JWPR

Journal of World's Poultry Research

2021, Scienceline Publication

J. World Poult. Res. 11(1): 64-72, March 25, 2021

Research Paper, PII: S2322455X2100009-11
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DOI: https://dx.doi.org/10.36380/jwpr.2021.9

Biosecurity Practices and Characteristics of Poultry Farms in Three Regions of Cameroon

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Received: 04 Jan. 2021
Accepted: 19 Feb. 2021

ABSTRACT

The outbreak of diseases is the main factor affecting poultry production in Cameroon. The implementation of biosecurity measures in poultry farms is essential to reduce disease outbreaks. This study aimed to assess biosecurity practices in poultry farms in three regions of Cameroon. The study was carried out using a structured questionnaire on 90 randomly selected poultry farms. Most of the farmers were men (85%) with deep litter (77.8%), battery cage (2.2%), and both deep litter and battery cage (20.0%) housing systems. Amongst the farms surveyed, 9/30 (30.0%) in the Centre; 8/30 (26.7%) in the Littoral; and 13/30 (43.3%) in the West were aware of biosecurity measures. The biosecurity score (BS) of surveyed farms ranged between 2 and 3. The findings indicated that 39 farms (12 in the Centre, 14 in the Littoral, and 13 in the West) were at moderate risk, and 51 farms (18 in the Centre, 16 in the Littoral, and 17 in the West) were at high risk. Reasons for keeping chickens and the number of chickens per farm did not significantly influence BS, while the farm category could significantly affect it. The outbreak of diseases correlated with BS, showing a tendency of increase in the outbreak of diseases with increasing BS. This study underlines the fact that biosecurity practices in Cameroon have not been well implemented by chicken farmers. This leads to disease outbreaks, and consequently, important economic losses as well as massive use of drugs that may be unsafe for human consumption. Therefore, the effective monitoring of biosecurity in chicken farming should be encouraged by extension of training to the farmers to support the efficient production of chickens by respecting biosecurity that drastically reduces the risk of disease outbreaks and provides good quality chicken products for human consumption.

Keywords: Assessment, Biosecurity practices, Biosecurity scores, Cameroon, Poultry farms

INTRODUCTION

Chicken farming is a growing sector in Cameroon that creates income generation in rural and urban areas (Guetiya et al., 2016), representing a good source of essential nutrients. Amongst food animals, chicken production is quicker and cheaper than other meat sources. In addition, chicken products gain more attention in Islamic countries due to religious rules forbidding the consumption of some animal meats, such as pork, and therefore, play an important role in public nutrition (Paryad and Mahmoudi, 2008; Melesse, 2014; Sambo et al., 2015). The necessity of securing the food supply in terms of quality and quantity, consumers' awareness, and tendency to maintain a healthy and balanced diet, have all made the poultry sector a significant industry throughout the world (Aral et al., 2013).

Some infectious diseases, such as Highly Pathogenic Avian Influenza (HPAI) are zoonotic, resulting in a range of mild to serious diseases having fatal consequences in both poultry and humans (Beeckman and Vanrompay, 2009; WHO, 2011). The unprecedented widespread outbreaks of HPAI, which has occurred in many countries in Asia, Europe, and Africa since 2003, call for rapid and active response at regional, national, and international levels. Biosecurity is a key strategy to reduce the incidence of outbreak diseases, such as HPAI, by applying technical recommendations at the farm or poultry house (DAFF, 2011; Newell et al., 2011). Biosecurity measures are necessary to prevent the negative consequences of infectious diseases during chicken farming because they reduce the introduction, persistence, or dissemination of infectious agents (Loth et al., 2011), and minimize the direct and indirect negative economic effect of infections on stakeholders (farmers, customers, and suppliers) (Can and Altuğ, 2014). Furthermore, biosecurity measures are vital for better performance and quality of chicken production in the competitive world.

