotic residues in the eggs.

Introduction

Raising short-cycle species, particularly poultry, is one way of improving the socio-economic situation of populations (Fall et al., 2021). Thus, the encouragement of guinea fowl farming today may be motivated by several factors, including the growing demand for this poultry, its nutritional advantages, its economic profitability, and its relative sustainability compared with other forms of farming. In Africa in general, and northern Togo in particular, especially in the savannah region, the local guinea fowl is one of the most widespread poultry species; it is farmed in a low-productivity rambling system and is not subject to any prohibition. The breeding of local guinea fowl (*Numida meleagris*) is becoming increasingly important in Togo's rural development sector. This species makes up 20 % of the total poultry production and is the second most valued white meat in the country (Ossebi et al., 2023). Guinea fowl have a natural resistance to many poultry diseases, making them a promising alternative for smallholder farmers with limited access to veterinary services. (Issaka and Yeboah, 2016). Local guinea fowl are not subject to any health monitoring, as farmers claim they are hardy birds and less susceptible to common chicken diseases (Lombo et al., 2018; Abdallah and Oyebamiji, 2024). However, some observe symptoms such as diarrhea, nasal and oral discharge, general fatigue, swollen legs and the presence of parasites (lice, intestinal worms). The remedy to these diseases is normally carried out by

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https://doi.org/10.1016/j.vas.2025.100448

Available online 26 March 2025

occasionally using veterinary drugs and sometimes medicinal plants, without respecting pharmaceutical prescriptions and dosages (Djiotsa et al., 2023). Currently, various veterinary products are used in poultry farming without prescriptions from veterinarians to combat pathologies and improve production (Souhalio et al., 2023). Antibiotics occupy a prominent place among these products. Nevertheless, their uncontrolled use can lead to the formation of residues in products derived from these animals, especially when waiting periods are not respected by users. Moreover, the potential risks associated with the presence of residues in foodstuffs of animal origin are of several kinds: carcinogenic risks (Nitrofurans), allergic risks (Penicillins, Streptomycin), toxic risks (Chloramphenicol), modification of intestinal flora (Tetracyclines), selection of antibiotic-resistant bacteria (several antibiotics are concerned). One of the difficulties faced by farmers is the fact that there are so many people involved in the process, providing advice that is more or less contradictory. The veterinarian's specific skills mean that he or she must remain the privileged contact, the equivalent of our "general practitioner", as the orchestrator of the herd's health. Sometimes, for various reasons (cost, availability, etc.), this role eludes him or her. And yet, for every treatment, the veterinarian is the best person to assess the benefit/risk balance for the animals, including man and the environment. Recent studies have documented the presence of antibiotic residues in foodstuffs such as milk and eggs in Senegal (Bedekelabou et al., 2022). However, there is currently no information on these aspects with regard to guinea fowl eggs in Togo and this is because the UEMOA countries (Benin, Burkina-Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo) for example still do not have an operational system to detect veterinary drug residues in foods of animal origin (Mensah et al., 2014; European Food Safety Authority et al., 2022); these countries have not yet developed effective mechanisms to monitor and control these residues, which poses risks to food safety and public health. In view of the potential public health risks posed by the informal practice of antibiotic therapy on these farms, there was a need to verify the presence of antibiotic residues in guinea fowl eggs produced by farmers in the region of Savanna. For this reason, the present study was undertaken to take inventory of antibiotic use on guinea fowl farms in the Savannah region of Togo and the presence of antibiotic residues in eggs from these farms. More specifically, the aim was to explore guinea fowl farms in the Oti, Tandjoare and Tone prefectures in the Savannah region in order to enumerate the main avian pathologies most frequently encountered, examine the state of antibiotic use and detect antibiotic residues in eggs from these farms.

Material and methods

Study period and location

The study was carried out in three districts of the Savannah region of Togo, where most of the guinea fowl farms are situated as the climatic conditions are favorable for their production. The districts included Tone, Tandjoire and Oti (Fig. 1). Data collection (collection of eggs and data from farmers) began on July 20, 2023, and ended on August 31, 2023. Antibiotic residues in eggs were measured from September 1 to 11, 2023 in the laboratory of the Centre d' Excellence Regional sur les Sciences Aviaires (CERSA).

Biological material

Healthy guinea fowl eggs (no more than 5 days of storage) were the biological material used in this study. Four hundred and thirty-five (435) eggs were collected from 87 farms in the study area. Eggs were randomly collected from each farm by assigning numbers to the available eggs and using a random number generator to ensure unbiased sampling reproducibility and transparency. The number of eggs sampled was variable due to different farm sizes, laying periods and egg storage duration.

