KNOWLEDGE, ATTITUDE AND PRACTICES RELATED TO MICROBIAL SAFETY AMONG STREET POULTRY PROCESSORS IN EMBAKASI, NAIROBI COUNTY, KENYA

BY ARON KING'UYU KITONYI

A56/12623/2018

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF THE DEGREE OF MASTER OF SCIENCE IN FOOD SAFETY AND QUALITY

DEPARTMENT OF FOOD SCIENCE, NUTRITION AND TECHNOLOGY

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

2022

DECLARATION

This dissertation is my original work and has not been submitted for award of a degree in any other university.

Date: _18th August 2022

Signature: ____  _____

The work is submitted with our approval as university supervisors:

Prof. Michael W. Okoth.

Department of Food Science, Nutrition and Technology, UoN

____  18th August 2022

Signature Date

Dr. Lucy Njue

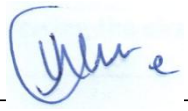
Department of Food Science, Nutrition and Technology, UoN

_____  _____18/082022_____

Signature Date

Dr. Josphat N. Gichure

Department of Food Science, Nutrition and Technology, SEKU

_____  _____ _____18th August2022_____

Signature Date

PLAGIARISM DECLARATION FORM FOR STUDENTS

UNIVERSITY OF NAIROBI

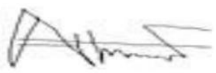
NAME: ARON KING'UYU KITONYI
REGISTRATION NUMBER: A56/12623/2018
FACULTY: AGRICULTURE

DEPARTMENT: FOOD SCIENCE, NUTRITION AND TECHNOLOGY

COURSE NAME: MASTER OF SCIENCE FOOD SAFETY AND QUALITY
TITLE OF THE WORK: KNOWLEDGE, ATTITUDE AND PRACTICES RELATED TO MICROBIAL SAFETY AMONG STREET POULTRY PROCESSORS IN EMBAKASI, NAIROBI COUNTY, KENYA.

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this dissertation is my original work and has not been submitted elsewhere for examination, award of a degree, or publication. Where other people's work or my work has been used, this has properly been acknowledged and referenced per the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work.
4. I have not allowed, and shall not allow anyone to copy my work to pass it off as his/her work
5. I understand that any false claim in respect of this work shall result in disciplinary action, per University Plagiarism Policy.

Signature:  Date: 18th August 2022

DEDICATION

I dedicate my study to my lovely Dad Albanus Kitonyi King'uyu, for his continuous support in my academic progress and advancements.

To my family and all friends, I highly acknowledge and appreciate all the help I have received from you. For my lovely mother Eunice Mbinya, lovely wife Pascaria Muthiani, sister Grace and Lucky your support was helpful. To my lovely and able son Theophilus King'uyu, thank you for being a motivation to me.

All those who made a contribution and provided guidance for this study feel appreciated and may God bless you.

ACKNOWLEDGEMENTS

To the Almighty God for giving me the strength and wisdom for this study be honor and glory.

To my supervisors: Prof. Michael W. Okoth, Dr. Lucy Njue and Dr. Josphat Gichure for your supervision guidance and support I am quite grateful.

I highly appreciate all those who willingly participated in the study by choosing to honestly answer the questions and provide samples for analysis.

TABLE OF CONTENTS

LIST OF TABLES.

LIST OF FIGURES.

ABBREVIATIONS

ANOVA	Analysis of Variance
CFU	Colony Forming Units
FAO	Food and Agriculture Organization
ISO	International Organization for Standardization
KAP	Knowledge, Attitude and Practices
ODK	Open Data Kit
pH.	Potential hydrogen
SPPSS	Statistical Package for Social Sciences
TVC	Total Viable Count
WHO	World Health Organization
KEBS	Kenya Bureau of Standards
HACCP	Hazard Analysis and Critical Control Point
CCP	Critical Control Point
QMRA	Quantitative Microbiological Risk Assessment

DEFINITIONS OF SOME TERMS USED IN THIS DISSERTATION

Poultry: Any bird that is domesticated and considered to be edible bird.

Carcass: Body a slaughtered bird after bleeding and dressing.

Poultry processor: Any individual who participates in modification of original state of poultry products to a new or modified state.

Street foods: Mass consumed ready to eat foods that include beverages intended for immediate consumption or consumption at a later time without further processing or preparation (FAO, 2012).