Various assessment studies have highlighted substantial weaknesses in the implementation of biosecurity measures in chicken farms (Abdurrahman et al., 2016; Maduka et al., 2016; Yitbarek et al., 2016). In Cameroon, few studies have assessed biosecurity practices. Kouam and Moussala (2018) studied the level of implementation of biosecurity measures on small-scale broiler farms in the Western Highlands of Cameroon and found that level of implementation was poor and there was a significant relationship between farm biosecurity score (BS) and farm production system.

The HPAI H5N1 virus has caused widespread mortality in the poultry sector among many African countries (Egypt, Ethiopia, and Nigeria). This situation of disease outbreaks, particularly in Cameroon has raised a concern about the level of implementation of biosecurity measures on chicken farms (MINEPIA, 2009). The present article outlines the biosecurity practices implementation on chicken production with the aim of contributing to improving chicken management practices in resource-limited conditions, specifically in Cameroon. The current study had three objectives of appraising the chicken production system, assessing the level of biosecurity practices, and examining any relationship between the biosecurity practices and the socio-technical characteristic of farms and farmers in three regions of Cameroon.

MATERIALS AND METHODS

Study areas

The study was conducted in three regions of Cameroon, including the center, the littoral, and the west regions (Figure 1). The central region covers 68926 km^2 and is composed of rolling hills on a vast plain with a mean altitude of 700–800 m, with lowered mounds. The climate has two wet seasons. The population density is low, with about 36 inhabitants/km^2 (NIS, 2006; BUCREP, 2010). The littoral region has an area of 20239-km^2 with more than 2,202,340 inhabitants. The population density is 124 inhabitants/km^2. The west region represents an area of 13872 km^2 characterized by highlands with a mean altitude of 1600 m and narrow valleys with catchments separating them. The population density is estimated at 143 inhabitants/km^2 (BUCREP, 2010).

Study design and data collection

Study areas were selected as they could represent a high potential for chicken production due to favorable conditions (Teleu Ngandeu and Ngatchou, 2006). Data were collected using structured questionnaires. The data were collected from governmental authorities and poultry farmers by data collector/field assistants. The research team worked in partnership with local veterinary agencies to recruit participants since most of them are scared of sanitary control by governmental authorities. The farms were randomly selected; 30 farms in the center, 30 farms in the littoral, and 30 farms in the western regions. The objective of the study was explained to the farmers and their verbal informed consent was obtained before administering the questionnaire. Chicken farms were evaluated for biosecurity practices and scored. Biosecurity measures were grouped according to some indicators of biosecurity events (events outside the premises, events at the farm boundary, events between farm boundary and poultry house, events inside poultry house).

Questionnaire design

A set of preliminary questionnaires were prepared and tested with 10 farmers in Yaoundé, Cameroon for biosecurity practices a few months after the avian influenza outbreak. Thus, necessary modifications were made based on the feedback and the final questionnaire was prepared based on the pilot survey. The structured questionnaire with both open-ended and closed questions was applied to 90 chicken farmers or farm employees by a team of two persons, the interview lasted for 45-60 minutes. The questionnaire had three parts: 1)socio-demographic characteristics of farmers, 2) information about poultry farming systems, 3) inquiry into biosecurity measure implementation.

Biosecurity scoring system

The scoring system used in this study was developed from the biosecurity indicators observed in the evaluation of biosecurity practices on the farm as previously reported with scores of 0-3. Criteria used for scoring biosecurity practices were adopted from USAID (2009). Thirty-three biosecurity indicators were recorded and characterized with scores of 0-3 (3.00 for the worst incorrect practice,2.00 for the occasional respect of biosecurity measures, 1.00 for average compliance with biosecurity measures of biosecurity measures, and 0.00 for the best correct practice). The BS of each farm was the average of the scores of the biosecurity indicators. Accordingly, a low mean BS value indicates a higher level of biosecurity.