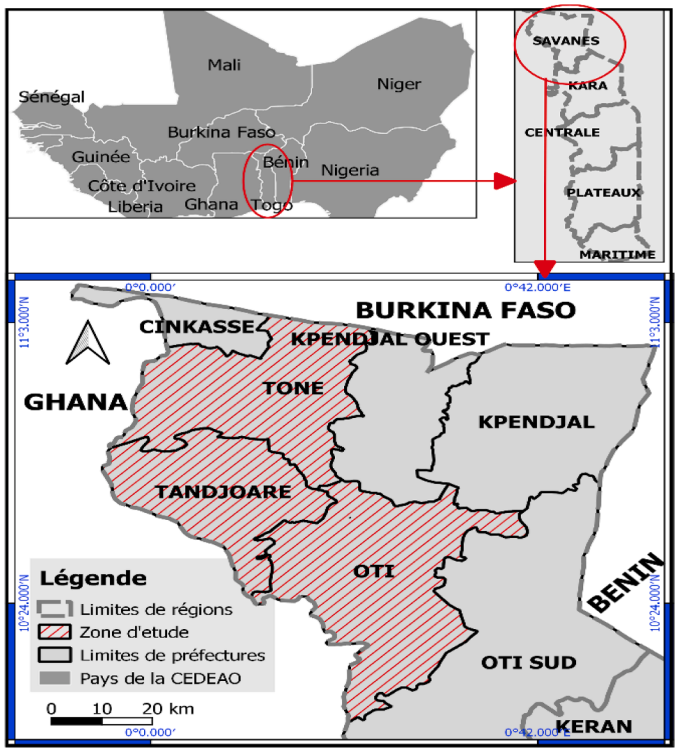


Fig. 1. Study area. Source: (Tcheou et al., 2024).

Technical material

The field equipment consisted of material for administering the survey questionnaire. On the other hand, appropriate equipment for egg sampling, marking and handling was used. These included a permanent marker and egg trays. In addition, a motorcycle was used to move around the farms. The Premi®Test (manufactured by R-Biopharm) and other laboratory equipment needed to study residues in eggs were used to analyze the samples. These included an incubator with adjustable temperature, micropipettes; cones, etc.

Sampling and eggs collection

The sample size was determined using the formula of Schwartz (1972).

$$n = t^2 \times p(1-p)/m^2$$

n: Required sample size
t: required 95 % confidence level (typical value 1.96)
p: expected prevalence based on previous reference data, we used a prevalence of 24 % in reference to Bedekelabou et al. (2022)
m: margin of error at 10 % (typical value 0.1)
n: $[(1.96 \times 1.96)*0.24 \times 0.76]/(0.1 \times 0.1) = 70.07$, that is around 70 farms for the study.

For the present study, 87 of the 180 guinea fowl farms listed in the ESF Togo (Breeding and Family Solidarity in Togo) project database were surveyed based on inclusion and exclusion criteria. The inclusion criteria involved farms actively engaged in guinea fowl production during the study period, accessible for data collection, and farmers' willingness to participate in the study while the exclusion criteria involved farms that had ceased operations, those located in areas beyond logistical reach or farms whose owners declined to participate.

Farm selection and survey design

A cross-sectional, descriptive survey of the farms using a questionnaire before egg collection was carried out. Survey and sampling sites were chosen in several localities in the three districts (Oti, Tandjoare, and Tone). The questionnaire was used to investigate farmers' practices, sanitary prophylaxis and biosecurity on farms. The aim was to correlate the results of antibiotic residue measurements with the quality of farming practices. Pre-testing was done in order to guarantee the validity and reliability of the questionnaire utilized in the study. This entailed giving the questionnaire to a select group of farmers who did not participate in the primary research. The pre-test feedback was utilized to find and fix any unclear or problematic questions, improve the phrasing, and make any necessary format adjustments. Before the questionnaire was sent to the entire research group, pre-testing was done to make sure the questions were more understandable and properly gathered the necessary data. Eighty-seven (87) farmers were engaged during the interviews lasting thirty minutes each.

Mortality rates were assessed based on farmers records covering their current production. Farmers reported mortality as the number of dead birds and this was calculated as a percentage of their total flock size. Pathological symptoms were identified based on a list of common clinical signs provided during the survey. Data was collected through structured questionnaires, with frequencies computed to determine the prevalence of each reported symptom, and percentages calculated based on total respondent numbers.

Antibiotic residues using premi®test

Antibiotic residues were detected using the Premi®Test method. Premi®Test is based on growth inhibition of *Bacillus stearothermophilus*, a bacterium highly sensitive to many antibiotics and sulfonamides. Standardized spores are embedded in agar supplemented with selected nutrients. Covering a wide range of antibiotics, Premi®Test is a rapid, sensitive, reliable and ready-to-use test (Gaudin et al., 2008). After homogenizing the egg white and yolk in a vial, we removed and transferred 100 µl of the solution into the Premi®Test ampoule. We then pre-warmed the samples in the Premi®Test incubator for 10 min at 80 °C (pre-incubation). After this pre-treatment, we incubated the samples for approximately three hours at 64 °C (±0.5 °C). When the negative control turns from purple to yellow, the results can be read. Throughout the procedure, temperature was strictly monitored using incubator thermometers to maintain the specified pre-incubation and incubation conditions and the samples were handled in a sterile environment to minimize contamination risks.

Reading the results: Reading the "presence/absence" result is limited to a color comparison. In the absence of antibiotics (negative sample), spores germinate and grow, leading to acidification of the medium and a color change from violet to yellow. Conversely, in the presence of antibiotics, spores are inhibited and do not grow. In this case, the color of the medium remains violet.

Data collection and analysis

The data collected during the surveys were first entered by Kobocollect and analysis was performed using Excel software (version 2016). Descriptive statistics were performed on the data using means, percentages, and confidence intervals to capture the positivity rates. To identify factors associated with the presence of antibiotic residues in eggs, logistic regression analyses using Lasso (L1 regularization) and Ridge (L2 regularization) models were performed in R software. The models were chosen to handle potential issues of multicollinearity and overfitting by penalizing the coefficients. The variables included in the models were biosecurity measures, the existence of prophylaxis plans, withdrawal period, frequency of antibiotic usage and confinement status. Data were standardized to ensure comparability across variables. Additionally, a Chi-square test was performed to compare the positivity rates between the different localities.

