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HAEMATO-BIOCHEMICAL CHANGES AND PREVALENCE OF ZOONOTIC BACTERIA ISOLATED FROM MARKETED INDIGENOUS CHICKENS IN KIAMBU COUNTY, KENYA

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ABSTRACT

This study investigated the safety status of indigenous chicken sold in markets of Kiambu County Kenya, mainly for human consumption and the likely associated haemato-biochemical changes. Thirty chickens were purchased from the county markets, the body condition assessed and manifesting clinical signs recorded. Swabs for bacteriology using conventional methods, were aseptically taken from the cloaca, oropharynx, liver and spleen. Forty-seven percent (47%; 14/30) of the chicken were in a poor state, 43% (13/30) in fair, and only 10% (3/30) exhibited good body condition. Ten bacteria genera were identified from 244 isolates in the four organs. The cloaca had (102/244; 41.8%), the oropharynx (113/244; 46.3%), the spleen (22/244; 9.0%) and liver (7/244; 2.9%). *Escherichia coli* were the most prevalent (93.3%) while *Serratia* and *Pseudomonas* were the least prevalent (3.3%) each. Relative to normal values the mean basophil and band cells were significantly high ($p=0.05$; $p=0.001$) in chicken with bacteria in the liver. Both mean serum ALT levels ($p=0.0005$) and mean Band cells value ($p=0.0014$) were significantly high in chicken with bacteria in the oropharynx. This study demonstrated that the marketed chickens were carriers of known pathogenic and zoonotic bacteria, example; *Escherichia coli*, *Streptococcus agalactiae*, *Listeria monocytogenes*, *Campylobacter coli* and *jejuni*. Presence of bacteria in the liver and spleen indicated bacteremia which may contribute to alteration of haemato-biochemical parameters of sub-clinically infected chickens. These findings are expected to facilitate and encourage hygienic handling of poultry meat to avoid cross-infection and co-infection, and use of clinical-pathology to measure poultry health status for enhanced disease diagnoses.

KEYWORDS: Bacteria isolates, indigenous chicken, zoonoses, market cross-infection, haemato-biochemical.

INTRODUCTION

Poultry, primarily chickens, are the most extensively reared livestock type worldwide and the most abundant species (Permin and Hansen, 1998; Kingori *et al.*, 2010). Their products have been reported as one of the most vital and preferred source of animal protein for man worldwide (Permin and Hansen, 1998). The global population of poultry is projected at approximately 16.2 billion, of which 71.6% is in developing countries (Nduthu, 2015). More than 80% of human population in East Africa lives in rural areas, with more than 75% of these keeping indigenous chickens (Kingori *et al.*, 2010; Nduthu, 2015; Ahmed, 2018). Kenya has an estimated population of over 37.3 million domesticated birds. Among these, 31.578 million (84.6%) are indigenous chickens, 3.1 million (8.3%) are layers and while 2.1 million (5.6%) are broilers. The remaining 0.522 million (1.4%) constitute other poultry species (MOLFD, 2007). Despite the large proportion of chickens kept in rural areas, there is scarce data published on research findings in rural poultry health and the likelihood of its contribution to zoonosis.

According to Ahmed (2018), the major challenges encountered in poultry production include disease, predation, feed shortage and scarcity of information on appropriate indigenous poultry health practices. Co-infections including concurrent diseases are a common finding in poultry production. This is often subclinical bacterial infections accompanied by ecto- and endo-parasite infestations.

Some bacterial diseases of chicken are of importance, resulting in high mortality under rural conditions (Permin and Pedersen, 2002). These include diseases caused by *Escherichia coli*, which affect all ages, but especially chicks; non-typhoid salmonellae, which affect all ages, but mainly chicks (*Salmonella pullorum* in chicks less than 3 weeks of age and *Salmonella gallinarum* in growers and adults). Others include *Pasteurella multocida* in growers and adults; *Avibacterium paragallinarum* causing Infectious coryza in growers as well as adults; *Clostridium perfringens* in all ages, but mainly in growers; *Mycobacterium avium* in adults; *Mycoplasma gallisepticum* and *Mycoplasma synoviae* in all ages.