Statistical analysis

Data were analyzed by SPSS software, version 20.0. Categorical variables were expressed using frequencies and percentages while continuous variables, such as BS of farms, were expressed as means and standard deviations. The associations and relationships were assessed using the Chi-square test and Pearson's correlation, respectively, and variations in means were assessed by one-way ANOVA followed by Tukey post hoc test. The difference was considered significant for a p-value <0.05 with a confidence interval of 95%.

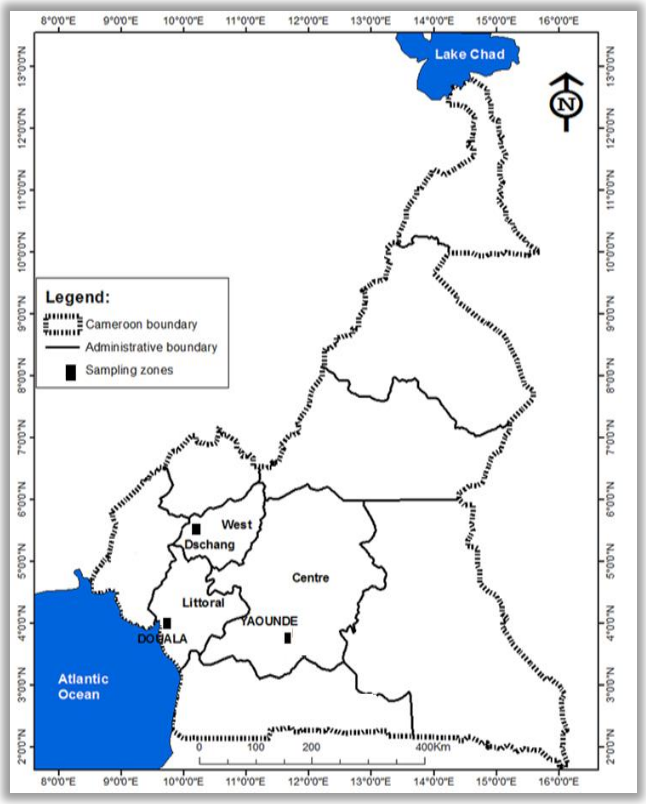


Figure 1. The map of Cameroon showing study areas marked by small black squares.

RESULTS

General characteristics of the studied farms

The participating farmers were mostly men (85%), and most of the farmers (74.4%) had no formal training in chicken production and 60% of farmers had more than three years of experience (Figure 2). Diseases were the most constraint faced by chicken farmers (100.0%), followed by financial constraints (93.3%). Some farmers (13.3%) produced chickens for only family consumption, while others (20.0%) produced for family consumption and also sold the surplus. The higher percentage of farmers (66.7%) who own the majority of chickens (97.5%) produced chickens for only commercial purposes. Farms make income from the sale of live chickens and table eggs to fecal droppings to crop farmers and carcasses of dead chickens to breeders. The flock size in the surveyed farms ranged from 50-10,000 chickens. About ten (12.2%) of farms hosted 200-500 chickens, followed by 501-1000 birds (15.6% of farms), and 1001-2000 chickens (13.3% of farms). Regarding the age of the chickens, 33.3% were < 4 weeks, 38.9% were between 4 to 8 weeks and 27.8% were ≥ 8 weeks. The three main types of chicken were broiler (55%), layer (43%), and backyard chickens (2%). Three housing systems of chicken farming were deep litter system (77.8%), combination of the deep litter with battery cages (20.0%), and battery cages (2.2%). The deep litter housing system hosted 97.9% of the total chicken population (TCP). Ninety-three percent of farms affirmed using veterinary drugs for disease control. The veterinary drugs used were obtained from veterinary pharmacies, markets, and uncertified/unknown sources**.** Reasons for production, flock size, age of birds, housing system, as well as sources of day-old chicks, feed, and veterinary drugs are presented in Table 1.