Hazard Analysis Critical Control Point (HACCP): A systematic approach to identifying, evaluating, and controlling hazards.
Critical control point (CCP): A step in the process in which the control measure is applied to prevent a significant food hazard to an acceptable level and defined critical limits are measured.
Critical limits: The maximum or the minimum value set for a chemical, physical and biological hazard for the CCPs.

Knowledge: Being familiar with or having an understanding of something.
Consumer: A person who buys goods and services for their own use or benefit.
Operational prerequisite programs: Control measure that is applied to prevent a significant food hazard from happening.

GENERAL ABSTRACT

Microbial contamination on poultry meat poses safety concerns to consumers and on commercial view, spoilage bacteria also play a bigger role towards economic losses. Control may depend on the awareness and behavioral traits of the processors. This study aimed at exploring knowledge, attitudes and practices related to microbial safety among poultry processors in Embakasi, Nairobi County, Kenya.

The study was based on a cross sectional design using a structured questionnaire that was administered to 136 randomly selected street poultry processors in Embakasi, Nairobi County, Kenya. Thirty samples were collected at different processing stages and from different processors for total viable count microbial tests.

The majority of respondents (82%) were aged 25-30 years, mean age was 28.9 (SD = 5.4). Everyone in the study was aware that consumption of unsafe food can cause illness. In general, the processors had high knowledge (90.8%) on microbial safety. The three least knowledgeable respondents scored 44.4% correct answers on knowledge on food safety of the administered questions. The respondents had positive attitude towards food safety with 74.6% being the average of the right attitude. The lowest score on attitude on food safety was 62.5% for two respondents. The respondents had an average of 74.6% on the right practices' questions asked. Having participated in food safety training, higher experience in poultry processing and higher education level as compared to level of knowledge was associated with practising more preventive behaviours and having the right attitude.

For the processors with knowledge of more than half (>50%) the microbial results show that the total viable count on the final product was within the allowed limit for ready to eat products. Processors with knowledge slightly less than half (<45%) the end product was found to have total viable count more than the allowed limit for ready to eat products. Attitude and Practices were found to have little significance on the microbial load; however, it was noted they were directly proportional to the knowledge level.

The total viable count was found to decrease by average rate of 76% during processing with washing after evisceration being critical stage towards the reduction. Temperature of more than 75^0C for 1 minute was found to be critical in elimination of the microorganisms. The elimination of microorganisms was more effective in events where chlorinated water was used. PH was of little significance as there was minor deviation of PH of the water used during processing for most of poultry processors.

This study provides information about knowledge, attitude and practices regarding microbial safety among poultry processors in Embakasi, Nairobi. It is clearly evident in this study that level of knowledge has positive impact on the practices, attitude of processors and eventually microbial contamination. It highlights the importance of targeting lack of knowledge for improving on food safety among the processors. The results of this study will form a useful base for training for poultry processors.

CHAPTER ONE: INTRODUCTION.

1.1 Background information

Live poultry is a carrier of micro-organisms contaminated in feathers, interstitial track and skin (Cunningham, 2016). According to Cunningham (2016), micro-organisms commonly associated with poultry products include but not limited to *Campylobacter* species, *Listeria monocytogenes*, *Escherichia Coli and Salmonella* species. Standard operations procedures in poultry processing should have effect in lowering the level of micro-organisms at each processing stage. According to Ştiinłifice *et al.*, (2011), gastro-enteritis diseases have been a global problem mainly resulting from consumption of contaminated foods. Meat and meat products are not only an important source of protein but can also be a contributing factors of gastro-enteritis (Ştiinłifice *et al.*, 2011). Poultry meat poses a great risk to human health as prior study at Kenya have shown prevalence of *Salmonella* species and *Campylobacter* species on products at the market level ready for human consumption (Mageto *et al*., 2015).

Microorganisms form part of the intestinal micro flora of chicken and are considered harmless to the bird (Reich *et al.*, 2018). Prior slaughter, inspection is carried out by veterinary officer to assess the wellness of the birds. However, mostly birds don't show sign of illness by the general microorganism and it becomes impossible to isolate the carrier animals from non-carrier ones before slaughter. During slaughter cross contamination occurs and microorganisms are spread all over the carcass (Shange, 2015) and to other birds that were not initially contaminated. Cross contamination cab be contributed by processing equipment, wash water, food handlers, storage conditions and processing parameters. Microbial load may also increase above critical limits due to leaving the processed meat for long after slaughter (Kassa *et al*., 2010).