Results and discussion

Characterization of guinea fowl breeding during the survey

Table 1a shows the population of guinea fowl in the farms visited. The majority of the farms visited (59) had <25 guinea fowl representing 67.81 %. Two percent (2 %) of the farms had >100 flock size. The majority of farm buildings in the study area (79 farms) are built with raised walls and concrete floors (Fig. 2). Table 1b shows that 5.74 % (5) of farmers specialize in guinea fowl production, 17.24 % (15) in meat guinea fowl production and 77.01 % (67) in mixed farming (guinea fowl and meat production).

The current survey showed that guinea fowl farms in the savannahs were small. This leads us to conclude that additional efforts need to be made in pathology management, as the smaller the farm, the more pathologies need to be managed. Our results are similar to those observed by Massawa et al., (2020) on Sudan-Sahelian guinea fowl farms in Cameroon (Far North Region) who showed that nearly 25 % of farmers have 10 to 15 guinea fowl on their farms.

Biosecurity and farm types

Of the 87 farms surveyed, 78 (89.65 %) are equipped with foot baths (Fig. 3). Almost all the guinea fowl farms surveyed (84, 96.55 %) adopted the semi-intensive system. Forty-seven (54.02 %) of the farmers indicated that they always regularly cleaned their guinea fowl houses. For those with a specific type of breeding (guinea fowl production and fattening), 70 % (14 out of 20 farmers) revealed that they carried out a sanitary resting period at the end of a production cycle. With regard to hygiene practices, 96.55 % (84 out of 87) of the poultry farmers

Table 1
Guinea fowl characteristics and farm management practices adopted by farmers in the farms surveyed.

Characteristics	Unit	Percentage (%)
(a)		
Number of heads per farm		
< 25	59	67.81
25– 49	19	21.83
50 – 100	8	9.19
≥ 100	1	1.14
(b)		
Types of farms		
Mixed farming (Breeding for meat and fertilized eggs for reproduction)	67	77.01
Guinea fowl rearing (breeder eggs)	5	5.74
Breeding for meat (fattener)	15	17.24
(c)		
Existence of a health or monitoring officer		
Veterinary assistance	1	1.15
Support from a veterinary agent or technician	76	87.36
No supervision	10	11.49
(d)		
Drugs used		
Newcastle Vaccines	65	74.44
Antibiotics	54	62.22
Vitamins	45	52.22
Pest control	53	61.11
Vitaminized antibiotics	66	76.0
(e)		
Respect for dosing		
Breeding respecting doses	41	47.12
Breeding not respecting doses	46	52.87

(a) Population of guinea fowl in the farms surveyed; (b) Breeding purpose; (c) Existence of health officer; (d) Veterinary drugs used in farms; (e) Respect for posology.

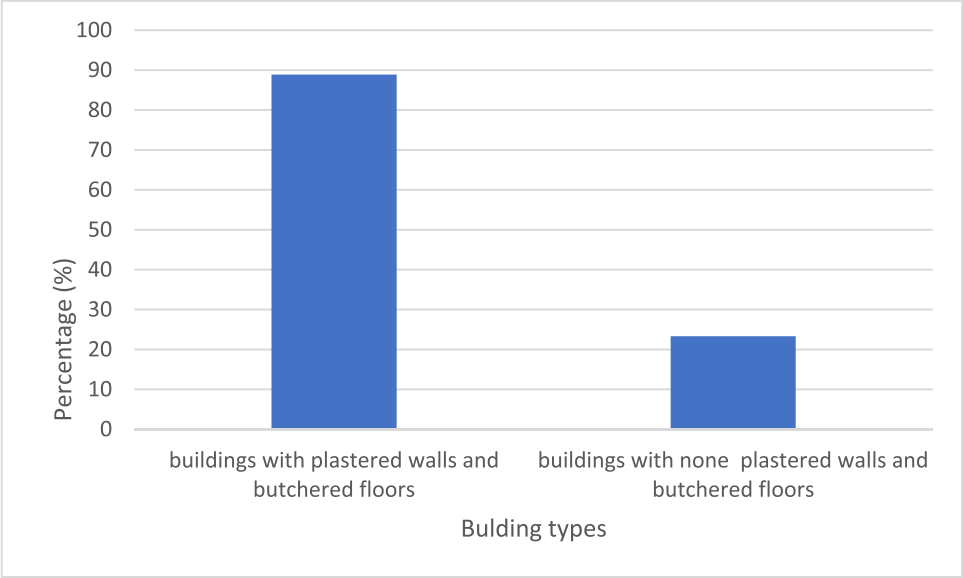


Fig. 2. Types of livestock housing.

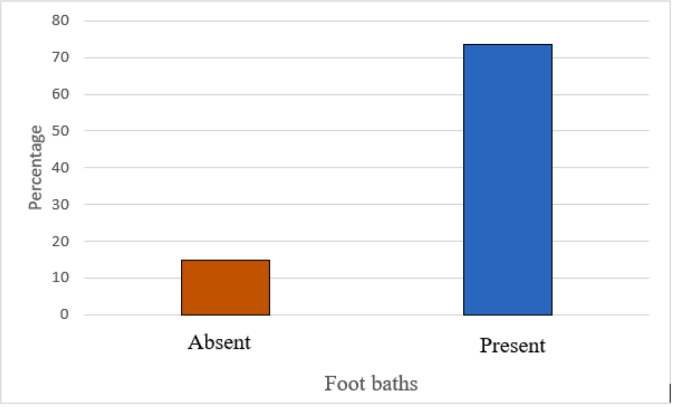


Fig. 3. Biosecurity on the farm: Presence or absence of footbaths.