Table 1. Characterization of different poultry farms surveyed

Variables	Number of farms (%)	Number of birds (%)
Reason for keeping birds		
Commercial	60 (66.7)	107100 (97.5)
Family consumption	12 (13.3)	140 (0.1)
Both (semicommercial)	18 (20.0)	2590 (2.4)
Number of birds per farm		
<200	11 (12.2)	7930 (7.2)
200-500	16 (17.8)	6900 (6.3)
501-1000	14 (15.6)	29000 (26.4)
1001-2000	12 (13.3)	35800 (32.6)
2001-10000	37 (41.1)	30200 (27.5)
Age of birds at study time		
< 4 weeks	30 (33.3)	45170 (41.1)
4-8 weeks	35 (38.9)	33450 (30.5)
≥ 8 weeks	25 (27.8)	31210 (28.4)
Housing system		
Deep litter	70 (77.8)	107490 (97.9)
Battery cage	2 (2.2)	2000 (1.8)
Both	18 (20.0)	340 (0.3)
Source of day-old chicks and feed		
AGROCAM	5 (5.6)	7500 (6.8)
ALIVET	5 (5.6)	3000 (2.7)
BELGOCAM	6 (6.7)	10000 (9.1)
NAPCAM	5 (5.6)	3000 (2.7)
SPC	18(20.0)	36900 (33.5)
ALIVET/SPC	5 (5.6)	1400 (1.2)
SOCAVE	6 (6.7)	4500 (4.1)
NAPCAM/SPC	5 (5.6)	4000 (3.6)
SPC/AGROCAM	9 (10.0)	16000 (14.6)
Unknown	26 (28.6)	23530 (21.4)
Source of veterinary drugs		
Veterinarypharmacy	52 (57.8)	89980 (82.1)
Market	22 (24.4)	7300 (6.7)
Unknown	16 (17.8)	12280 (11.2)

Total number of farms questioned = 90 Total number of chickens in farms questioned = 109830.

Biosecurity implementation in farms surveyed

Positive responses on biosecurity indicators for each region are presented in Table 2. Biosecurity indicators with more than 80% of positive responses in all three regions were concerning appropriate carcass disposal, rodent-proof, disinfecting feeders/drinkers regularly, prophylactic chemotherapy to healthy chickens, usage of veterinary drugs, and presence of diseases in the past three months. Biosecurity indicators with less than 50% positive responses in all three regions included awareness of biosecurity practices, washing/disinfecting of vehicles, on-farm necropsy, separation of chicken according to types and age, chickens occasionally allowed to move out of the poultry house. The mean BS ranged between 2 and 2.8 (Table 3). The difference was significant among the mean BS of Centre, Littoral, and West regions (p< 0.001). Regarding the obtained data, 12 chicken farms in the Centre region, 14 chicken farms in the Littoral region, and 13 chicken farms in the West region were at moderate risk (BS=2), while 18 chicken farms in the Centre, 16 chicken farms in the Littoral regions, and 17 in the West region were at high risk (BS=3). The BS means varied with the reason of keeping chickens as well as with the flock size (Table 3). The BS was significantly influenced by the farmer category (p = 0.004). Table 4 shows that the flock size did not significantly (p > 0.05) affect the BS and disease outbreaks. However, variations of mean BS amongst farms were significant (F = 4.171, p = 0.046) and the highest mean BS was in farms with ≤ 1,000 chickens. Disease outbreaks did not correlate with BS, showing a tendency to increase disease outbreaks with increasing BS. The reason for keeping chickens did not significantly (p>0.05) affect disease outbreak within the last three months. In general, chicken farms with low flock size were more at risk than high flock size farms and had disease outbreaks as a major constraint.