Consumption of any food contaminated with microorganisms or their toxins results to food poisoning which in some cases can be a serious adverse health condition (Jay *et al.*, 2019), the contamination may arise from poor preservation methods, cross-contamination from food contact surfaces and equipment, unhygienic food handling practices, or from the food handlers who harbor microorganisms in their body.

A production process should be able to eliminate hazards that the food may pose to consumers. This has not been the case as studies have shown prevalence of these microorganism in already fully processed raw poultry products at market level (Mageto *et al*., 2015). This implies that wrong techniques and insufficient sanitation programs are being applied during processing. Considering that street poultry processors use simple procedures and without much consideration on the standards procedure contamination can be escalated posing a greater risk to consumers.

This study KAP study was conducted to determine the drawback that led to microbial contamination. Assessment of the level of awareness, knowledge, practices and attitudes of poultry processors will form a training base for future trainings focused on improving food safety among street poultry processors. The processing parameters at different processing stages were also evaluated in order to determine the standard operating procedure for poultry processing.

Total Viable Count (TVC) is a microbial hygiene indicator can therefore be used to monitor the hygienic conditions along the food processing chain. It estimates the concentration of microorganisms such as yeasts, molds and bacteria. A High TVC indicates poor hygienic conditions during food processing. Foods are also classified into three categories as sampling plans may differ depending on if the food will be subjected to a lethal treatment of *Salmonella* from time of sampling to the time of consumption. Poultry and poultry products lie on category II of foods. Category II foods are those foods that are meant to be consumed by adult populations and won't be subjected to a lethal treatment that kills *Salmonella.*

1.2 Statement of the problem

Poultry processors lack adequate empirical information on efficiency of different interventions during chicken processing (Ştiinłifice *et al.*, 2011). Process parameters such as pH, temperature and time have been seen to have an impact on the control of micro-organism on poultry meat (Keerthirathne *et al.*, 2016). Prior studies have shown occurrence of micro-organism on raw poultry in market level at high levels (Mageto *et al.*, 2015). This implies that the interventions at processing line are not fully effective.

There is a great health risk for consumers of street vended foods. The street processing environment is normally unregulated and unhygienic posing a great risk of the streets foods

contamination. These foods however, play an important role in delivering cheap, nutritious and convenient food to urban dwellers. Food-borne illnesses associated with consumption of poultry meat include Campylobacteriosis. Various studies indicate that *Campylobacter* causes substantial human disease burden in low to middle – income countries including Kenya. The specific data regarding epidemiology data of food borne-illness associated with poultry meat for Kenya is scarce. In sub Sahara Africa, 25% of 3.8 million deaths cases of children under 5 years of age happening annually are caused by diarrheal disease and food borne illnesses are the most contributing factors.

Studies have determined prevalence of these microorganisms in the end poultry products (Mageto *et al.*, 2015) to be between 33-64%. However, online testing has not been taken into consideration to determine the impact of each processing stage on the level of general micro-organisms. With a known impact of each processing parameter at all stages of poultry processing it would be easy to control the process and optimize results. Most poultry slaughterhouses lack standard decontaminations methods that eliminate the microbial risks though they may be committed to reducing microbial contamination. This study focused on addressing these gaps to improve on food safety of street processed poultry products.

1.3 Justification of the study

Zoonosis is one of the less prioritized risk in most of less developed countries (Frings *et al.*, 2018). Most of food borne illness may go unnoticed and only a few cases may be reported. This makes it hard for disease surveillance teams to gather data in control of disease and cases of food-borne illness continue to occur. Most food-borne illness will disappear after sometime even without treatment and people may not even seek treatment. This study seeks to control the microbial risks associated with poultry products that occur during processing.

In a food processing facility, trainings strengthen food handling practices and food safety aspects (Chotinun *et al.*, 2021). However, it does not always change behaviour for everyone in the processing line (Jenpanich, 2015). Intrusive factors and hindering factors should always be considered in order to change practices in a food processing facility. KAP study was conducted to quantify and measure incidents by use of questionnaires and statistical processing of the

information collected. The results by KAP study can be used by trainers in order to address the lack of knowledge and awareness among personnel during processing.