surveyed complied. The results of the survey show that out of 87 farmers interviewed, 1 (1.15 %) benefited from veterinary assistance (on a very permanent basis) and 10 (11.49 %) were not supervised. Seventy-six (87.36 %) relied on the support of a veterinary officer or a livestock technician for animal monitoring (Table 1c). Our results agree with those of Meutchieye et al. (2020) who indicated that local guinea fowl were not subjected to any health monitoring because, according to their owners, they are hardy birds and less susceptible to common poultry diseases. Similarly, Keutchatang et al. (2019) asserted that poultry farmers do not call on a veterinarian to monitor their flocks, but seek advice from other animal health professionals, which they equate with a veterinary prescription. Self-medication can also lead to misuse or abuse of medicines and subsequently leave residues of drug agents in the poultry products.

Farm monitoring

This prophylaxis plan covers vaccination against infectious diseases (Newcastle, Gumboro, Infectious Bronchitis and Avian Pox). From Table 1d, we can see that farmers protect their guinea fowl much more from Newcastle disease. They also make extensive use of vitamin-based antibiotics and antiparasitic agents to combat microbial and parasitic infections. Out of 87 farmers, 13 (14.94 %) stated that they did not comply with the prophylaxis plan, and 64 (73.56 %) had a prophylaxis plan and stated that they complied with it (Fig. 4). Table 3 shows that the farmers use plants in phytotherapy without knowing it. The plants mentioned are used by the farmers for the prevention and treatment of pathologies. While some farmers use plants for phytotherapy, their unstructured approach and lack of dosage knowledge may limit the efficacy of these methods in controlling diseases, indirectly increasing reliance on antibiotics. The results underscore the importance of structured prophylaxis and biosecurity practices in minimizing residue risks. These findings warrant further studies to optimize prophylaxis plans, educate farmers on effective phytotherapy, and enhance biosecurity measures to mitigate antibiotic residues in farming systems. Our results further support those of Bedekelabou et al. (2022) who opined that the issue of biosecurity on poultry and pig farms has provided results that highlight the need to reinforce good biosecurity practices in the animal production sub-sector. This previous work carried out in the Plateaux and Maritime regions on pig and poultry farms showed that 51 % of poultry farms had foot baths, compared with only 4 % of pig farms. Lastly, hygiene measures were in place on 82 % and 37 % of poultry and pig farms respectively. In the same vein, Kadja et al. (2021) asserted that practicing hygiene on a farm means putting in place sanitary safety measures. If these measures are not properly managed, not only will they compromise the profitability and quality of production, but they will also give rise to public health risks, including the appearance and development of antibiotic resistance (as in the case of enterobacteria) and viral.

Pathological symptoms encountered

Fig. 5 illustrates the pathologies and symptoms observed on guinea fowl farms in the savannahs. Among the symptoms of frequent pathologies, we noted that internal parasites have a prevalence of 15.55 %, diarrhea (all types) (12.22 %), leg paralysis (11.11 %) and digestive disorders (10 %). Mortality among guinea fowl under one month of age was 45.55 %. The majority of farms had several pathological symptoms. This is because our survey took place during the winter (mid-August to mid-September) when many cases of disease are observed.

This finding corroborates Niyibizi's (2012) conclusion that a temperature of 28 °C and a humidity level of 80 % constitute favorable climatic conditions for the emergence of pathologies. The symptoms often encountered in these farms include diarrhea, respiratory difficulties; and digestive disorders, among others. Similarly, Massawa et al., (2020) observed that the symptoms often encountered on farms are

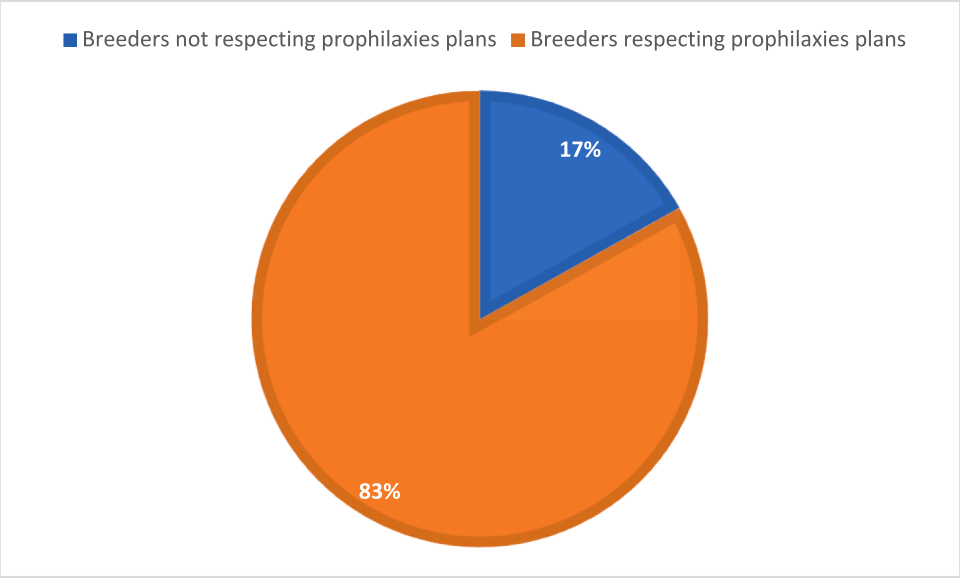


Fig. 4. Existence of prophylaxes plan.

