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Broiler Production, Processing and Supply in Fako Division: Practices, Procedures, Challenges and Health Implications on Products Consumers

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Abstract

The trend towards increased consumption of livestock products "out of the home" and the haphazard nature of the overall production activities in Fako Division in Cameroon owing to changing lifestyles and increase in population density necessitated this investigation. Increasing non respect of norms in the poultry industry is setting in significant changes in value chain, with possible profound negative health implications on product consumers. The main objective of this study was to assess broiler production, processing and supply practices, procedures, challenges and public health implications within Fako Division. One hundred and twenty (120) smallholder and commercial farmers (83 male and 37 female) were surveyed and a total of 120 questionnaires were administered on broiler value chain, including but not limited to production management (use of antibiotics and other antimicrobials, types of antibiotics, reasons for use, use/misuse pattern/frequencies and their awareness on antibiotics withdrawal periods), transportation (infrastructure/vessels), and processing norms (infrastructure, equipment, source of water and environment). Complementary information was obtained through researcher-participatory involvement in production activities in three of the farms and interviews with key informants. To determine antibiotic residues, 100 broiler meat samples of slaughter weight (7 - 8 weeks) collected from broiler farms, chicken slaughter centers and meat shops/kiosks at the various markets in Buea, Tiko, Mutengene and Limbe, were analysed by agar well diffusion tests. Our results reveal that 96% of respondents used antibiotics and other chemicals (not disclosed)

at subtherapeutic levels to enhance growth and prevent disease outbreaks. Likewise, 66% of the respondents were aware of drug withdrawal periods, but only 52.4% of respondents implemented it. Cross tabulation of the results showed that a greater proportion (57.3%) of those who received training implemented withdrawal periods but a majority (64.2%) of them were unaware of the possible negative effects of unorthodox practices on the health of broiler meat consumers. The supply chain was characterised by poor transportation infrastructure and a complete lack of proper storage facilities. Broiler processing facilities in the various markets were rudimentary and in deplorable conditions. Chicken was slaughtered and processed with water of doubtful quality on dirty tables and muddy environments by dirty and improperly dressed personnel. Available materials were used for packaging without due consideration for their sanitary conditions. Key informant information indicated that chicken meat was not evaluated for residues despite the indiscriminate use of veterinary drugs as fuelled by trade liberalization. Results of Laboratory analysis of meat samples showed that 66% of the broiler meat samples contained antimicrobial residues capable of limiting microbial growth to a lesser extent. This study reveals that the broiler value chain poses significant public health risks to broiler meat consumers in Fako Division. There is a need for proper sensitization campaigns for the actors of the broiler value chain to curb antibiotic resistance development and transmission of other diseases of public significance to product consumers within Fako Division. Stricter regulation on the non-therapeutic use of veterinary drugs in broiler production for public consumption is also necessary. Policies that regulate animal slaughter house and meat inspection to ensure hygienic slaughter and prevent contamination during slaughter must be enforced.

Keywords

Broiler Chicken, Production Management, Processing, Storage, Antimicrobial Residues, Fako Division

1. Introduction

Poultry production and product consumption are gradually growing in the world. Poultry accounts for about 33% of the global meat consumption and is expected to grow at 2 to 3% per year in the world [1]. Over the past 50 years, the poultry sector has expanded, consolidated and globalized, driven primarily by strong demand, making it possibly the fastest growing and most flexible of all livestock sectors [2]. Meeting this growing demand has been facilitated by the expansion of intensive animal production systems where antimicrobials are used routinely to maintain health and productivity [3]. In 2017, antimicrobial use (AMU) in animals represented 73% of all antimicrobials used worldwide [4], and its use contributes to the rise of antimicrobial resistance (AMR) [5]. In sub-Sahara African countries, poultry farming is a major sustainable resource for rural communities,

it contributes for 45% of the livestock production value in Central and Southern Africa [6]. In Cameroon, with an estimate of 52 million headcounts (broiler and layers), poultry production provides at least 34.26% of the total meat harvested from the terrestrial food-producing animals in Cameroon per year [7]. Several publications indicate that large size poultry farms were more efficient, but these farms are few in the developing countries. As one of developing country, Cameroon poultry sector is not yet to satisfy the growing needs of customers. There is a trend towards increased consumption of livestock products, especially poultry in Fako Division in Cameroon due to increased population. The poultry sector of Fako Division has witnessed tremendous growth over the past decades. This growth has largely been propelled by the participation of the private sector which has been facilitated by infrastructural development in the division [8]. FAO [9] estimated that the per capita consumption of livestock products in developing countries could rise to as much as 44% by 2030. To meet this demand, FAO [9] predicted that commercial livestock production has to increase with a consequent of increased use of veterinary drugs such as antibiotics, vaccines and growth promoters. This pressure on poultry products has set in negative production, processing/supply practices that have significant health implications on product consumers. Some of these negative production practices are the failure of farmers to adhere to the standard zootechnical practices like antibiotic drug administration and withdrawal periods. Uncontrolled antibiotic usage, lack of proper biosafety measures for their withdrawals have resulted in a decreased quality of meat [10] [11]. Antibiotics are currently used widely in developing countries, partly due to incidence of infectious diseases in many areas and sometimes as a means to overcome poor animal management practices [12]. Wadoum [13] affirmed that, nowadays, use of antibiotics as growth promoters in developing countries such as Cameroon has facilitated efficient production of poultry allowing Cameroonians to purchase, at a reasonable cost, high quality meat and eggs. While these uses benefit all involved, the edible poultry tissues may contain harmful concentrations of drug residues. Poultry meat is a better substitute for mutton and beef based on nutritional specifications and affordability. Furthermore, usage of antibiotics has facilitated their efficient production and also enhanced the health and well-being of poultry by reducing the incidence of diseases. Unauthorized use of these antibiotics, the failure to follow label directions or inappropriate withdrawal period of time before slaughter could lead to contamination of edible poultry tissues with antibiotic residues, with potential adverse effects on human health [14] [15].

Currently, approximately 80% of all food-producing animals receive medication for part, or most of their lives. The most commonly used antimicrobials in food-producing animals are the ^{2}lactams, tetracyclines, aminoglycosides, lincosamides, macrolides, pleuromutilins and sulfonamides [16]. Nevertheless, the use of these antibiotics in food producing animals can leave residues in foodstuffs such as meat, milk and eggs. Antibiotic residues in foods of animal origin may be the cause of numerous health concerns in humans. They range from direct toxicity on consumers exhibiting allergic reactions, immunopathological diseases, car-

cinogenic effects (e.g., sulphamethazine, oxytetraycyclin), mutagenicity, nephropathy (e.g., gentamycin), reproductive disorders, bone marrow toxicity (e.g., chloramphenicol), allergy (e.g. penicillin) and the destruction of useful microflora present in the gastro-intestinal tract especially of children leading to indigestion [12] [17]; to indirect hazard through the generation of resistant strains of pathogenic bacteria which can be transferred to humans and the residual contamination of manures used in crop production [18] [19].