Methods of indigenous chicken production, mostly backyard or free-range systems, entail low biosecurity measures. Hence, a high risk of infectious diseases including zoonoses (Conan *et al*., 2012). Examples of infectious bacterial diseases of poultry with zoonosis importance include: campylobacteriosis, listeriosis, mycobacteriosis, collibacillosis, salmonellosis and staphylococcosis (Whitehead and Robert, 2014; Nga *et al.,* 2019). Campylobacteriosis is a top foodborne zoonosis globally, frequently linked with handling and consumption of poultry meat. Various studies have shown that *Campylobacter* organisms cause a significant burden of human disease in low to middle-income countries (Carron *et al.,* 2018).

Most of *Echerichia coli* strains occur as commensals in gastro-intestinal tract of animals and humans, however, some that have shown pathogenicity to varying degrees. The most important is enterohaemorrhagic *E. coli* (EHEC), particularly the O157:H7 serotype which causes hemorrhagic diarrhea and kidney damage in humans. Septicemia due to *E. coli* is also a severe, potentially deadly disease of fowls and humans (WHO, 2018; Wigley *et al*., 2013; Kaper *et al.,* 2004; Ratnam *et al.,* 1988).

Salmonellosis is another problem globally for both animals and humans. Most of *Salmonella enterica* serotypes infect many animal species causing disease and diarrhoea in humans. The most significant foodborne *Salmonella* serotypes are *Salmonella* Typhimurium and *Salmonella* Enteritidis in terms of number of cases and severity of infection (Wigley *et al.,* 2013). This study investigated the safety status of indigenous chicken sold in selected markets of Kiambu County Kenya, mainly for human consumption.

Haematological and biochemical parameters are good indicators of the health assessment for both animals and humans and yet they are rarely used. Sub-clinical bacterial infections may be contributing towards morbidity losses experienced by poultry farmers. It is, therefore, of interest to monitor changes in haemato-biochemical parameters of marketed chickens to establish their respective levels as some of these parameter-changes could be associated with bacterial infections. Limited studies have been done on assessment of clinico-pathological parameters in poultry disease diagnoses (Permin and Pedersen, 2002; Wamboi *et al.,* 2020).

The purpose of this study was to determine safety and health statuses of marketed indigenous chickens. Determine the prevalence of pathogenic and zoonotic bacteria prevalence in sub-clinically infected, marketed indigenous chicken, and the probable associated haemato-biochemical changes. Results of this study are projected to add towards and encourage use of clinico-pathological parameter analysis in assessing poultry health status. Second, creation of awareness to; 1) farmers on the risk posed by disposing off sick birds by selling them to ignorant consumers in the markets, 2) purchasers of respective chickens for consumption to ensure the meat is properly cooked prior to consumption, 3) handlers of poultry meat to observe strict hygiene, where possible to wear protective gear so as to minimize contamination and infections, and 4) chicken farmers purchasing for restocking to ensure the new stock is isolated/quarantined and treated appropriately before mixing with other farm birds to avoid introduction and spread of the bacterial diseases.

MATERIALS AND METHODS

Study area

This study was conducted in three chicken markets (Wanginge, Uthiru, Gitaru) located in Kabete and Kikuyu Sub-Counties of Kiambu County, Kenya; they were taken as representatives of the County due to the large numbers of chicken sold in these markets. The physiographic and natural land conditions of the study area are as described in Kiambu Agriculture, Livestock & Fisheries 2018-2021 Strategic Plan (Anonymous, 2018). Kiambu County was selected for the study because the chicken markets in Kabete and Kikuyu sub-counties are conveniently in close proximity to the Faculty of Veterinary Medicine, University of Nairobi that was the analysis site. Furthermore, the major poultry markets in Kenya are located within Kiambu County (Kothari, 2004).