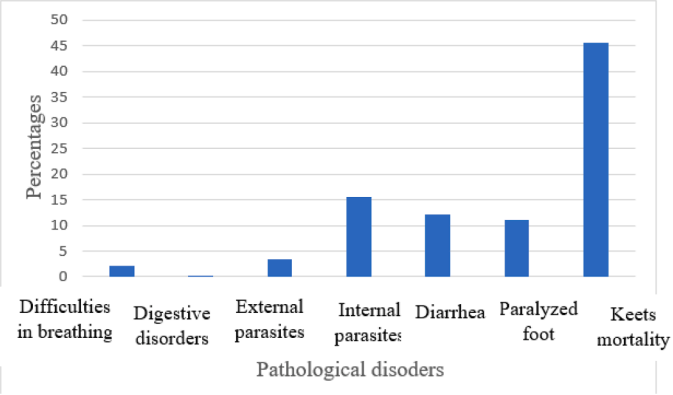


Fig. 5. Pathological symptoms encountered in the surveyed farms.

diarrhea, nasal and oral discharge, general fatigue, swollen legs and the presence of parasites (lice, and intestinal worms). To address this challenge, >34 % of poultry farmers administer tree bark and leaves to their flocks by adding them to their drinking water. In addition to this treatment, guinea fowl are occasionally given antibiotics and sometimes vaccinations (Newcastle). According to Gobvu et al. (2022), around 53 plants are used therapeutically in guinea fowl production in Zimbabwe.

Types of antibiotics used

Table 2 shows the families of antibiotics used on the Savannah White Gold project farms. The most used are tetracycline (oxytetracycline) and oxapenems (amoxicillin). The study found that 31 farmers at times practiced self-medication, obtaining medicines for their animals themselves from the markets. Non-compliance can be divided into two categories: over- or under-dose. The results of the survey revealed that only 41 farms out of 87 users (47.12 %) complied with the recommended dose, while the remainder (46 farms or 52.87 %) did not (Table 1e). In all the farms we visited, the oral route is the only method used to administer medication. They are incorporated into the drinking water. Of 51 (56.66 %) farms reporting the use of antibiotics, the withdrawal period ranged from 3 to 9 days. That they were not complying, as they consumed or sold these eggs during the withdrawal period. On the farms we visited, we found that despite compliance with the prophylaxis plan,

Table 2
Characteristics of antibiotics and their frequency of use by guinea fowl farmers.

Antibiotics class	Composition	Trade name (quoted by the farmers)	Percentage (%)
Oxapenems	Amoxicillin	Dimoxan ws	11.11
Tetracycline	Oxytetracycline	Limoxin ws, Dvxin 200 ws	16.66
Polymyxin	Colistin	Colo 480 ws, Colexil oral	5.55
Macrolides	Erythromycin	Dvxin ws,	5.55
Aminoxides	Streptomycin	Est-mix	5.55
Tetracycline + Polymyxin+Macrolide and Vitamins	Oxytetracycline+ Colistin +Erythromycin and Vitamins (*A* + D3 + *E* + B1 + B2 + B6 + B12 + K3)	Aliseryl	35.38
Tetracycline + Polymyxin+Vitamins	Tetracycline + Colistin + Vitamins (*A* + D3 + K3 + *E* + B2 + B12 + PP + Pantothenate de calcium)	Tetracolivit	20.20

cases of certain diseases persisted. For example, guinea fowl mortality (45.55 %) is a regular threat on the farms we visited. This result could be explained by other factors in the sanitary prophylaxis plan, such as the type of medication used and the dose administered.

Our results show that vaccines are the most widely used (74.44 %), followed by antibiotics with a percentage of 62.22 %, anti-parasitic (61.11 %) and finally vitamins, which the farmers used as anti-stress agents with a percentage of 52.22 %. However, the results of our studies show that anti-stress agents and antibiotics are still the most widely used on poultry farms. This is because they are used after every vaccination, deworming or change of premises.

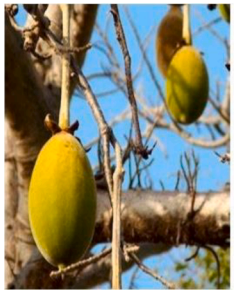
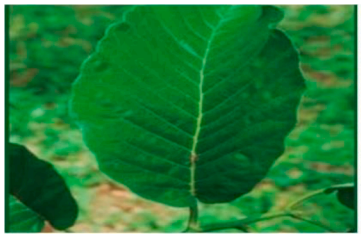
As far as antibiotics are concerned, oxytetracyclines and oxapenems are the most widely used. They are often used in combination with vitamins. These results are in line with those of Tcheou et al. (2024), who showed that one of the most widely distributed antibiotics on the Togolese market by veterinary medicine wholesalers was oxytetracycline. However, according to Gambogou et al. (2020). tetracolivit, alyseryl, keproceryl and limoxin are the kinds of antibiotics most widely

Table 3
Plants and their therapeutic remedies as provided by guinea fowl farmers.