Additionally, farmers administer water of doubtful quality in dirty drinkers to their animals, increasing the likelihood of bacterial disease occurrences hence increasing burden on antibiotic use. Worse of all, antibiotics used are sub-therapeutic instead of curative. Inadequate extension services and animal health delivery systems in the country have prompted farmers to buy antimicrobials from veterinary shops and administer to chicken by themselves. Under such circumstances, correct dosages are unlikely to be observed and antibiotics may be found in tissues, particularly when the birds are slaughtered without the observance of withdrawal period hence, development of bacteria resistance [12]. These health risks led to withdrawal of approval for use of antibiotics as growth promoters in the European Union from January 1st, 2006. However, in order to ensure consumer safety, worldwide regulatory authorities have set the Maximum Residual Limits (MRL) for several veterinary drugs [20] [21]. These MRL, are expected to regulate the maximum permitted levels of the drug residues for each antibiotic that are considered safe in foods of animal origin [22].

Furthermore, there are multiple failings in the slaughter and processing procedures that result in meat contamination and allow the transmission of pathogens: inadequate infrastructure, poor hygiene, lack of ante/post mortem inspection, use of contaminated processing and supply equipments and bad water source [23]. In Fako Division, poultry is bought and processed in the market with water of very doubtful qualities on tables exposed to all sorts of contaminations from dust, mud and flies. These bad practices listed above pose serious negative health implications on product consumers as these are linked to transmission of diseases such as cholera and typhoid fever. It is very possible that the cholera outbreaks that have claimed lives in this division might be connected with these negative practices. Also, slaughtering animals with residues of antibiotics may pose serious public health hazards in the form of development of antibiotic resistance, allergic manifestations, or alteration of useful microflora of digestive track to no microflora [11] [24] and therapeutic failures among such infected individuals [25]. Monitoring antibiotic residues and the presence of pathogenic bacteria in animal-derived foods for human consumption should therefore be of great concern for public health agencies [13] [14]. The public health risk to antimicrobial residues seems particularly high in developing countries, where there may be no local legislations regulating maximum tolerance limits for market products and even recommended withdrawal times are readily violated [12]. Therefore, studies on antimicrobial status in foods for human consumption are of paramount im-

portant for public health information and to take right measures to prevent health problems.

The contributory factors to poor practices in production, processing and supply of poultry in Fako division are multifaceted. Basically, the emergence and re-emergence of poultry diseases some of which are zoonotic and the general lack of supply and processing facilities especially in the open markets. The intensive system of poultry production and the breeds used allows for easy occurrences and spread of diseases, causing significant morbidities mortalities. For fear of financial loses to incur, farmers resort to indiscriminate administration of antibiotic drugs. Now since antibiotic resistance to most drugs has become real, most drugs have lost their efficacies in treating poultry diseases. As such, most farmers undermine the manufacturer's instructions and go ahead estimating does that can bring significant progress to the problems faced. These unconventional practices become the order of the day due to inconsistent regulatory frameworks and follow ups on antibiotic drug use and lack of regular public health awareness campaigns on food safety and one health. To be able to avert these, constant monitoring of every sector of the broiler chain must be closely followed and only drugs with high efficacies at a cheaper cost be homologated for use. Provision of standard and functional processing and supply facilities in strict compliance with hygiene and sanitation regulations for public slaughter is essential for reducing post production contaminations. Constant health tips on antibiotic resistance, food safety and the overall implication on one health (public health) might change consumer's perception and influence the choice of what they purchase and consume. The resulting impact of this might be a modification of the production and supply practices within the broiler chain.

Evaluating production management and processing practices in the poultry sector in Fako Division will help inform policy-making geared towards revamping the bad practices in poultry production and processing practices, as well as help stakeholders in poultry industry, public health officials and councils in preventing diseases and reducing development of bacteria resistance in product consumers. This paper assesses broiler production, processing and supply in Fako division: practices, procedures, challenges and health implications on products consumers. Specifically, we characterize and evaluate the current broiler production management practices in Fako Division, Cameroon as well as evaluate the processing and handling procedures/supply facilities and how they affect meat quality and also assess meat quality by determining the level of chemical (antibiotic) residues in meat and we also predict possible health risks associated with broiler meat consumption in Fako Division.

2. Research Objective

The main objective of this study was to assess broiler production, processing and supply practices, procedures, challenges and public health implications within Fako Division in the South West Region of Cameroon.

3. Materials and Methods

3.1. Study Area

The study was conducted in four selected localities (Buea, Limbe, Tiko and Mutengene) of Fako Division, Southwest Cameroon where broiler production and human population density is comparatively high. These areas are easily reachable and large numbers of customers are concentrated. The Division is located at Latitude 4.1036˚ N to 4.4975˚ N and Longitude 8.6385˚ E to 9.3377˚ E. It covers an area of 2093 km^2 and 2014 had a total population of 1,515,888 inhabitants [26] including the Bakweri people who are the indigenous inhabitants of the region. Of the six divisions in the South West Region, Fako is a cosmopolitan area with numerous urban and semi-urban towns [26]. Besides, the division belongs to a humid forest with monomodal rainfall which offers favorable climatic conditions for the development of agricultural products. Agriculture is the major economic activity of the people, employing a large proportion of the population with tomatoes, plantains, maize, cassava, and cocoyam as the main or most common food crops and poultry, pigs, goats and to lesser extent cattle as the domesticated livestock. The division is known for its rich cultural heritage, natural resources, and biodiversity. It is the home to the Mount Cameroon National Park and other notable landmarks in the division including the Limbe Botanical Gardens, and the Bimbia Slave Trade Village. **Figure 1** is a map of Fako Division showing its various Sub-Divisions and major cities surrounding this Division. The division is the home division and working locality of the researchers which makes easy to collect true information from the farmers as well as trader/processor and retailers.

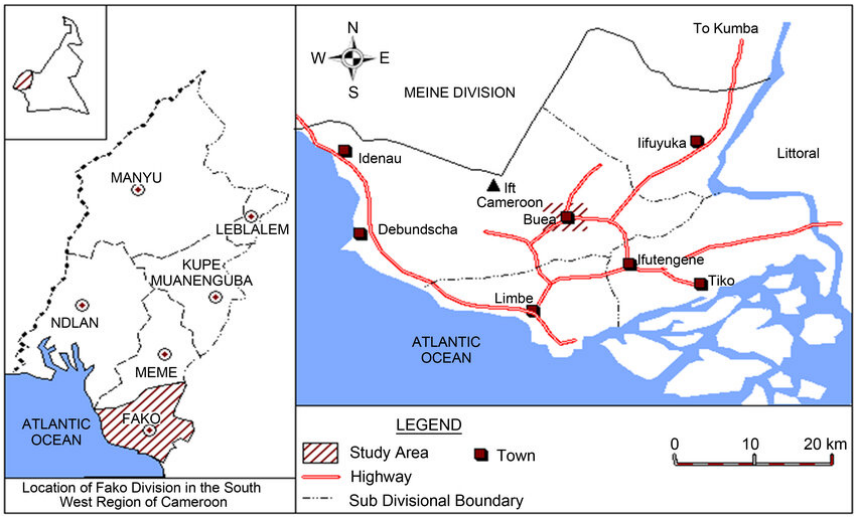

Figure 1. Map of the study area [27].

3.2. Sampling Design and Nature of Data

This study involved a comprehensive sampling strategy to capture a diverse range of perspectives from poultry farmers and related stakeholders in the South West

Region of Cameroon. A total of 120 poultry farmers were selected for participation, comprising 95 small-scale farmers and 25 commercial farmers. The selection process was designed to ensure representation from various farming practices and to facilitate a thorough understanding of the local poultry production landscape.