Table 2. Percentage of poultry farms with positive responses on indicators of biosecurity events

Indicators of biosecurity events	Number (%) of farms with "yes" response		
	Centre	Littoral	West
Events outside the premises			
Awareness of biosecuritypractices	9 (30.0)	8 (26.7)	13 (43.3)
Certified sources of quality chicks and feeds	19 (63.3)	8(26.7)	23(76.7)
Acquisition of second-hand equipment	7 (23.3)	20 (66.7)	13 (43.3)
Purchase of veterinary drugs in veterinary pharmacy	18 (60.0)	14 (46.7)	13 (43.3)
Farm boundary events			
Visitorsallowedintopremises	11(36.7)	14 (46.7)	5 (16.7)
Washing/disinfecting of vehicles	12(40.0)	4 (13.3)	8 (26.7)
Events between farm boundary and poultry house			
Presence of good feed storage facility	27 (90.0)	15(50.0)	24 (80.0)
Appropriate carcass disposal	22 (73.3)	4 (13.3)	9 (50.0)
On-farm necropsy	14 (46.7)	0 (0.0)	11 (36.7)
Certified commercial feed sources only	19 (63.3)	8 (26.7)	15 (50.0)
On-farm carnivores (dogs and cats)	19 (63.3)	8 (26.7)	13 (43.3)
Washing hands/shower before and after handling chickens	19 (63.3)	10 (33.3)	22 (73.3)
Rodent-proof	25 (83.3)	28 (93.3)	27 (90.0)
Residence of farm workers within premises	18 (60.0)	28 (93.3)	11 (36.7)
Functional footbath at the entrance of poultry house	12 (40.0)	8 (26.7)	17 (56.7)
Events inside the poultry house			
Separation of chicken according to types and age	27 (90.0)	22 (73.3)	19 (63.3)
Proper ventilation	15 (50.0)	11 (36.7)	19 (63.3)
Availability of clean water	15 (50.0)	14 (46.7)	22 (73.3)
Frequent changing of bedding with dry ones	22 (73.3)	14 (46.7)	17 (56.7)
Chickens occasionally allowed to move out of the poultry house	15 (50.0)	1 (3.3)	5 (16.7)
Washing/disinfecting poultry house prior to restocking	30 (100.0)	30 (100.0)	30 (100.0)
Washing feeders/drinkers regularly	30 (100.0)	27(90.0)	27 (90.0)
Disinfecting feeders/drinkersregularly	30 (100.0)	26 (86.7)	8 (26.7)
Isolation of apparently sick chickens	30 (100.0)	25 (83.3)	25 (83.3)
Prophylactic chemotherapy to apparently healthy chickens	30 (100.0)	30 (100.0)	30(100.0)
Usage of veterinary drugs	30 (100.0)	5 (16.7)	27 (90.0)
Consultation of veterinarians only in case of problems	30 (100.0)	25 (83.3)	11 (36.7)
Presence of diseases in the past three months	30 (100.0)	30 (100.0)	30 (100.0)

Total number of farms surveyed = 90

Table 3. Mean biosecurity score of poultry farms classified according to different parameters

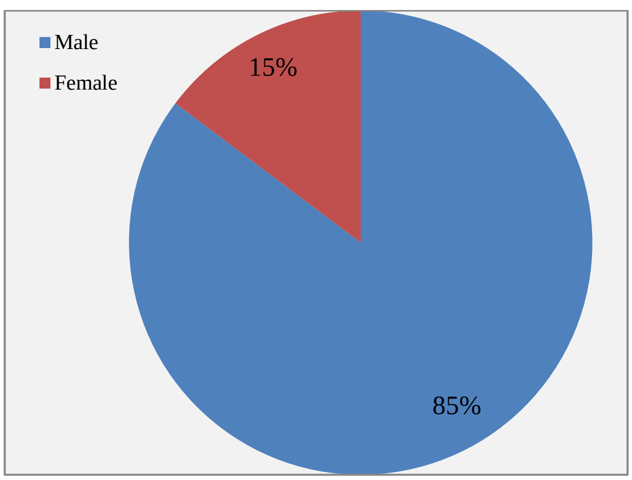
Parameter	Mean biosecurity score (Number of farms)
Reason for keeping chickens	
Commercial	2.3 ± 0.2 (60)
Semi-commercial	2.6 ± 0.1 (12)
Family use only	2.8 ± 0.1 (18)
Number of chickens per farm	
<200	2.7 ± 0.2 (11)
201-500	2.6± 0.1 (16)
501-1000	2.5 ± 0.1 (14)
1001-2000	2.4 ± 0.1 (12)
>2000	2.0 ± 0.2 (37)
Farmer category	
Trained	2.2 ± 0.2 (23)
Untrained	2.6 ± 0.1 (67)