Given the increasing consumption and demand of poultry products (Shibia *et al.*, 2017) it is necessary to facilitate poultry processors with information to curb the risks associated with microbial contaminations of poultry products. This study was conducted to establish activities that happen during slaughter and parameters at which they are carried out to establish their effect on microbial levels of the carcass. Factors in each stage was considered and their impact on the microbial level.

White meat is associated with more health benefits than red meat and consumption patterns are slowly shifting to white meat (Shibia *et al.*, 2017). Over time, poultry production will increase and there will be need for safe control measure during poultry processing.

1.4 Aim of the study

This study will contribute to upgrade the quality of street poultry products and minimize the microbial risks associated with consumption of street poultry products.

1.5 Purpose of the study

To assess efficiency of interventions on microbial levels on the carcass at different processing stages among street poultry processors in Embakasi, Nairobi County.

1.6 Objectives

1.6.1 Main objective

The main objective is to assess knowledge, attitude and practices related to microbial safety among street poultry processors in Embakasi, Nairobi County, Kenya.

1.6.2 Specific objectives

i. To establish the street poultry processors' knowledge, attitudes and practices on food safety in Embakasi, Nairobi County.
ii. To determine the effects of different processing parameters and conditions at the different processing stages among street poultry processors in Embakasi, Nairobi County.
iii. To assess microbial safety of street processed poultry products in Embakasi, Nairobi County.

1.7 Research questions

i. What is the street processors' knowledge, attitudes and practices towards achieving food safety during processing of street poultry products in Embakasi, Nairobi?
ii. What are the effects of different processing parameters and conditions at each stage of poultry processing among the street poultry processors in Embakasi, Nairobi County?
iii. What is the microbial safety of street processed poultry products in Embakasi, Nairobi County?

1.8 Assumptions

i. The processors provided accurate information on the interventions used: including antimicrobials concentration.
ii. The KAP survey score has impact on microbial level contamination.

1.9 Limitations

i. There was challenge of permission by producers as they tend to see the study as ruin of their business.
ii. Microbial analysis was expensive and financial constraint was a challenge limiting number of analyzed samples.

CHAPTER TWO: LITERATURE REVIEW.

2.1 Poultry farms

Poultry keeping should be ranked on higher end amongst the farm economic activities which provide reasonable and stable income to poor households of small and marginal farmers. While a substantial improvement took place in the poultry farming industry in Kenya over the last two decades (Kamau, 2018), little seemed to have happened by way of small poultry for small people. Perhaps the usual story of agricultural advancement taking place for the rich farmers and those doing it for commercial purposes then the poor remaining outside the mainstream happened in the poultry also. Very large farms on the outskirts of Nairobi and at several other places are living evidence of the above.

The practices applied at poultry farms during poultry production have impact on microbial contamination of the birds. Birds from different farms have varying microbial contamination levels depending on the conditions of the farms (Trampel *et al.*, 2014). Factors such as feeds, hygiene of the farm, bird stress, age and knowledge of the farmer affect these microbial levels.

2.2 Poultry slaughter

Good Manufacturing Practices and Good Hygiene Practices are important in ensuring only quality poultry meat leaves the slaughterhouses. In Nairobi large scale poultry slaughterhouses have modern systems while small-scale processors use convectional systems to process poultry (Kamau, 2018). The conventional systems or “old system” has no stunning, slaughter on the floor/surface and no chilling system or temperature control. The poultry slaughter process starts with beating at the poultry head or stabbing at neck to kill the bird in most advanced large scale poultry slaughter houses(Trampel *et al.*, 2014). In Smallscale processors bleeding usually takes more time as the bird may not have passed stunning and is still struggling and body organs utilizing blood. The struggle and bird stress at this stage have their impact on the microbial contamination for instance, struggling leads to blood spillage and the bird touches unintended surface. Scalding technique used is by pouring boiled water over the carcass for feathers removal, more than one carcass can be dipped in the water and usually the water is used for

number of birds before discarding(Trampel *et al.*, 2014). The most considered factor for discarding the water used is low temperature such that is no longer effective for de-feathering. The carcasses are then cut and eviscerated and split the carcass on the floor or table.