Plants cited by farmers	Remedies
Caïl-Cédrat: *Kaya senegalensis* 	Medicinal plants with febrifuge and antibiotic, tonic and antidiarrheal, anti-infectious and deworming therapeutic properties
Neem (margousier): *Azardirachta indica* 	Internal and external pest control
Néré: *Parkia biglobosa* 	Fevers, gastrointestinal problems and infections
Gingembre: *Zingiber officinale* 	Anti-inflammatory, antioxidant, improves digestion

(*continued on next page*)

Table 3 (*continued*)

Plants cited by farmers	Remedies
Poivre: *Piper nigrum* 	Stimulate digestion and appetite; relieve flatulence
Moringa: *Moringa* ***oleifera***  	Strengthens the immune system, anti-oxidant properties, anti-inflammatory and improves digestion
Karité: *Vitellaria paradoxa*  	Anti-inflammatory, anti-microbial, healing
Baobab: (*Adansonia digitata*)   	Anti-microbial, rich in protective antioxidants and anti-viral
Iriko: (*Milicia excelsa*)  	Gastrointestinal disorders, skin problems, joint and muscle pain

(Source of photos: https://www.istockphoto.com/photos/).

purchased at rates of 21 %, 19 %, 14.6 % and 13 %, respectively by poultry farmers in the markets of Lome. Guinea fowl farmers also used vitamin-based antibiotics in significant quantities. Dosage is crucial for the proper use of medication. Our findings reveal that only 47.12 % of farmers adhere to the prescribed dosage. This low compliance rate can result in ineffective treatment of birds.

Antibiotic residue detection

Table 4 shows that out of 87 samples analyzed, the number of positive samples was 43, with an overall prevalence of 49.43 % (Chi-square statistic = 14.92; dof = 2; $P = 0.00058$). The results of the logistic regression analysis revealed that biosecurity and confinement (coefficients, 0.8415 and 0.8416, respectively) were positively associated with the presence of antibiotic residues but prophylaxis, withdrawal period and frequency of antibiotic use (coefficient = 0.000) had no significant contribution from the Lasso regression plot (Fig. 6). Similarly, the Ridge regression plot showed a positive association for all the variables but that of prophylaxis association was less (coefficients, 1.287, 1.157, 0.600, 0.675 and 0.675, respectively) (Fig. 6). The logistic and Ridge regression analyses underscore the significance of biosecurity and confinement practices in influencing the presence of antibiotic residues. Poor biosecurity likely increases disease outbreaks, necessitating antibiotic use, while inadequate confinement management may exacerbate stress and infection risks among birds. These findings highlight the critical role of stringent biosecurity protocols and optimal confinement practices in reducing reliance on antibiotics. Earlier studies carried out in Togo by Gambogou et al. (2020) also proved the same results indicating that good hygiene practices and the use of antibiotics, none of the respondents had received training in this area. Each farmer or trader had his or her own frequency of equipment maintenance and did not consult a veterinarian to administer antibiotics. This is explained by the absence of quality standards and good improvements in productivity and national production. In this study, the proportion of positive samples for antibiotic residues was quite alarming (18.7 %). The presence of residues in the eggs could be due to non-compliance with withdrawal time or to the threshold limit for antibiotic use. This finding corroborates that of the Kemp (2020) report, which shows that the egg and broiler production system is dominated by self-medication and that farmers are neither supervised nor controlled and are for the most part trained in the use of antibiotics. Similarly, Aguidissou et al. (2020) conducted a study in Benin examining antibiotic therapy practices in poultry farming and arrived at comparable findings, underscoring the necessity for enhanced training in poultry farming and the formulation of effective antibiotic therapy practices. Poultry farming standards and their application are necessary conditions that could contribute to improving productivity and national production.

Relationship between antibiotic use during sampling, dosage, withdrawal time and presence of residues

The positive laboratory residue results (prevalence rate 49.43 %) observed came from farms that administered antibiotics at the time of sampling. Our results are similar to those of Niyibizi (2012) who found in Senegal on laying hen farms, that the Premi®Test method found a 100 % prevalence of positive cases of antibiotic residues in eggs in their study, where antibiotics were administered at the same time as sampling was carried out. In Africa, different techniques have been employed to examine the presence of antibiotic residues in poultry products. Idowu et al. (2010) in Nigeria reported that out of 900 egg samples analyzed using the disk diffusion test, 32 (3.6 %) contained antibiotic residues, while 18 eggs (2 %) gave positive results with the Premi®Test method. A study by Nonga et al., (2015) in the Morogoro municipality in Tanzania showed that all 70 eggs analyzed with the DelvoSP® kit were positive for antimicrobial residues, and the results obtained by the agar diffusion test showed that 21.4 % of egg samples contained antimicrobial residues. A similar result was reported by Alhadj et al. (2022) in Chad, where a prevalence of 26.4 % of samples was found to be contaminated with antibiotic residues. In another study in Ghana, Donkor et al. (2011) reported the presence of antibiotic residues in 15 eggs (6.8 %) out of a sample of 220 eggs using the Bacillus subtilis BGA test. Kabir et al. (2004) in Kaduna State, Nigeria, found a prevalence of 1 % on 200 eggs examined using a microbial disk diffusion inhibition test with Bacillus cereus ATCC 11778. Likewise, in Ouagadougou (Burkina Faso), Zerbo (2014) observed a high prevalence (77 %) of antimicrobial residue in 100 eggs sampled from stores, kiosks and layer farms using the microbial disk diffusion inhibition test.

Although the findings of these studies somewhat differ, they clearly show that the problem of antibiotic residues in foodstuffs remains a concern for consumer health in Africa and that farmers awareness of the importance of antibiotic residues in foodstuffs on consumer health is relatively low.

According to Mensah et al. (2014), antibiotic residues in food of animal origin are of concern due to the toxicological risks to the consumer and the risk of non-compliance with regulatory requirements in trade. The control and monitoring of antibiotics and their residues in foods of animal origin is particularly important to ensure the safety of foods and to protect the consumer.