1) Geographic Distribution:

The participants were drawn from four key towns in the region:

Buea: 60 farmers

Limbe: 20 farmers

Tiko: 20 farmers

Mutengene: 20 farmers

This geographic spread allowed for the inclusion of different agricultural practices and market conditions, enhancing the representativeness of the sample.

2) Sampling Method:

A stratified random sampling approach was employed to categorize farmers into small-scale and commercial sectors. This method ensured that each group was adequately represented in the final sample, allowing for a comparative analysis of production practices and challenges faced by different farmer types.

3) Questionnaire Administration:

A structured questionnaire was developed to gather quantitative data regarding current production and management practices applied in broiler farms. The farmers recruited for the survey were based on their willingness to provide the information needed for the study. Questionnaires were administered to selected chicken farmers to collect information on drug use, type of antibiotics/antimicrobials, purpose of drug use and observance of withdrawal period. The questionnaires were administered directly to farmers in their respective locations, with trained enumerators facilitating the process to ensure clarity and accuracy in responses. The questionnaire included both closed and open-ended questions to capture a wide range of information.

4) Additional Stakeholder Insights:

In addition to the 120 farmers, qualitative data were obtained through guided onsite interviews with 10 poultry traders and 5 butchers. These interviews aimed to gather insights into market dynamics, supply chain issues, and consumer preferences related to poultry products as well as transportation equipment's and processing tanks. Drug dealers were also interviewed to get information on diseases frequently reported by broiler farmers and antimicrobials used to control or treat these diseases. The traders and butchers were selected based on their active engagement in the poultry market within the study locations, ensuring that their perspectives reflected real-world practices and challenges. Through a guided instrument, the Regional Delegate for MINEPIA South West was interviewed using a face-to-face mode to gather information on the government's role in regulating broiler production management practices within Fako Division, their awareness on antimicrobial use malpractices as well as their health implications on broiler product consumers and their role in ensuring the supply of meat of high quality to consumers within Fako division.

5) Data Collection Process:

The data collection was conducted over a period of four weeks, allowing sufficient time to engage with participants and gather comprehensive responses. All participants provided informed consent prior to participation in the study, and ethical considerations were upheld throughout the research process

Sample broiler chicken carcasses were purposively selected based on willingness and cooperation of chicken owners. Specifically, sources of broiler meat samples were farmers with chicken at slaughter age (7 - 8 weeks), chicken slaughter centers at the various markets in the four localities, chicken meat shops. Freshly dressed carcasses were purchased from each participating farm or centers and 50 g of breast muscles were cut and packed in separate clean plastic bag, labeled accordingly and stored in cool box with ice pack during field sampling. The samples were all subsequently transported to the laboratory at the Faculty of Science's Life Science Laboratory, University of Buea, and stored at −20˚C until analysis.

3.3. Broiler Meat Sample Processing and Antimicrobial Residues Analysis

Five grams of thawed meat was minced in 5 ml of sterile distilled water and homogenized using a mortar and blender for 5 min, centrifuged for 5 min at 5000 rpm. The supernatant decanted into a sterile test tube as muscle tissue extract and used in antimicrobial residues analysis. Assessment of antimicrobial residues in broiler muscle tissue extract samples was carried out using one bacterial growth inhibition tests namely the agar well diffusion test that used *Bacillus subtilis* as the test organism. 5% Gentamycin was used in validation of agar well method for the zone of bacterial growth inhibition and used as a positive control. In agar well diffusion method, antibiotic residues were tested on Muller Hinton (MH) Agar (Oxoid Ltd, Basingstoke, UK) by disc diffusion method as described by Luangtongkum [28]. Uniform streaking of *Bacillus subtilis* was done followed by creating wells on the media using sterile boring glass rods. A 100 µl of the test muscle tissue extract was pipetted in the wells and the plates were incubated at 37˚C for 24 hours. The tests were performed in duplicate. Positive and negative control wells were also included in each culture plate as stated above. The cultures were examined for bacteria growth inhibition zone after 24 hrs of incubation. Interpretation of diameter measurements as sensitive and resistant will be as per the general guidelines according to National Committee for Clinical Laboratory Standards [29].

3.4. Data Analysis

Data collected from questionnaires were coded while those obtained from interviews were transcribed and analysed using the SPSS statistical package version 21.0. Where necessary, cross tabulations were used to establish relationships and chi square test was used to test for significant differences between the responses.

4. Results

4.1. Broiler Chicken Production Management and Common Diseases Reported by Farmers

A total of 120 smallholder and commercial broiler chicken farmers were surveyed and interviewed in the selected farms from four localities within Fako Division. The median flock size was 250 (ranged 100 - 5000). The chickens were managed under deep litter intensive system and chicken house floor was normally covered with wood shavings as litter materials. Feeding and watering was through common feeders and drinkers. Broilers were fed on commercial feeds preferably broiler mash. Most farmers had a prophylaxis program they followed to either prevent or cure diseases in the farm. With regard to the prophylaxis program, vaccination and other veterinary interventions were routinely done. A majority of the chicken farmers have never had any formal training in broiler production (**Figure 2**). Though with low literacy rate in the activity, most of the farmers (98.3%) were aware of disease transmission through pest as vectors (**Figure 3**).

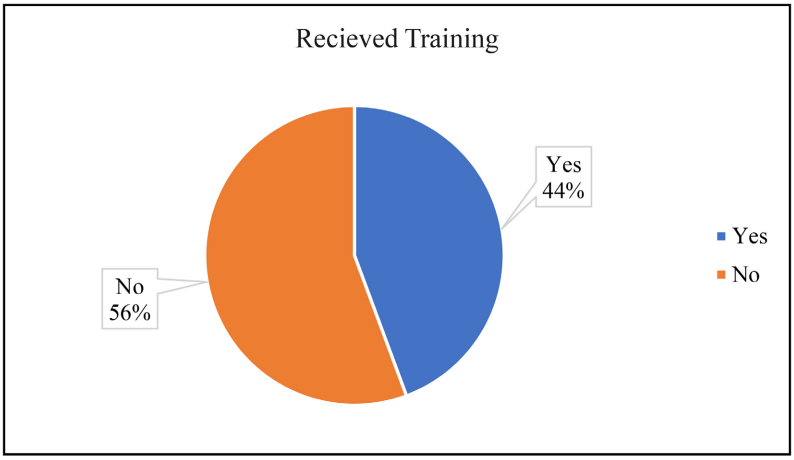

Figure 2. Literacy status of respondents.

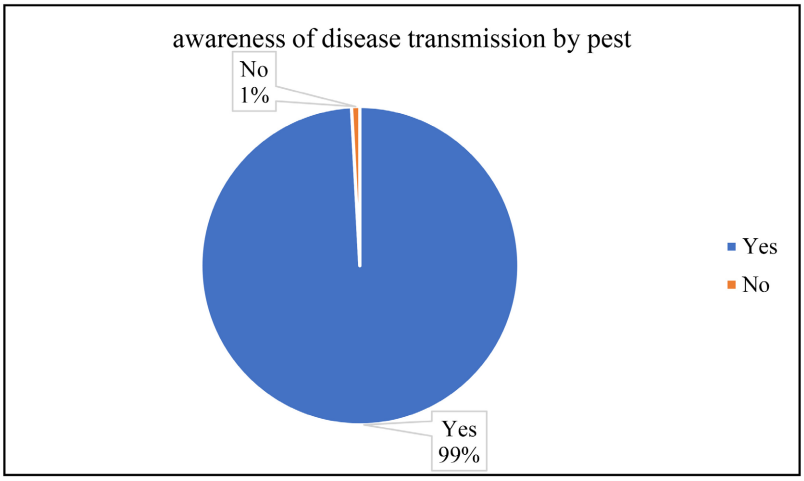

Figure 3. Awareness of disease transmission by pest.