In modern system, birds normally arrive to slaughter houses in cages, crates or containers. After arrival they are rested for 1-3 hours but 2 hours is the most recommended (Trampel *et al.*, 2014). This is because at 2 hours the best quality meat will be obtained. Less than 2 hours the glycogen concentration will still be high and longer than two hours the ph. raises leading to darker meat. Feeds should not be given to the birds during the resting period. This helps in reducing the fecal matter in the intestine of the birds. However, small scale and street poultry processors have food in the bird cage all the time as they are not sure if they will slaughter the birds at the end of the day. These processors only slaughter upon order and food withdrawal will starve the birds.

During the waiting period inspection is carried out by authorized veterinarian. Generally, the health of individual bird cannot be singled out on large scale processing as the inspector generally emphasize on obtaining the health status of the whole flock (Trampel *et al.*, 2014).

The birds are then automatically or manually unloaded into stunning channel. There are two different stunning methods; electric stunning in which electric current is passed through the head of the bird and use of a controlled atmosphere e.g., carbon (IV) oxide.

Bird can then be bled automatically or manually. It is usually done by single sided cut or double-sided killer. Bleeding takes place in a bleeding tunnel for 3mins 30 seconds. About 35% to 50% of the blood comes out of stunned birds, with the rest remaining mainly in the organs. Feather Removal /Scalding; the birds stay on the shackles. Birds are scalded (immersed in hot water) to loosen the feathers. Heat breaks down the protein holding the feathers in place. Soap may be added to water to facilitate de-feathering and picking of the feathers in a later stage. Mechanical picker is used to remove the feathers at the right temperature. It takes about 30 seconds to pick with the right temperature (Trampel *et al.*, 2014). In some cases, the picker breaks the wings. Heads are removed by catching them between two guide bars. Tension obtained also removes the esophagus and the trachea.

To eviscerate manually, a circular cut is made around the vent and body opened to draw out the internal organs. The kidneys and lungs remain inside because they are hard to remove. Lung

removers or scrapers are used to force water into the body cavity and loosen up the embedded organs, allowing them to be removed easily.

Inspection is carried out on all carcasses to help in grading the products. The carcass is then washed with chilled chlorinated water.

The carcass temperature is lowered quickly to prevent microbial growth. Soaking the carcass in chilled water is the most common method of chilling poultry. At this stage the carcass is ready for packing but may undergo further processing such as grading, deboning and cutting.

2.3 Sources of microorganisms in poultry products

Natural source of contamination of poultry carcass is feathers, skin, feet and digestive track (Marmion *et al.*, 2021). The internal tissues are usually sterile for all health birds. The carcass can also be contaminated by the environment: soil, sewage, water, processing equipment, packaging material, personnel and air.

The professionalism and expertise of the abattoir's personnel is a key influential factor for the quality of produced carcass. For instance, gut removal should be done in a manner to prevent rupture that could lead to contamination of the meat.

Processing equipment's may harbor a number of microorganisms. Some equipment's are complicated and bit hard to clean. Some parts of processing equipment such as mechanical holders are made up of rubber and microorganisms are like to build up on them.

Water used during processing may be source of microbes and also a media of cross contamination.

The processing environment may contain aerosols which contaminate the carcass during processing.

The slaughterhouse personnel can also be source of microbial contamination as the handle the product along the line of processing.

Packaging material can also contaminate the final product after processing.

2.4 Knowledge, attitudes and practices in slaughterhouses on microbial quality/KAP study

It is responsibility of everyone in the processing facility to handle food in a manner that doesn't cause contamination of the product. Food borne illness indicates failure of the people along the food chain at some point failing to adhere to safety practices. According to Dias *et al* 2017, more than half (50%) of food borne illness originates from improper handling of food.

Practices such as proper hand washing lower the risk of contamination during processing. It is the responsibility of the management to ensure it trains the employees on the health practices and activities that lower the risk of microbial contamination. However, the employees may be aware of the good practices they should follow during processing but have attitude that is against them (Chotinun *et al.,* 2021). This implies that they will be just theories among them and will not put them into practices out of their will. This call for important assessment of their attitude and a study to identify the areas that are failing in order to give the trainers the correct data for improvement (Jenpanich, 2015).

World Health Organization (WHO) has documented 'five keys to safer food manual', (WHO, 2006). The five key areas include; keep clean, separate raw and cooked foods, cook thoroughly, keep food at safer temperatures and use safe raw material and water. This manual serves as a good guidance that governs practices towards safer food.