According to the Codex Alimentarius (2021), the maximum residue limit (MRL) in poultry eggs includes 400 μg/kg of tetracyclines, 300 μg/kg of polymyxin, 50 μg/kg of erythromycin, 500 μg/kg of neomycin, 2000 μg/kg of spectinomycin and 300 μg/kg of tylosin. In the present study, the MRL for the Premi®Test, yielded 6 μg/kg of penicillin G, 11 μg/kg of amoxicillin, 150 μg/kg of cloxacillin, 160 μg/kg of chlortetracycline, 160 μg/kg of oxytetracycline, 100 μg/kg of doxycycline, 75 μg/kg of sulfadimethoxine, 90 μg/kg of sulfadiazine, 200 μg/kg of erythromycin, and 90 μg/kg of tylosin. These MRLs are acceptable since they are relatively lower than the Codex Alimentarius MRLs in eggs for the aforementioned substances.

Table 4
Overall prevalence of antibiotic residues in eggs sampled from the 3 districts.

Locality	Number of samples	Positive samples	Expected Positive	Contribution of Chi-square (Positive)	Negative samples	Expected Negative	Contribution of Chi-square (Negative)
Oti	27	20	13.34	3.34	7	13.66	3.24
Tone	30	16	14.83	0.09	14	15.17	0.009
Tandjoare	30	7	14.83	4.14	23	15.17	4.03
Total	87	43	43	7.57	44	44	7.36
Overall prevalence		49.43 %					
Chi-square statistic	-	14.92	-	-	-	-	-
P-value	-	0.00058	-	-	-	-	-
Degree of freedom (dof)	-	2	-	-	-	-	-

P-value: Probability significant at $P < 0.05$.

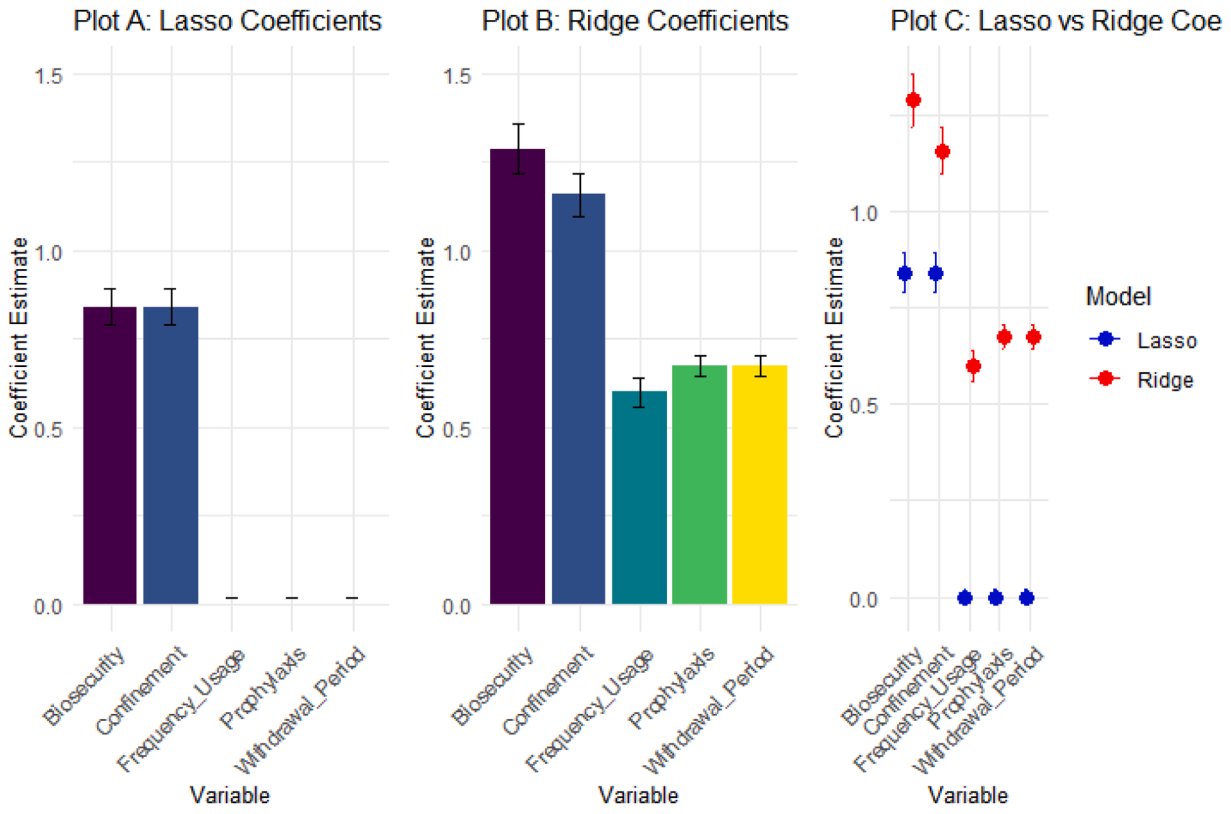


Fig. 6. Variables associated with the presence of antibiotic residues in eggs.

This means that the high rate of non-observance of the withdrawal period is not a major problem at present but may raise future concerns. Thus, a withdrawal period must be observed on farms to limit the long-term dangers that antibiotic residues can pose to egg consumers in the savannah region of Togo.