All the farmers admitted to have faced diseases related problem, with diarrhea (probly linked to coccidiosis was the most common symptom (60.8%) followed by coughing (18.3%) and lameness (10.8%) (Figure 4). As a result, most of them (83.3%) practice self-treatment as opposed to those who consult the veterinarian (Figure 5), with the most popular medications (96%) used being antibiotics (Figure 6) to either treat or prevent diseases occurrences. The type of chemicals used and purpose of use in broiler production in Fako Division are presented in Table 1.

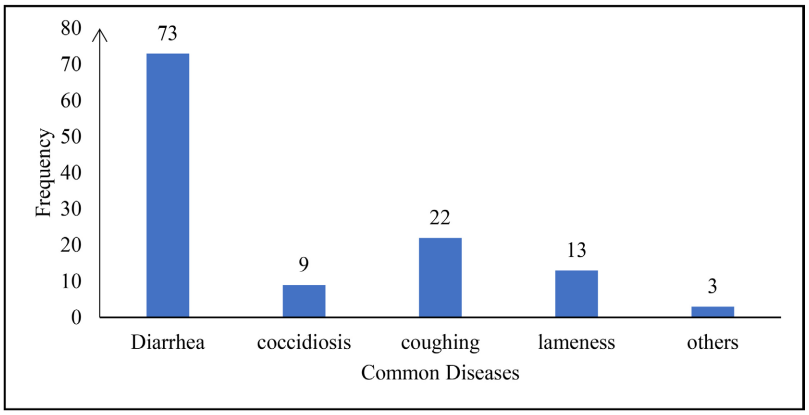

Figure 4. Common disease faced by broiler farmers in Fako division.

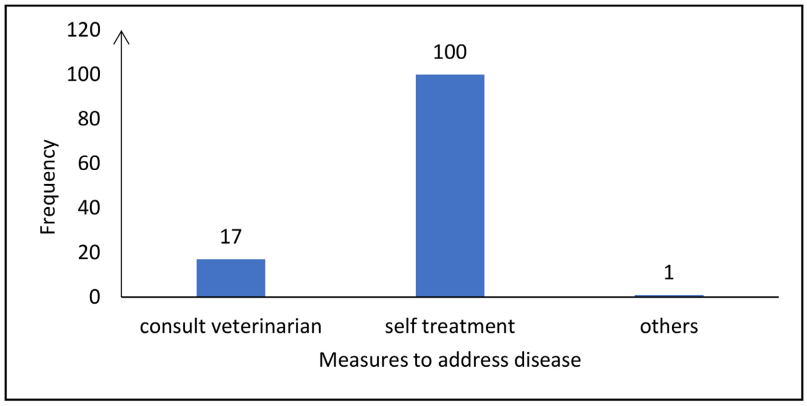

Figure 5. Common disease faced by broiler farmers in Fako Division.

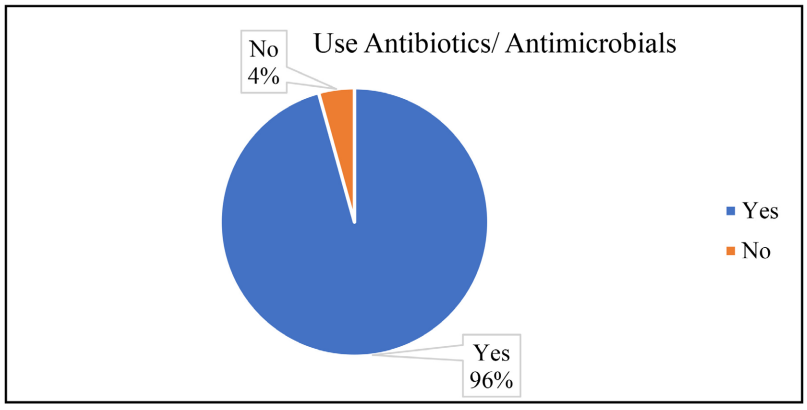

Figure 6. Used of antibiotics/antimicrobials by respondents.

Table 1. Types of drugs commonly used in Fako Division.

Drug Used	Number of farmers used	Purpose of used
Tetracycline's	110 (91.67%)	Treatment & prophylaxis
Amprolium	110 (91.67%)	Treatment & prophylaxis
Different types of vaccines	1 15 (95.83)	Treatment & prophylaxis
Sulphonamides	100 (83.33%)	Treatment & prophylaxis
Natural Herbs	4 (3.33%)	Treatment & prophylaxis
Vitamins	110 (91.67%)	Growth Enhancer

Regarding antibiotic/antimicrobial withdrawal periods, up to (66%) of the farmers had knowledge of (**Figure 7**) but only 52.4% implemented it. Veterinary personnel (72.2%) and drug retailers (11.2%) were found to be very instrumental in educating farmers on withdrawal periods. It was observed that 83.89% only stop due to disappearance of symptom, while 80% of the respondents were unaware of possible health risks of unorthodox practices of antibiotic administration to broiler consumers.

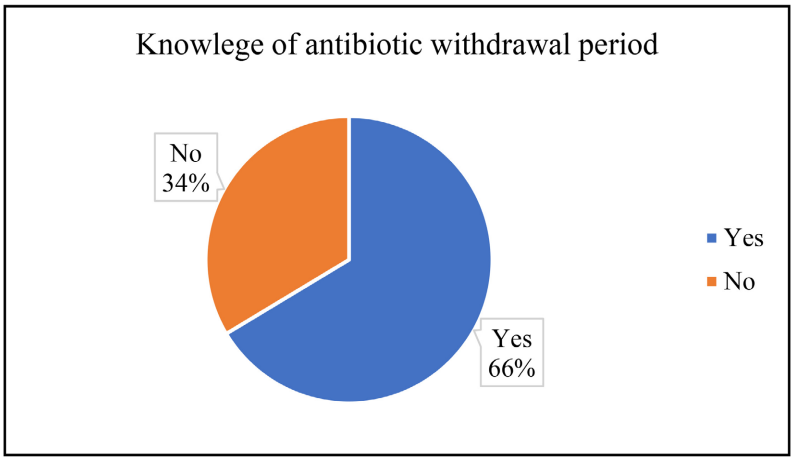

Figure 7. Farmer knowledge of antibiotics withdrawal periods in broiler production.

4.2. Broiler Chicken Processing and Supply Practices

All slaughterhouses in the study area performed "batch slaughtering". The birds were killed, bled, skinned, eviscerated, and split on the same spot using very dirty tables. Personnel hygiene was very poor as they lack aprons, use very dirty boots, had no head cover, dirty dresses with no disinfectant. Water used for scalding was too dirty as the same batch of water is used for all the birds being eviscerated on that day. The slaughtering process of the chicken was done by cutting the neck of the chicken and allowing it to beat itself to death mostly in muddy environments. Some butchers cut the neck of the chicken and held it down with their fleets while others had a slaughtering bucket. The buckets were not clean and had a lot of chicken feathers and blood in and around them which pose risk of contamination

to the meat. We also observed lack of chilling facility to store the meat for safety and poor packaging as well. The butchering tools were not regularly washed and many of the workers did not wear protective cloths.