Total number of farms surveyed = 90

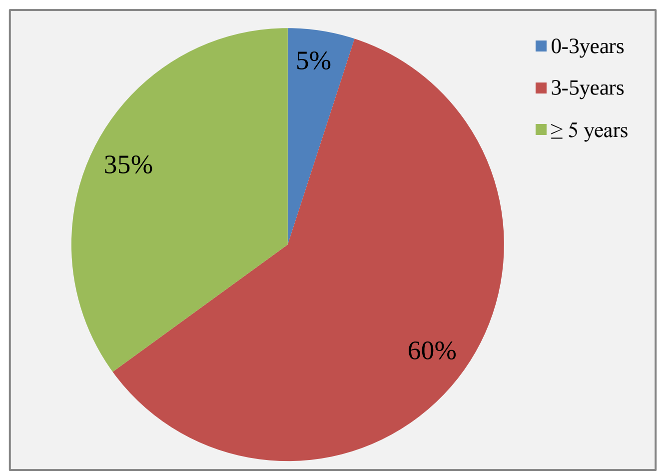
Table 4. Mean biosecurity scores in poultry farms in three regions of Cameroon

Study areas	Mean biosecurity scores	Number of farms (%)	Number of farms with the disease outbreak	Flock size
Center	2	12 (40.0)	5 (16.7)	>1000
	3	18 (60.0)	6 (20.0)	≤1000
Littoral	2	14 (46.7)	4(13.3)	>1000
	3	16 (53.3)	6 (20.0)	≤1000
West	2	13(43.3)	4 (13.3)	>1000
	3	17 (56.7)	8 (26.7)	≤1000

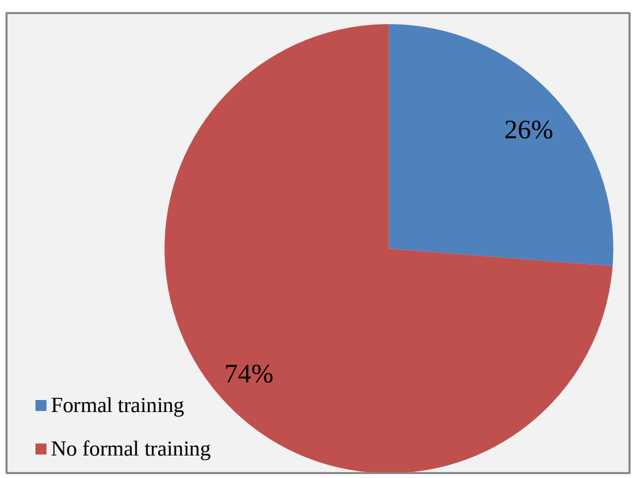
Total number of farms surveyed = 90



(a) Gender



(b) Work experience



(c) Qualifications in poultryfarming

Figure 2. Characteristics of participating poultry farmers (n = 90) in the present study

DISCUSSION

The present study assessed the level of implementation of biosecurity practices in chicken farming and their possible impacts on poultry quality in three regions of Cameroon. Poultry farmers were mostly males and most of them were not trained in poultry production or biosecurity measures. Similar to the present study, previous studies have also shown that poultry farming is male dominant. Women are usually more involved in activities, such as trade, and growing crops (Abdurrahman et al., 2016; Fongang Fouepe et al., 2017). The level of farmer training significantly influenced biosecurity scores. Farms surveyed were using three main systems of production, but the main production system was the commercial system. This production system is mainly used because of its high productivity and incomes. Semi-commercial and family production systems also contribute to the provision of chicken and eggs as well as income generation but at a low level.