Future prospects

Based on the results of our study, our recommendations are addressed to:

Public health players

Public health officials should enhance awareness regarding the risks that antibiotic residues pose to consumer health and advocate for relevant authorities to regulate and enforce the conditions under which antibiotics are utilized in livestock farming. Competent public authorities should establish residue standards and regulations to ensure the protection of consumer health. For instance, authorities could implement a robust surveillance system for antibiotic residues, mandate routine testing with compliance certifications, and introduce stringent penalties for violations to enforce these standards effectively. Furthermore, it would be helpful to educate farmers on best practices for antibiotic therapy and poultry husbandry, such as organizing training workshops, providing accessible resources on withdrawal periods, and promoting alternative methods like probiotics. These efforts would not only benefit livestock management but also align with the One Health concept, fostering awareness of the interconnectedness between human, animal, and environmental health. Public campaigns and collaborations with media can further increase public awareness of the challenges associated with antibiotic use and ensure widespread understanding.

Veterinarians

It is advisable to recommend greater rigor in prescribing medicines, by raising awareness among farmers at the grassroots level of the rules to be respected for the rational use of antibiotics.

Farmers

They need to be made aware of, and trained in, issues relating to veterinary drugs: which drugs are authorized, which are prohibited, and which may be harmful to human health. Above all, they need to be helped to understand the concept of the acute reference dose (ArfD) waiting period before consuming egg products and foodstuffs containing residues of toxic products (especially veterinary and antimicrobial drugs, which they frequently use for treatment, prevention and sometimes as growth promoters) and MRL. In the event of a major force affecting the health of birds requiring antibiotic treatment during egg-laying, farmers must withdraw eggs from human consumption in accordance with the withdrawal period for the antibiotic used.

Consumers

Consumers can demand a traceability sheet for eggs (as for any other foodstuff), indicating the farm of origin and the withdrawal period. In perspective, our work deserves to be continued on the positive samples to be able to identify and quantify the different antibiotic molecules involved, in order to estimate the risks incurred by the consumer. This study should also be carried out on other guinea fowl by-products (carcasses, gizzards, etc., meat that are highly prized by the public). We also recommend a larger-scale study to take better account of the general situation regarding the prevalence of antibiotic residues in savannah white gold eggs, and indeed throughout the country.

Conclusion

The quality of food products has become an imperative. Today's consumers want to know about the quality of the food they eat. They want a food product to give them a good taste sensation and provide them with the necessary nutrients, but above all they want it to be safe for their health. Today's consumers are increasingly concerned with food safety, and in particular with microbiological and toxicological quality assurance.

This study first revealed the main pathologies prevalent on the Togo Savannah guinea fowl farms surveyed, where bacterial diseases are present at high prevalence. In order to prevent or combat these diseases, various antibiotics are used, namely anti-infectives, anti-parasitic and anti-stress agents. The use of these antibiotics needs to be regulated to ensure proper administration, especially to animals whose eggs are destined for human consumption.

This study has also provided preliminary information on antibiotic residues in eggs from guinea fowl farms that may be marketed for consumption). The prevalence obtained (49.43 %) shows that farmers use antibiotics and sell or consume the eggs of birds treated in this way, regardless of the waiting period. This indicates that the dangers of antibiotic use in animals and their potential impact on human health are poorly understood. It would be interesting to investigate further with additional studies to specifically and quantitatively detect the types of antibiotic residues that persist.

Ethical Approval

The Bioethics Committee for Health Research (CBRS) met on January 18, 2024 to evaluate the research protocol for the following study: "Study of antibiotic therapy, antibiotic residues and antibiotic resistance in the poultry industry in northern and southern Togo".

Following the pools of study reports presented by resource persons, the CBRS decided on:

1. Presentation of the file

- Study protocol documents: the documents are well presented.
- Data collection tools are available and well developed.

2. Scientific validity of the study

Scientific design: The study is scientifically well known.

Hypothesis: The problem is well defined.

Methodology: The methodology is well described and adapted to the type of study.

Feasibility: The protocol is feasible.

Objectives: The objectives are clear and precise

Interest of the study: The interest of this work for public health is undeniable.

Scientific references: The scientific references are quite extensive.

1. Ethical acceptability

The questionnaire and consent form are available and well developed.

2. Conclusion

The CRBS, with the unanimity of its members present, issued a FAVORABLE OPINION for the commencement in Togo the study protocol: "Study of antibiotic therapy, antibiotic residues and antibiotic resistance in the poultry industry in the north and south of Togo".

CRediT authorship contribution statement

Priscilla Bèlè Tcheou: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Andre Pouwedeou Bedekelabou:** Project administration, Methodology, Formal analysis, Conceptualization. **Benjamin Adjei-Mensah:** Writing – review & editing, Writing – original draft, Visualization, Software, Formal analysis, Data curation. **Cocou Claude Kpomasse:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation. **Essodina Talaki:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Investigation. **Mounerou Salou:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Data curation, Conceptualization.

Declaration of competing interest

We the authors (Priscilla Bèlè Tcheou, Andre Pouwedeou Bedekelabou, Benjamin Adjei-Mensah, Cocou Claude Kpomasse, Essodina Talaki, Mounerou Salou) of the accompanying article, write to declare that there is no personal or professional conflict of interest with our work.

Acknowledgements

We would like to express our indebtedness to the World Bank (IDA 5424) for funding through the "Centre d'Excellence Régional sur les Sciences Aviaires" (CERSA) and to the staff and technicians at the University of Lomé, Togo for their enormous support.

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