4.3. Interview with Key Informants (Vet Shops/Drug Dealers)

Seven veterinary shop sellers/owners (5 males and two females) whose shops were located in the study area were interviewed. They mentioned that diseases occurrences were amongst others, the most limiting chicken production constraints in Fako Division. These include white and green diarrhea, coccidiosis, Newcastle disease, coughing, and lameness mostly fueled by lack of biosecurity measures. Just as mentioned by farmers, commonly used drugs include oxytetraclines, amprolium, flumequine, ashidox, erofoxan, norfloxan, virunent and different types of vaccines. A lot of production malpractices were also echoed such as the use of growth hormones and Super Gro with long withdrawal periods, poor administration and disposal of vaccines, and acquisition and administration of drugs from non-veterinary drug dealers due to lack of enforcement of regulation by the competent authorities. The common veterinary services they provided include disease diagnosis based on clinical signs and pathological lesions, prescribing treatment, vaccination, advice on feeding, general advice on management and biosecurity measures. They also reported that normally, farmers obtained advice from the shop keepers on which drug to use for their chicken. Results also showed that most of these farmers abuse drug use because they had never experienced or had reports of any case of poisoning due to eating broiler meat with antimicrobial residues.

4.4. Laboratory Results of Antimicrobial Drug Residues Analysis in Broiler Chicken Meat Samples

A total of 100 samples were collected and qualitatively analyzed for antimicrobial residues. The Agar Diffusion test results indicated that 66% of the broiler meat samples contained antimicrobial residues of smaller and higher concentrations.

Researcher observations

Some of the key observations made by the researchers in the cause of data collection are as indicated below:

- Farmers administer antimicrobials at subtherapeutic levels for fear of disease outbreaks
- No proper disposal of manure
- Use of dirty water to feed chicken
- Feeding of chicken in dirty containers
- Buildings and farms located at close proximities
- Sale chickens still undergoing chemical treatments
- Presence of foot bath in some farms but hardly in use
- Most farms and buildings lacking fences
- Non respect of farm biosecurity

- Transportation and processing of chicken under deplorable conditions
- Use of water from varied impure sources (streams, wells, rain collections etc) to process and feed chicken

5. Discussion

5.1. Production and Management Practices

Most of the buildings constructed for poultry house didn't consider the basics of biosecurity in the study area which increase chances of disease outbreak in the farm as it plays important role for the entry of infections into the farm [30]. Besides that, biosecurity measures that need to be followed before entry of farm such as appropriate use of foot bath, changing boots and clothes is lacking, which is also important for the hygienic poultry production as these are the essential biosecurity steps that needs to be followed for hygienic broiler production [31]. All these observations are indication of a lower awareness regarding the housing management of broiler flocks for hygienic production. Similarly, high prevalence of infection symptoms such as diarrhea in the farm may be due to uncemented floors as these floors are very difficult to clean and disinfect. Also, Krishna further states that there is high prevalence of reinfection of subsequent flocks by previous infected microbes in the same farm, if the farm is constructed by mud or uncemented floors. This therefore accounts for the excessive use and consequently misuse of antibiotics and other antimicrobials in the farms.

The overuse of antibiotics in poultry production has led to increased antibiotic resistance, making it harder to treat disease in humans and animals alike [32]. This overuse has also led to environmental contamination, with antibiotic resistant bacteria found in the soil, air and water samples near chicken farms [33]. Some common antibiotic residues detected in poultry products include; tetracyclines, sulfonamides, macrolides and fluoroquinolones [34]. Some regulatory agencies around the world such as the US FDA and the European Medicines Agency (EMA) have established maximum residue limits for antibiotics in food products, though vary depending on food and country. Consequently, the FDA's MRL for tetracycline in chicken meat is 2 ug/kg and sulfonamides 0.1 ug/kg as determined by EMA for poultry meat [35]. According to studies by [36], antibiotic residues of concentrations up to 100 ug/kg (44% of sample) was found in China, 50 ug/kg (36% of samples) found in India and 20 ug/kg (24% of samples) found in Brazil. Though quantifications are lacking, these percentages of detection of residues (66% of samples) fall in line with that obtained in this present study. In the USA, the Food and Drug Administration (FDA) for the above reasons has provided guidelines to remove the use of antibiotics at sub therapeutic levels in livestock and poultry [37]. Such consideration is being carried out by the European Union and is currently considered illegal in Cameroon.

The farms and buildings were also found to be located at very close proximities. Very short farm distance with other nearby farms causes high risk of contamination between the farms causing poor biosecurity for the flock. This does not align

with the EPIG, [38] standard which states that there should be minimum broiler farm distance of 2 km. We recorded farms with distance of 200 m apart and some 100 m. This may be due to the lack of awareness about the importance of minimum farm distance among the farmers. The research found that some farmers used to keep manure very near to the broiler house. However, Krishna, [31] indicates that poultry manure is cheap source of disease and parasite, one gram of infected poultry manure can infect one million of chicken. The existence of such kinds of practice may be due to the lack of sufficient space with them or lack of awareness about the hazards of it. Breach of biosecurity by the unnecessary entry of humans and other farm animals as observed in this study might be present in the farms because majority of the farmers were not found to construct fences. A previous study done by Yong [39] indicated that the introduction of other farm animals was also one of the sources of *Salmonella* infection for the poultry. Poor economic condition, higher financial risk and lack of awareness about the biosecurity measures and its importance may be the reasons for the absence of fences around the poultry farms.

Pest experienced by the entire farm is also the result of lack of hygienic practices and control strategy in the farm. Very poor situation of feed storage may attract the pests, and there is easy chance of contamination by bacteria and fungi. The rodents are very important source of transmitting *Salmonella* in the broiler flock [31]. Very high presence of disease problem and high mortality percentage in broiler flock in the division is due to the poor hygiene practices and structure and poor maintenance of broiler house. This result is also supported by Prabhakaran, [40] and Sharma, [41] who mentioned that high disease prevalence and mortality is indicative of poor biosecurity in the poultry farm.

This study revealed that there is great awareness through trainings (being it formal or informal) on the proper management of broiler farms. However, only few of them from researcher on farm observations were seen to adopt and carryout standard zootechnical activities. Some of these included; giving dirty drinking water to chicken or adding clean water on left overs, giving clean drinking water in dirty drinkers, poor positioning of drinkers leading to spillage on floors and soiling of litter, administration of drugs based on offhand estimation administration of drugs at subtherapeutic levels as a routine etc. Failure to adopt these recommended practices could be attributed to several reasons some of which may be due to the lack of money, or sheer laziness as many see it as cumbersome, reluctance to build scientific housings as many perform the activity on rented lands as a secondary income generating activity, non-enforcement of government regulations and lack of regular monitoring and inspection activities by the competent government authorities. Additionally, unsecured market, frequent threat of highly contagious disease such as bird flu, lack of compensation and insurance policies might discourage farmers from investments for biosecure constructions. All these are responsible for the numerous health challenges faced in broiler farm management, resulting to indiscriminate use of veterinary drugs especially antibiotics to overcome these challenges.