Study design

A purposive sample taking design was used for the study. This was based on convenient sampling where chickens were obtained from purposively selected market centres. The study was cross-sectional. Thirty indigenous chickens were randomly selected and purchased from the three chicken markets. The sample size of study chickens was calculated based on the formula by Martin *et al* (1987) and Kothari (2004). Market distribution of the birds was: 12 (Uthiru), 12 (Waginge) and 6 (Gitaru). Information on the possible origins of the marketed chickens was captured through administration of a simple questionnaire to the chicken traders. All the chickens were transported alive and untethered in cages, immediately after purchase, to the

Department of Veterinary Pathology, Microbiology and Parasitology, University of Nairobi (UoN) where they were physically examined before and after being killed humanely; then samples were aseptically taken for bacterial isolation and identification.

Ethical approval
The Faculty of Veterinary Medicine Biosafety Animal use and Ethics Committee (BAUEC) approved this study; approval number is REF: FVMBAUEC/2018/177.

Determination of body condition of chickens
The body condition was as reported by Wamboi et al. (2020). The method used for scoring was as described by Gregory and Robins (1998); the scoring scale ranged from 0 to 3 based on prominence of the keel bone.

Sample collection, handling and transportation
After external physical examination and killing of the chicken, cloacal, oropharyngeal, hepatic and splenic swabs were taken for bacterial isolation and identification. Sampling was done in strict asepsis using sterile bacteriology swab under Bunsen burner flame. The swabs were placed in Stuarts transport media, labelled and immediately transported to the bacteriology laboratory for processing (McVey *et al*., 2013).

Bacterial isolation and characterization
Primary culture was done on Sheep blood agar (SBA), MacConkey (MAC) agar, Cystine Tellurite blood agar (CTBA), incubated aerobically for 24 hours at 37^0 C. Culture was also done in Campylobacter Agar Base (Karmali) mixed with Campylobacter selective supplement (Karmali), SR0167E, incubated under micro-aerophilic condition at 37^0C for 48 hours (Oxoid, Kenya manufactured Media) for isolation of *Campylobacter spp*.

Sub-culture was done following primary culture to obtain pure colonies of the isolated bacteria. From MAC, all non-lactose fermenters were sub-cultured onto Salmonella Shigella Agar (SSA); all lactose fermenters were sub-cultured onto Eosin Methylene Blue (EMB) Agar. From SBA all the colonies were sub-cultured onto nutrient agar for biochemical test analysis (Markey *et al.*, 2013; Pohjola, 2017). The isolated *E. coli* were further cultured on Sorbitol MacConkey Agar and characterization done to specifically check for presence of the serotype O157:H7; Enterohaemorrhagic *E. coli* (EHEC).

Identification of bacterial pathogens was done centered on growth pattern and colony features on primary, selective and differential media. Additionally, Gram stain, IMViC, Catalase, Oxidase, Urease and motility tests were done according to standard test procedures for identification of isolates (Steubing, 1993; Mathan *et al.*, 2013). *Streptococcus* organisms were confirmed through growth on Sodium azide crystal violet blood agar (SACVBA), while respective species differentiation was done through Christie, Atkins and Muench-Peterson (CAMP) test, as described by Bae and Bottone (1980).

Listeria spp. was isolated using the selective medium Cysteine tellurite blood agar (CTBA) after refrigeration at 4°C overnight (Bae and Bottone, 1980; Njagi *et al.*, 2004). Members of genus *Campylobacter* were detected using polymerase chain reaction (PCR) technique after culture of the organism (Miller *et al*., 2006). Other bacteria were characterized through biochemical tests after culture.

Analysis of haemato-biochemical parameters
Haemato-biochemical parameters analysis was as reported by Wamboi et al. (2020). Haematological parameters were analysed as described by Coles (1976) and Dacie and Lewis (1991), while biochemical parameters were analysed as described by Doumas (1975), Bergmeyer et al. (1978) and Sakas (2002).