Unfortunately, during the present study, disease outbreaks were still the main constraint faced by all the farmers (100.0 %) as earlier reported by Fongang Fouepe et al. (2017). This constraint could be responsible for the uncontrolled usage of veterinary antibiotics as previously mentioned by Gondam et al. (2016) and Guetiya et al. (2016). In the present study, the flock size of most farms ranged from 200 to 2000 chickens and the chicken population was more concentrated in this range. Abdurrahman et al. (2016) reported a different situation in poultry farms of Zamfara State, Nigeria, where the total chicken population was represented by flock sizes of < 200 chickens and 2001-10000 chickens. The same common flock size was reported by Maduka et al. (2016) in Jos state, Nigeria. Flock size less than 200 chickens was found in family farms, while flock size of 200-500 was found in farms with both semi-commercial and strictly commercial production systems. In fact, family farms in this study were used for only family consumption purposes, and normally, the flock size should be small. Previous studies in Nigeria reported that flock size with less than 200 poultry was found in family farms (Geidam et al., 2011). However, flock sizes higher than 500 chickens were found in both family and commercial farms (Esiobu et al., 2014). A report in Cameroon on the traditional poultry sector revealed the flock size within the range of 4,000-10,000 broilers and 2,000 to 5,000 layers per farm (Ekue et al., 2000; Fongang Fouepe et al., 2017). Broilers were more representative in TCP, followed by layers, while backyard chickens were less. The high representativity of broilers could be explained by the short time of production (six weeks) compared to the production times of the backyard (at least 4 months) and layer (at least 18 months). Muhammad et al. (2010) and Maduka et al. (2016) reported the presence of a higher number of broiler farms than layer farms but more layers represented the TCP in stocking capacity. Chickens were mainly housed on a deep litter during the survey and this could be explained by the fact that the litter is cheaper and available. This observation was reported in previous studies conducted in Nigeria (Muhammad et al., 2010; Geidam et al., 2011; Maduka et al., 2016).

Biosecurity is an important tool for the limitation of disease outbreaks and economic losses as earlier mentioned by Conan et al. (2012) but in the present study, the level of awareness on biosecurity amongst the surveyed chicken farmers was too low. This lack of awareness about biosecurity could be explained by the fact that the majority of chicken farmers were not trained in poultry farming. Poultry farms with trained farmers had a lower mean BS than farms with untrained farmers. During training on poultry production, farmers become aware of biosecurity measures and their importance to prevent the occurrence of some common diseases.

In fact, biosecurity involves a set of measures known as biosecurity measures that can be used for farm classification according to the biosecurity score system. In the present study, biosecurity was attributed to each biosecurity measure, leading to the classification of chicken farms surveyed in two groups according to the USAID (2009) biosecurity score system. These two groups include moderate and high-risk levels. This classification could be justified by the weak awareness of farmers on biosecurity as observed during the survey. Maduka et al. (2016) reported different results in Jos, Nigeria, where chicken farms were classified as good, very good, and excellent according to BS. Nigerian farmers had a good knowledge of the basic biosecurity measures needed for day to day running of poultry farms especially the ones dealing with sanitation of the farm (Ajewole and Akinwumi, 2014). Diseases were the major constraints in investigated farms as a result of a failure in biosecurity implementation. Small-scale chicken farms were at a high-risk level, probably because their flock sizes were small, they did not care about it and the economic loss could not be important. In addition, Negro-Calduch et al. (2013) reported that biosecurity measures are rarely applied in small-scale production units. In the present study, the flock size and the training level of the farmer were major reasons for not complying with certain biosecurity measures. This observation can be justified by the simple fact that failure in biosecurity was remarkable in chicken farms of small flock sizes where farmers were not trained. Furthermore, chicken farms hosting small flock sizes were mostly classified at high risk.