5.2. On Farm Management Practice

Unawareness and lack of implementation of antibiotic withdrawal periods by majority of farmers resulted in up to 66% contamination of broiler meat with drug residues. Because the inhabitants of Fako Division prefer freshly processed chicken as opposed to frozen ones, sales are ongoing in the farms and markets while being administered medications. Many farmers simply sold their chicken based on demand once it has reached the table size irrespective of the treatments being offered prior the sales. This does not therefore offer any opportunity for observance of withdrawal period coupled with the lack of a functional if any or a complete absence of broiler chain monitoring system to ensure supply of safe meat to the general public. The situation is worsened by the fact that some farmers argue out the phenomenon of antibiotic resistance resulting from such unorthodox practices. Most say they have never witnessed a case of meat poisoning or someone consuming broiler meat and dying due to non-respect of withdrawal period. This therefore seems to say that a good number of these farmers have not understood the concept of withdrawal periods and links with antibiotic resistance development in product consumers.

At the trader/processor level, the results indicate that there is some awareness and compliance of safe broiler handling practices especially during transportation time. This may be due to the fact that there is high mortality during transportation at day time due to high temperature [40]. But, lack of use of disinfectant by trader/processor for cleaning the vehicle may be due to lack of awareness level. This cleaning practice without disinfectant may not remove the microbes efficiently and could attribute to spread of pathogens to new flock which is transported by the same vehicle. Although, there is low chance of mortality due to quick slaughter, but still there is probability to infect the consumers as a result of cross contamination due to unhygienic slaughtering process. FAO, [42] also supports the finding of the research which mentioned that in small scale processing there is very less practice of disinfection of transport vehicle because of lack of knowledge.

The study also reveals that the processor and butcher had no facility to separate sick birds, clean area from dirty area. So, birds were slaughter either knowingly (due to carelessness) or unknowingly and mixed on dirty surfaces. This may be the very important cause of food borne infection for the consumers and may be due to lack of awareness program for the workers about the importance of separate handling of sick and healthy bird in the processing. As found by Kiilholma, [43] slaughtering of sick and dead birds without inspection in unhygienic places causes foodborne infection for the consumers. There used to be some minimal level of inspection of these slaughter environments by the competent authorities in the local councils of the division. Unfortunately, today, there are hardly such inspection activities being carried out. This among so many other factors may attribute to care free attitudes by some members of the competent government authorities charged with inspection as well as the political instability within the division.

5.3. Management Practices during Processing

Lack of post mortem examination by veterinarian or meat inspector during the processing may further lead to high chances of slaughtering and selling of the subclinical infected birds. This may be due to lack of implementation of law and willingness in stakeholders. Verreth, [44] mentioned that, there was high risk of transmitting the zoonotic disease from broiler to humans like *Salmonellosis, Campylobacteriosis* from consumption of uninspected meat. The unhygienic way of evisceration by most of the processor and butcher may be due to lack of training and awareness programs about risk of contamination of meat. As stated by Nauta [45], evisceration is the most important critical control point during processing where there is a high chance of contamination of meat by faecal microbes. As the processor and butcher do not separate healthy and sick bird, clean and dirty areas, there is risk of cross contamination during slaughtering and washing practices due to use of same equipment, place and same bucket of water to wash many carcasses. This washing process can not sufficiently remove the microbes present on the carcass [46]. Use of unsafely stored and dirty water to clean the carcass may be further contaminating the carcass. At this point we found that risk of contamination of carcasses is tripled because feacal contaminations, use of dirty water and use dirty surfaces all constituted sure sources of contamination. FAO [47] recommends that water used for processing and cleaning the meat carcass should be of drinking quality. This is how ever very difficult to achieve at the level of this division or in Cameroon due to very low clean natural water index (less than 20% based on global classification). Another risk factor is slaughtering and processing without cleaning and disinfecting floor, wall and instruments by processors. This has also been found to result in high risk of cross contamination of meat [39]. This kind of practice may be due to lack of motivation low incentives resulting to the workers wanting do as many slaughtering per day as possible to increase their take home income.

The use of protective clothing was completely absent in all the slaughtering facilities. The purpose of protective clothing within the slaughterhouse is primarily to protect the meat product from contamination but can also be to protect meat handlers against directly transmitted zoonoses including leptospirosis and brucellosis. Scalding is one of the major processes employed during poultry slaughter for removing feather from the skin. Careful equipment design and processing conditions are required for scalding of poultry, because during this process carcasses come in contact to each other and act as a chance source of contamination.

5.4. Hygienic Practices at Storage

Storage of the carcass was another issue discovered during the study. There was no use of any cooling/chilling facility by trader/processor, before transport and during transport may be due to lack of awareness about the importance of chilling and hygienic transportation of meat. This statement is justifiable from the view point that many of the traders or butchers have coolers which they use in storing

meat and other food items at home. However, they do not use it storing meat during processing and transportation irrespective of the length of exposure time to local conditions. As mentioned by Corry [48], this may cause high risk of contamination because of poor packaging, open transport system without chilling and no consideration of duration of transport. This has led to a joint statement of FAO/WHO, [49], stating that these malpractices may cause the growth of *Staphylococcus, Campylobacter* in meat to undesirable levels and it leads to unsafe meat for consumption and can cause foodborne infection to the consumers. Although, all the butchers were aware of transmission of disease to consumer by contaminated meat, they were not found to applying hygienic practices in their processing and retailing of meat. We believe all these may be due to care free attitudes on the part of government, traders and butchers and a complete lack of serious punitive measures on defaulters. If this continues unpertubated, it might cause poor meat production resulting foodborne illness for consumers [46] as it represents a mode of silent circulation of pathogenic microorganisms at the detriment of public health.

5.5. Laboratory Analysis

Qualitative analysis for antimicrobial residues showed that there was a higher percentage (66.6%) of chicken meat with antimicrobial drug residues in Fako Division. These findings are in line with the findings elsewhere by; Salehzadeh [50] and Nonga [12], based on agar well diffusion test. The high incidence of antimicrobial residues recorded in the current study probably resulted from slaughter of chicken for sell which were under therapeutic or prophylactic regimens. This is verified by the higher rate of noncompliance to withdrawal periods as was mentioned by the farmers and observed by the researchers. Normally, broilers are grown actively often with drugs to attain maximum weight within a short period of time. This is of concern, because, backyard production provides a continuous supply of chicken meat to fast growing population within Fako Division. Meanwhile, there is no official residue monitoring program within the division and consumer response towards the dangers posed by residues exist but is silent. The meat samples analyzed in this study showed higher number of positive samples hence a high exposure rate of the public to antimicrobial residues through constant consumption of broiler meat. This implies that the localities of Fako Division consume small amounts of antimicrobials from broiler meat daily. Though most of the farmers wanted to see someone dying instantly of poisoning from broiler meats, this can hardy be the case. Residues bioaccumulate and can later lead to issues of antimicrobial resistance development as well as lung, kidneys and liver diseases.

This statistic also showed a violation of recommendations made by WHO and FAO. WHO/FAO, [51] have set maximum residue limits (MRLs), acceptable daily intakes (ADIs) for humans and withholding times for pharmacologically active substances including antimicrobial agents prior to marketing. The maximum res-

idue levels of oxytetracycline in meat is 100 μg/kg [52] while the sensitivity of *Baccillus stearothermophilus* to tetracycline ranges between 400 and 500 mg/kg [53].