Data management and analysis
Data was entered into Microsoft Office Excel 2016 spreadsheets. It was cleaned then verified as correct entries from the data collection book. The data was imported into Statistical Package for the Social Sciences SPSS version 22 (Corp, 2013). Percentages of occurrences of isolated bacteria were calculated out of the total bacterial isolates. A critical probability of 0.05 was adopted throughout as a cut-off point for statistical significance.

RESULTS

Origin of the marketed indigenous chicken
The chicken being sold at the various markets of Kiambu County from where the study birds were purchased, had been supplied from the various Sub-Counties of Kiambu County that is; Limuru, Ndeiya and Gatundu and others were supplied from Bomet County.

Body condition and physical examination findings of the study chickens
On physical examination, 47% of the chickens were found to be in poor body condition, 43% were fair and only 10% were in good body condition (Wamboi *et al.*, 2020). Table 1 below presents the various clinical manifestations and their corresponding body conditions.

Table 1: Various clinical manifestations and their corresponding body conditions as observed on the study chickens.

Body condition	Diarrhoea		Respiratory distress		Wounds		Deplumage	
	n=30	%	n=30	%	n=30	%	n=30	%
Poor	8	26.7	12	40	16	53.3	1	3.3
Fair	5	16.7	12	40	12	40	1	3.3
Good	0	0	0	0	0	0	0	0
Total affected	13	43.3	24	80	28	93.3	2	6.7

Bacteria isolated from various chicken organs

Total number of isolates were 244; from oropharynx 46.3% (113/244), cloaca 41.8% (102/244), spleen 9.0% (22/244), and liver 2.9% (7/244). Ten bacterial genera were identified, of these, six were identified to species level. Their respective prevalence was as illustrated in Table 2.

Table 2 : Prevalence of bacteria isolate types from various organs and sites in the study chickens.

Bacterial isolate types Number	Organ/site from which bacteria were isolated							
	Cloaca		Oropharynx		Spleen		Liver	
(n=30) for each organ/tissue	Number	%	Number	%	Number	%	Number	%
Escherichia coli	28	93.3	22	73.3	4	13.3	0	0
Staphylococcus aureus	6	20	16	53.3	4	13.3	2	6.7
Other *Staphylococcus*	10	33.3	20	66.7	6	20	2	6.7
Streptococcus agalactiae	0	0	1	3.3	0	0	0	0
Other *Streptococcus*	11	36.7	12	40	2	6.7	0	0
Proteus species	4	13.3	3	10	1	3.3	0	0
Bacillus species	13	43.3	7	23.3	0	0	0	0
Listeria monocytogenes	0	0	4	13.3	0	0	0	0
Other *Listeria* species	24	80	22	73.3	4	13.3	2	6.7
Serratia marcescens	0	0	1	3.3	0	0	0	0
Micrococcus species	0	0	3	10	0	0	0	0
Pseudomonas species	0	0	1	3.3	1	3.3	1	3.3
Campylobacter jejuni	4	13.3	1	3.3	0	0	0	0
Campylobacter coli	2	6.7	0	0	0	0	0	0
Total number of isolates (244)	102	41.8	113	46.3	22	9.0	7	2.9

Key: *n - chicken sample size and (%) - Percentage.*

Haemato-biochemical changes

The mean haematological and biochemical parameters that showed variation from normal documented range values were as reported by Wamboi et al. (2020). Chickens with bacterial infection in the liver had significantly ($p = 0.0001$) higher mean Band cells value (10.75%) than those without (1.88%). Basophil value was also significantly ($p = 0.05$) higher (0.75%) in those with bacterial infection relative to the non-infected (0.12%) Table 3.

Table 3 : Effect of presence of bacteria in the liver of study chicken on mean haematological parameters.