It was also noted that farms located in the Centre were mainly in proximity to humans compared to those in the other two regions, but the movement of people and other animals as well as allowing vehicles inside the gate were observed in the three regions. Several studies identified the proximity of poultry sheds to humans, roads or water bodies, and the movement of objects people and other animals in and out of the sheds, allowing vehicles inside the gate as risk factors for H5N1 outbreaks (Ahmed et al., 2012; Gilbert and Pfeiffer, 2012; Osmani et al., 2014). Failure in biosecurity implementation was remarkable in isolation of apparently sick chickens and functional footbath at the entrance of poultry house in the west region. In the present study, the low percentages of positive responses on biosecurity measures, such as vehicles drove into farm premises without washing and disinfection, farmworkers living outside the farm premises in the majority of farms, separation of chickens according to the type and age, and the use of second-hand equipment, were important components of risk factors. The occurrence of disease outbreaks within the last three months of the present study was one of the consequences of this failure to comply with biosecurity measures. This consequence could be great as several chicken farmers in the three regions investigated affirmed to consult veterinarian only in case of a problem. Other risk factors associated with disease outbreaks were receiving visitors to the farms, rodent-proof, on-farm carnivores, absence of good storage facilities, and non-realization of on-farm necropsy. Receiving visitors to the farms and farm workers living outside the farm premises were risks reported in Nigeria by Fasina et al. (2011), Wakawa et al. (2012), and M'etras et al. (2013). These risks could have serious implications on the spread of contagious poultry diseases by people as well as being of public health importance regarding zoonoses such as avian influenza as reported by Abdurrahman et al. (2016). In this present study, it was observed that failure in biosecurity implementation was associated with the number of chickens in the farm, thus more important was the flock size, more attention was paid to the biosecurity although farms of all flock sizes were at risk. The mean BS was higher in the West region than that in the other regions. Similarly, Kouam and Moussala (2018) revealed a higher BS for poultry farmers from the West region. A previous study reported that farmers have greater experience in the West (Ngandeu and Ngatchou, 2006). In addition, the capital city of the West region, Bafoussam, is the headquarter of the Cameroonian Association of poultry production professionals known under the acronym of IPAVIC. Thus, West region farmers are supposed to be more endowed with the latest information and innovations in poultry production compared to farmers in the other regions.

Poultry farming is a growing sector in Cameroon and contributes to income-generating (Esiobu et al., 2014; Maduka et al., 2016; Fongang Fouepe et al., 2017), and its products constitute good sources of proteins of high quality and other nutrients for human nutrition (Altan et al., 1993; Seuss-Baum and Nau, 2011). Failure in biosecurity measures could lead to disease outbreaks, causing mortality and important economic losses (Conan et al., 2012). Moreover, disease outbreaks result in the improper use of veterinary drugs, leading to the occurrence of their residues in chicken products (Guetiya et al., 2016; Gondam et al., 2016). It could also lead to drug resistance and transmission of diseases from one farm to another, one animal species to another, and from animal to human.

CONCLUSION

Three chicken farming systems, including family, semi-commercial, and commercial, are applied by chicken farmers in Cameroon. Chicken production generates both incomes and nutrients of high quality but biosecurity measures are not well-practiced and implemented, and this can lead to disease outbreaks and widespread use of veterinary drugs for disease control, resulting in drug resistance and residuals of veterinary drugs in chicken products. It is, therefore, urgent to put in place a good management system that will contribute to increase farm productivity and provide safer chicken products to consumers to fulfill the potential of chicken farming as an engine for the development of Cameroon.

DECLARATIONS

Authors' contributions

Fabrice De Paul Tatfo Keutchatang designed the research protocol, collect data, and drafted the manuscript under the guidance of Gabriel Medoua Nama and Germain Kansci. Data were analyzed by Fabrice De Paul Tatfo

Keutchatang and. Isabelle Sandrine Bouelet Ntsama All activities were coordinated by Gabriel Medoua Nama and Germain Kansci. Finally, all authors read and approved the final edition of the manuscript.

Competing interests

The authors declare that there is no conflict of interest

Acknowledgments

We acknowledge the cooperation of the chicken farmers who took part in this investigation because they believe that research and collaborations with scientists are an essential step to ensure the quality and safety of products consumed.

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