6. Conclusion

The general aim of this project was to contribute to efforts geared towards ensuring the elimination of drug residues in meat and to provide recommendations on production/management practices, processing and supply in order to prevent bacteria resistance development and to prevent contamination of meat during processing thereby limiting the incidences of diseases occurrences in product consumers. Intensive broiler production in Fako Division involves the use of antibiotics, growth promoters, and other chemicals to enhance growth and prevent disease outbreaks. This practice coupled with poor biosecurity measures is a risk factor to antibiotic resistance development in product consumers representing a significant public health problem. Broiler production, transportation and processing/storage practices in Fako Division are far below and violate standard put in place by FAO and WHO. Poor production practices have led to residue problems in a greater percentage of the meat sampled. Lack of proper hygiene, poor sanitation, and inadequate refrigeration facilities during processing and poor transportation infrastructure are some of the factors that contribute to product contamination. These can lead to the growth of harmful bacteria such as salmonella, campylobacter, and *E. coli*, which can cause foodborne illnesses in humans who consume contaminations. A good number of poultry farmers in Fako division have never received formal training for the activity. This does not really make a difference as those who have received formal training and those trained to enforce good practices do not observe it. This study revealed that the carefree attitudes observed with the various actors in the broiler value chain in Fako division, pose the lives of broiler product consumers at significant public health risks. There is therefore the need for the competent authorities of the local councils and those put in place by Ministry of Livestock Fisheries and Animal Industries to be serious in monitoring and regulating the broiler production, transportation and processing activities in Fako Division to save the lives of product consumers.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study, collection, analyses or interpretation of data; in the writing of the

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References

[1] Eshetie, T. (2019) Assessment of Broiler Production; Processing and Marketing Practices in Ethiopia: Identifying the Root Causes for Poultry Products Importation and Way Forward. *Novel Techniques in Nutrition & Food Science*, **4**, NTNF.000591. https://doi.org/10.31031/ntnf.2019.04.000591

[2] Mcleod, A., Thieme, O. and Mack, S.D. (2009) Structural Changes in the Poultry Sector: Will There Be Smallholder Poultry Development in 2030? *World's Poultry Science Journal*, **65**, 191-200. https://doi.org/10.1017/s0043933909000129

[3] Van Boeckel, T.P., Brower, C., Gilbert, M., Grenfell, B.T., Levin, S.A., Robinson, T.P., *et al.* (2015) Global Trends in Antimicrobial Use in Food Animals. *Proceedings of the National Academy of Sciences*, **112**, 5649-5654. https://doi.org/10.1073/pnas.1503141112

[4] Van Boeckel, T.P., Glennon, E.E., Chen, D., Gilbert, M., Robinson, T.P., Grenfell, B.T., *et al.* (2017) Reducing Antimicrobial Use in Food Animals. *Science*, **357**, 1350-1352. https://doi.org/10.1126/science.aao1495

[5] Chantziaras, I., Boyen, F., Callens, B. and Dewulf, J. (2013) Correlation between Veterinary Antimicrobial Use and Antimicrobial Resistance in Food-Producing Animals: A Report on Seven Countries. *Journal of Antimicrobial Chemotherapy*, **69**, 827-834. https://doi.org/10.1093/jac/dkt443

[6] Organisation for Economic Cooperation and Development/Food and Agriculture Organisation of the United Nations (2016) Agriculture in Sub-Saharan Africa: Prospect and Challenges for the Next Decade (Chapter 2, p. 62).

[7] Food and Agricultural Organization (2020). Lives Animals and Livestock Primary in Cameroon: Production, Animal/Slaughtered and Stocks.

[8] Betrand Ukum, U., L. Molua, E. and N. Akem, F. (2018) Poultry Price and Market Analysis in the South West Region of Cameroon. *Journal of Food Security*, **6**, 42-50. https://doi.org/10.12691/jfs-6-1-5

[9] FAO (2013) The State of Food and Agriculture. https://www.fao.org/publications/sofa/en/

[10] Mehtabuddin, A.A.M., Ahmad, T., Nadeem, S., Tanveer, Z.I. and Arshad, J. (2012) Sulfonamide Residues Determination in Commercial Poultry Meat and Eggs. *Journal of Animal and Plant Sciences*, **22**, 473-478.

[11] Mund, M.D., *et al.* (2017) Antimicrobial Drug Residues in Poultry Products and Implications on Public Health: A Review. *International Journal of Food Properties*, **20**, 1433-1446.

[12] Nonga, H.E., Mariki, M., Karimuribo, E.D. and Mdegela, R.H. (2013) Assessment of Veterinary Drug Use and Determination of Antimicrobial Residues in Broiler Chicken Meat in Urban District, Zanzibar. *Tanzania Veterinary Journal*, **28**, 30-38.

[13] Wadoum Guetiya, R.E., Zambou, N.F., Anyangwe, F.F. and Njimou, J.R. (2016) Abusive Use of Antibiotics in Poultry Farming in Cameroon and the Public Health Implications. *British Poultry Science*, **57**, 483-493.

[14] Singh, S., Shukla, S., Tandia, N., Kumar, N. and Paliwal, R. (2004) Antibiotic Residues: A Global Challenge. *An International Journal of Pharmaceutical Sciences*, **5**, 184-197.

[15] Hao, H., Cheng, G., Iqbal, Z., Ai, X., Hussain, H.I., Huang, L., *et al.* (2014) Benefits and Risks of Antimicrobial Use in Food-Producing Animals. *Frontiers in Microbiol-*

ogy, **5**, Article No. 288. https://doi.org/10.3389/fmicb.2014.00288

[16] Donoghue, D. (2003) Antibiotic Residues in Poultry Tissues and Eggs: Human Health Concerns? *Poultry Science*, **82**, 618-621. https://doi.org/10.1093/ps/82.4.618

[17] Nisha, A. (2008) Antibiotic Residues—A Global Health Hazard. *Veterinary World*, **2**, 375. https://doi.org/10.5455/vetworld.2008.375-377

[18] Dubois, M., Fluchard, D., Sior, E. and Delahaut, P. (2001) Identification and Quantification of Five Macrolide Antibiotics in Several Tissues, Eggs and Milk by Liquid Chromatography-Electrospray Tandem Mass Spectrometry. *Journal of Chromatography B*: *Biomedical Sciences and Applications*, **753**, 189-202. https://doi.org/10.1016/s0378-4347(00)00542-9

[19] Tagg, K. (2013) Human Health, Animal Health, and Ecosystems Are Interconnected. *BMJ*, **347**, f4979-f4979. https://doi.org/10.1136/bmj.f4979

[20] European Food Safety Agency (2008) Technical Guidance: Update of the Criteria Used in the Assessment of Bacterial Resistance to Antibiotics of Human or Veterinary Importance. *The EFSA Journal*, **732**, 1-15.

[21] Codex Alimentarius Commission (2012) Maximum Residue Limits for Veterinary Drugs in Foods. Updated as at the 35th Session of the Codex Alimentarius Commission. CAC/MRL 2: 1-40.

[22] Woodward, K.N. (2003) Antibiotics and Drugs|Uses in Food Production. In: Caballero, B., Ed., *Encyclopedia of Food Sciences and Nutrition*, Elsevier, 249-254. https://doi.org/10.1016/b0-12-227055-x/00051-1

[23] FAO (2010) Market-Led Quality Meat Production and Processing. FAO UN Complex. Pulchowk.