Haematology parameters	Liver bacteria isolates			
	Present	Absent	t-value	p-value
Haematocrit (%)	34.08	35.61	-0.55	0.5854
Erythrocyte count (× 104µl)	240.38	229.79	0.34	0.7360
Leucocyte count (× 103µl)	57.88	45.72	0.74	0.4660
Platelet count	42.75	35.39	0.48	0.6361
Lymphocyte (%)	36	31.58	0.63	0.5341
Monocyte %	14.75	15.93	-0.27	0.7920
Heterophil %	30.5	41.62	-1.35	0.1864
Eosinophil %	7.25	8.58	-0.32	0.7512
Band cells %	10.75	1.88	4.44	0.0001*
Basophil %	0.75	0.12	2.04	0.05*

*Key: *Significant difference at $p < 0.05$, (%) percentage, (µl) microliter.*

Presence of bacteria in the oropharynx showed a significant increase in the serum ALT mean levels ($p=0.0005$) and also a significant increase in the mean value of Band cells ($p=0.0014$). Presence or absence of

bacteria in the spleen and cloaca exhibited no significance difference on the tested haematological and biochemical parameters when their means were compared statistically. Presence or absence of bacteria in the liver had no significant difference on the biochemical parameters tested.

DISCUSSION

The study revealed that local, village indigenous chickens marketed in Kiambu County, Kenya, harboured both pathogenic bacteria and non-pathogenic bacteria some of which have zoonosis implication, including members of genera *Escherichia*, *Staphylococcus*, *Streptococcus*, *Listeria*, *Pseudomonas*, *Campylobacter*, *Proteus* and *Bacillus*. This is of great significance considering most of these chicken end up being consumed within the vicinity of Nairobi City County and its metropolitan residents.

It is notable that *Escherichia coli* organisms were the most isolated from the various organs and sites of the study chickens, which could be of public health concern. Despite most strains of this bacteria being normal flora within gastro-intestinal tract (WHO, 2018), some have been found to be pathogenic causing various forms of coliform infections in chickens and humans (Kaper *et al.*, 2004; WHO, 2018), that may result in various clinical symptoms ranging from mild diarrhea to serious hemorrhagic diarrhea and septicemia. Since village chickens are normally raised free-range, these bacteria are easily spread through faecal discharge within the homestead environment and could end up contaminating foods such as vegetables, some of which are eaten without cooking. This puts the village population at risk of contracting infections. Although *E. coli* serotype 0157: H7 has been documented as a cause of hemorrhagic diarrhoea and kidney damage in humans (Ratnam *et al.*, 1988; Kaper *et al.*, 2004; WHO, 2018), it was not isolated in this study. However, Bebora et al. (1993) recovered it from a case of septicaemia in chicks. This suggests that chickens could carry this entero-hemorrhagic serotype, thus a potential source of human infection. This could be a possibility from marketed indigenous chicken that are kept, transported, sold and handled with minimal or no biosecurity considerations.

The high prevalence of *Staphylococcus* among the bacteria isolated from the various organs and sites of the study chickens is an important consideration for consumers of indigenous poultry meat and products. *Staphylococcus aureus* is common in birds and commonly occurs in bones, tendon sheaths and leg joints (Cheville *et al.*, 1988). Devriese et al. (1983) reported presence of *Staphylococcus* organisms in processed poultry. *Staphylococcus aureus* is a key pathogen in humans that causes various clinical infections, being a primary cause of bacteremia and infective endocarditis. It is also a cause of osteoarticular, skin, soft tissue, pleuropulmonary, and device-related infections (referring to the host response to one or more microbial pathogen on or in an indwelling device/implant) in humans (Tong *et al*., 2015).

The isolation of *Streptococcus* organisms from oropharynx and cloaca of the study chickens can be explained by the previous report that this bacteria species is a normal intestinal flora of many avian species, including wild birds (Brittingham, *et al.*, 1988). The association of oropharynx and cloaca with the alimentary tract helps to confirm the reason for isolation of *Streptococcus*. Streptococcal infections in poultry can be localized or systemic resulting in septicemia; they can be acute or chronic. While septicemia may manifest as endocarditis and/or lameness in affected birds (Devriese *et al*., 2002; Chadfield *et al*., 2004), *Streptococcus*, especially *Streptococcus pyogenes*, or group A *Streptococcus* (GAS), causes mild infections such as pharyngitis and impetigo and serious infections such as necrotizing fasciitis and streptococcal toxic shock syndrome in humans (Walker *et al*., 2014).