[24] Mumtaz, A., Awan, J.A. and Athar, M. (2000) Rational Use of Drugs in Broiler Meat Production. *International Journal of Agriculture and Biology*, **2**, 269-272.

[25] Karmi, M. (2014) Detection and Presumptive Identification of Antibiotic Residues in Poultry Meat by Using FPT. *Global Journal of Pharmacology*, **8**, 160-165.

[26] Institute National de la Statistique (2015) Characteristiqes de la population. Annaire Statistique de Cameroon.

[27] Map of Fako Division; Enp and Fombe (2016). https://www.researchgate.com

[28] Luangtongkum, T., Morishita, T.Y., El-Tayeb, A.B., Ison, A.J. and Zhang, Q. (2007) Comparison of Antimicrobial Susceptibility Testing of Campylobacter Spp. by the Agar Dilution and the Agar Disk Diffusion Methods. *Journal of Clinical Microbiology*, **45**, 590-594. https://doi.org/10.1128/jcm.00986-06

[29] NCCLS (2000) Performance Standards for Antimicrobial Disk Diffusion and Dilution Susceptibility Tests for Bacteria Isolated from Animals. National Committee for Clinical Laboratory Standards NCCLS), Pennsylvania. *American Society for Microbiology Journals*, **9**, 405-422.

[30] East, I. (2007) Adoption of Biosecurity Practices in the Australian Poultry Industries. *Australian Veterinary Journal*, **85**, 107-112. https://doi.org/10.1111/j.1751-0813.2007.00113.x

[31] Subedi, K.P. (2013) An Assessment of Good Hygienic Practices of Broiler Value Chain of Kaski District of Nepal. Van Hall Larenstein University of Applied Sciences.

[32] Hafez, H.M. and Attia, Y.A. (2020) Challenges to the Poultry Industry: Current Perspectives and Strategic Future after the COVID-19 Outbreak. *Frontiers in Veterinary Science*, **7**, Article No. 516. https://doi.org/10.3389/fvets.2020.00516

[33] Abreu, R., Semedo-Lemsaddek, T., Cunha, E., Tavares, L. and Oliveira, M. (2023)

Antimicrobial Drug Resistance in Poultry Production: Current Status and Innovative Strategies for Bacterial Control. *Microorganisms*, **11**, Article No. 953. https://doi.org/10.3390/microorganisms11040953

[34] Bahmani, K., Shahbazi, Y. and Nikousefat, Z. (2019) Monitoring and Risk Assessment of Tetracycline Residues in Foods of Animal Origin. *Food Science and Biotechnology*, **29**, 441-448. https://doi.org/10.1007/s10068-019-00665-x

[35] European Medicines Agency (n.d.) Maximum Residue Limits.

[36] Majid, M., Maryam, M., Saeid, H., Majid, M., Enayat, B., Morteza, Z., Zahra, D., Margherita, F. and Gea, O.C. (2020) Antibiotic Residues in Poultry Meat: A Global Review. *Journal of Food Science*, **81**, 619-627.

[37] Simjee, S. and Ippolito, G. (2022) European Regulations on Prevention Use of Antimicrobials from January 2022. *Brazilian Journal of Veterinary Medicine*, **44**, e000822. https://doi.org/10.29374/2527-2179.bjvm000822

[38] EPIG (2010) Guide to Good Hygiene Practice for the Prevention and Control of Pathogenic Microorganisms with Particular Reference to Salmonella in *Gallus gallus* (Broilers) Reared for Meat on Farms. https://food.ec.europa.eu/system/files/2016-10/biosafety_food-borne-disease_salmonella_broilers_community-guide.pdf

[39] Yang, S., Hong, Y., Lee, H. and Song, C. (2010) Hygienic Management for Salmonella-Free Chicken Meat Production. *Korean Journal of Poultry Science*, **37**, 289-295. https://doi.org/10.5536/kjps.2010.37.3.289

[40] Prabakaran, R. (2003) Good Practices in Planning and Management of Integrated Commercial Poultry Production in South Asia. FAO Animal Production and Health Paper 159. Food and Agriculture Organisations of the United Nations.

[41] Sharma, B. (2010) Poultry Production, Management and Bio-Security Measures. *Journal of Agriculture and Environment*, **11**, 120-125. https://doi.org/10.3126/aej.v11i0.3659

[42] FAO (1992) Small-Scale Poultry Processing. http://www.fao.org/trade/docs/LDC-foodqual_en.htm

[43] Kiilholma, J. (2007) Food-Safety Concerns in the Poultry Sector of Developing Countries. https://www.researchgate.net/publication/242420054_Food-safety_concerns_in_the_poultry_sector_of_developing

[44] Verreth, D. (2009) A Risk Analysis for Broiler Chains in the Netherlands. Wageningen University.

[45] Nauta, M., Hill, A., Rosenquist, H., Brynestad, S., Fetsch, A., van der Logt, P., *et al.* (2009) A Comparison of Risk Assessments on Campylobacter in Broiler Meat. *International Journal of Food Microbiology*, **129**, 107-123. https://doi.org/10.1016/j.ijfoodmicro.2008.12.001

[46] Havelaar, A.H., Mangen, M.J., De Koeijer, A.A., Bogaardt, M., Evers, E.G., Jacobs-Reitsma, W.F., *et al.* (2007) Effectiveness and Efficiency of Controlling Campylobacter on Broiler Chicken Meat. *Risk Analysis*, **27**, 831-844. https://doi.org/10.1111/j.1539-6924.2007.00926.x

[47] FAO (n.d.) Slaughterhouse Cleaning and Sanitation. FAO Corporate Document Repository. Food and Agriculture Organization of the United Nations. http://www.fao.org/docrep/003/x6557e/x6557e02.htm

[48] Corry, J.E.L., Allen, V.M., Hudson, W.R., Breslin, M.F. and Davies, R.H. (2002) Sources of Salmonella on Broiler Carcasses during Transportation and Processing:

Modes of Contamination and Methods of Control. *Journal of Applied Microbiology*, **92**, 424-432. https://doi.org/10.1046/j.1365-2672.2002.01543.x

[49] Food and Agricultural Organization FAO (2003) Statistic Data, 2003. http://faostat.fao.org

[50] Salehzadeh, F., *et al.* (2006) Oxytetracycline Residue in Chicken Tissues from Tehran Slaughterhouses in Iran. *Pakistan Journal of Nutrition*, **5**, 377-381. https://doi.org/10.3923/pjn.2006.377.381

[51] WHO/FAO (1988) Evaluation of Certain Veterinary Drug Residues in Food. Thirty Second Report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series, No. 763, 40-45.

[52] WHO (1996) Evaluation of Certain Veterinary Drug Residues in Food. Forty Fifth Report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series, No. 864, 34-38. https://iris.who.int/bitstream/handle/10665/41844/WHO_TRS_864.pdf?sequence=1&isAllowed=y

[53] Pavlina, J., Dudrikova, E., Sokol, J., Nagy, J., Mate, D., Pipova, M. and Cabadaj, R. (2003) Determination of Oxytetracycline Residues in Milk with the Use of HPLC Method and Two Microbial Inhibition Assays. *Bulletin of the Veterinary Institute in Pulawy*, **47**, 211-216.