Isolation of *Listeria monocytogenes* and other *Listeria* species from the study chickens that did not manifest any symptoms of disease was consistent with the findings of other investigators (Marsden, 1994; Zander *et al*., 1997; Njagi *et al*., 2004). This genus of bacteria can have strains that are potentially pathogenic. While other *Listeria* spp. were isolated from all the four organs sampled, *Listeria monocytogenes* was obtained from oropharynx, and only in four of the 30 study chickens, which was similar to the findings of previous studies done in Kenya (Njagi 2003; Njagi *et al.*, 2004). Previously, Njagi (2003) isolated *Listeria monocytogenes* from only 2 out of 40 indigenous chickens obtained from the market. However, in that previous study, Njagi (2003) did not isolate *Listeria* species from the cloaca, contrary to the current study in which *Listeria* were isolated from the cloaca of the study chickens at 80%. In humans, *L. monocytogenes* is the most important *Listeria* spp, causing pregnancy losses in healthy women, and septicaemia or central nervous system (CNS) disease in immuno-suppressed, debilitated, newborn or elderly persons (Saleh *et al.*, 2012).

Pseudomonas, though notably isolated at low prevalence from the oropharynx, spleen and liver of the study chickens, can be a serious poultry pathogen and a zoonotic bacterium especially *Pseudomonas aeruginosa*, as reported by Elsayed et al. (2016). Kebede (2010), in his study, established that *Pseudomonas* infection was associated with increased mortality in recently hatched chicks and embryos. This renders *Pseudomonas* infection a serious economic challenge in poultry farms. In chicken, *Pseudomonas* pathogenicity is associated with respiratory infection, keratoconjuctivitis, sinusitis and septicaemia and soared embryonic death rates in hatcheries (Saif *et al.*, 2003; Hai-ping, 2009). In humans, it is considered an opportunistic organism majorly associated with nosocomial infections that are difficult to

treat. It is also associated with a broad range of diseases such as urinary infections, burns, respiratory infections, and septicemia. It is the chief cause of ventilation-associated pneumonia in human intensive care units (Fazeli *et al*., 2012).

Campylobacter species, especially *Campylobacter jejuni*, have been reported as common isolates from faeces (Hughes and Rees, 1997) and this may explain isolation of *Campylobacter coli* and *Campylobacter jejuni* mainly from cloaca and oropharynx of the study birds. It has also been established that chickens are carriers of *Campylobacter* (Osano and Arimi, 1999), thus explaining the possibilities of isolating them from indigenous chicken. Isolation of *Campylobacter* is of major importance in chickens sold for consumption in the market owing to its zoonotic potential. *Campylobacter coli* and *C. jejuni* are among the most common causes of human gastroenteritis in the world. Although the food poisoning caused by the organisms can be severely debilitating, it is rarely life-threatening, but it has been linked with subsequent development of Guillain–Barré syndrome, which usually develops two to three weeks after the initial illness (Carron *et al.*, 2018; Fujimoto and Amako, 1990).

The high prevalence of bacteria isolates in this study, with some being pathogenic, may be attributed to non-observance of biosecurity and disease preventative measures during the rearing of the chickens at the farm-level as well the practice of mixed farming where the chickens are in close proximity with other domestic animals that could be shedding both pathogenic and non-pathogenic bacteria. The chickens may pick bacteria from the contaminated environment, including scavenging on manure and beddings of other domestic animals (Sanaa *et al*., 1993) and probably mixing with chickens from other neighboring homes. At the market, cross-infections from chicken to chicken is inevitable, as the chickens share cages/places prior to being sold.

Another study, investigating the same cohort of chickens for parasite carriage and hemato-biochemical changes (Wambui *et al.*, 2020) made observations that may support presence and occurrence levels of the bacteria in the study chickens. The study demonstrated that the birds were infested with endoparasites (nematodes - *Heterakis gallinarum*, *Sublura brumpti* and *Allodapa suctoria;* cestodes - *Raillietina echinobothrida,* Hymenolepi,s and protozoa - *Eimeria* species), ectoparasites (lice - *Menacanthus stramineus, Liperus caponis*, *Goniocotes gallinae*, and *Echinophaga gallinaceae* (stick-tight flea), and hemoparasites (*Leucocytozoon* spp., *Plasmodium* spp. and *Agyeptiniella* spp, *Haemoproteus* spp), which tend to cause stress to the birds through competition for nutrients, blood sucking and irritation (Magwisha *et al.*, 2002; Bala *et al.*, 2011; Tamiru *et al.*, 2014; Angyiereyiri *et al.*, 2015; Taylor *et al.*, 2015; Zeryehun and Yohannes 2015; Berhe *et al* 2019). Stress causes immune-suppression (Dhabhar, 2009), thus enabling bacteria to multiply and establish themselves. Observation of the various clinical signs when the birds were examined at the market place (poor holding conditions, signs of diarrhea, respiratory distress) is indication that the birds had underlying diseases; some deliberately being disposed by the farmer for economic reasons selfishly even after they noticed that the birds were sick, which would take advantage of unsuspecting buyers in the market. The significant changes depicted in the tested haemato-biochemical parameters are also an indication of disease in the chickens. However, there is a need for controlled studies to expound on the association of blood haemato-biochemical parameters and bacterial infection in domestic chickens.

Bacterial isolation from the spleens and livers is an indicator of the chickens being sick (bacteraemia/septicaemia); meaning that these birds are sources of virulent bacteria, some of which can cause disease to humans, on consumption. Mohammed (2014), in his study, documented isolation of *E. coli* from liver of naturally infected chickens. This was also shown in an experimental study done on turkeys by Arp (1982), while Bebora et al. (1979) isolated *Salmonella* organisms from livers of naturally infected chickens. This, therefore, is an alert that some of the chicken sold in the markets may be sick and owners are disposing them to avert loss through death of the chicken. Buyers purchasing chickens for consumption should therefore ensure proper inspection and cooking prior to use of their meat for food. Chicken(s) purchased for restocking should, be isolated/quarantined and treated appropriately before mixing with the other birds, in order to avoid introduction and spread of the bacteria and respective diseases to existing stock in the farm. In addition, those handling and/or slaughtering the birds need to be made aware that they could acquire infections from the birds and be encouraged to wear protective clothing while at work.

CONCLUSION

Some of the indigenous chickens sold in markets are clinically sick, as indicated by isolation of bacteria from the liver and spleen (bacteraemia or septicaemia) during the study. The chickens harbor bacteria of economic and public health importance.

- Some of the bacteria isolated from these indigenous chickens and which are of public health importance include: *Escherichia coli, Campylobacter coli, Campylobacter jejuni, Listeria monocytogenes,* other *Listeria* spp., *Staphylococcus aureus,* other *Staphylococcus* spp. and *Serratia marcescens*
- The marketed birds were stressed, as a result of co-infections with parasite burden coupled with rough-handling during transportation and holding time in the market, as indicated by presence of wounds on their bodies.

RECOMMENDATIONS

- Creation of awareness to chicken traders and consumers of the possible infections that can arise from indigenous chickens being sold in the markets.
- Training of chicken traders as well as small-scale farmers on available control strategies against bacteria, especially those of zoonotic and economic importance.
- Creating awareness on humane handling of the birds as they are taken to the market. Apart from harming the birds, stress causes immune-suppression, thus allowing higher multiplication of bacteria resident in the birds.
- Development and enforcement of a policy addressing strict poultry meat inspection as well as proper cooking of chicken meat or products. This is to ensure that marketed chickens and/or their products are safe for human consumption.
- Regular disease control including deworming and practice of biosecurity procedures in rearing of indigenous chicken to promote health and reduce incidences of co-infections.
- There is a need for controlled studies to expound on the association of blood haemato-biochemical parameters and bacterial infection in domestic chickens.

CONFLICT OF INTERESTS

All authors declare that they have no conflict of interest.

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