2.5 Intervention methods for microbial contamination control

In poultry slaughterhouses temperature and time are the major control parameter of contamination. Short time processing reduces the contamination occurrence while chilling immediately after processing reduces microbial load. In some cases, wash water is treated with antimicrobials to reduce microbial load. Temperature is also used to denature and kill micro-organisms (Ontario F., 2021).

Cleaning and disinfection of all surfaces that will come in contact with the food are also important intervention methods (Tove S., 2011). Cleaning is normally the prerequisite process proceeding sterilization or disinfection which involves physical removal of contamination that doesn't necessarily kill microorganisms (Ontario F., 2021). It mostly involves use of physical

means to manually remove dirt visible by eyes using water and rinse water. Disinfection on the other hand, involves use of agents that destroy germs and other harmful microbes or deactivates their normal vegetative state and non-resistant bacteria spores (Ontario F., 2021). Sterilization is use of chemical or physical means that destroys all forms of microorganisms. Food processing facilities employ the above three method impact on food safety (Ontario F., 2021). However, different approaches and procedures are used on different occasions and facilities (Ontario F., 2021).

2.6 Meat control act in Kenya as applied on poultry products

Meat Control Act is an act of parliament to enable control to be exercised over meat and meat products intended for human consumption and over slaughterhouses and place where such neat is processed (Meat Control Act., 2012).

It is a requirement that all poultry products meant for human consumptions are subjected to ante mortem and post mortem inspection (Meat Control Act., 2012). The scalding tank water should be replaced and on continuous flow to prevent build-up of contamination (Meat Control Act., 2012). Plucking machines should not litter the feathers and plucking should be in such a way that they a collected and stored on a separate container (Meat Control Act., 2012). Evisceration troughs are required to be constructed of stainless steel or any other suitable surface that doesn't facilitate microbial contamination (Meat Control Act., 2012). Inedible products should be stored on well-fitting and leak proof containers (Meat Control Act., 2012).

Material found not fit for consumption after processing should be kept on a separate room securely and disposed regularly (Meat Control Act., 2012).

2.7 Informal markets: social-economic and environmental impacts

Street products processors are small scale entrepreneur that form part of the informal sector. Like other players in the formal sector, they play a key socioeconomic role. Restaurants are termed as formal sector players (Makita *et al.,* 2012). In Kenya the informal sector has grown into a lucrative trade that competes with the formal sector. The sector offers a good income source for developing entrepreneur with only a minimum outlay capital. This low-cost opportunity of self-

employment serves as a good bridge for poverty alleviation and also a major food security factor among the urban dwellers.

Street processed foods offer affordable nutritional status to a section of urban population such as workers, shoppers, travellers and school children. In 1991, a study at Morocco showed that through consumption of street processed food consumers were able to obtain daily requirements for a meal (Dawson and Canet, 1991).

Given the increased rural to urban migration in developing countries, many towns have turned to melting pots of ethical groups that bring their cultural food eating habits that on the informal sectors can offer. The ethnic groups benefit from the sector and obtain the virtue of feeling different from the large ethnic population.

Despite the positive impact of the sector to the community, they also offer negative impacts. It has been identified in this study that some of the processors and vendors are children who are supposed to be going to school. This field also exposes the youth to negative vice such as drug abuse leading to high rates of juvenile delinquency. They have also been associated with dumping garbage carelessly on the environment as observed in the present study. However, the major contribution to this problem is poor infrastructure that the processors don't have accessible waste disposal method or area.

Most of these facilities are located along the walk ways and have led to increased overcrowding of the streets by blocking pedestrians' walk ways. The increased congestion led to disturbance on traffic and interference of city planning.

This sector is very viable and has high economic importance and that means if it is to be sustainable better control measures should be put in place.

2.8 Public health issues associated with street processed ready to eat foods

Consumption of poultry meat in Kenya is predicted to increase from 120.68 thousand metric tons in 2018 to 164.6 in 2030 (Shibia et al., 2017). The poultry products in the current market have been associated with microbial risks. However, producers are aware of the risks but lack empirical information on control them (Cunningham, 2016). This study aims to facilitate

information on microbial risks at each processing stage and the impact of various processing parameters on the microbial load and how they can be mitigated to improve the process.

Microbial contamination in poultry starts as early as in the incubation stage (Trampel et al., 2014). The hatcheries may be contaminated with pathogenic bacteria which spread through air (Lazarov et al., 2018). However, there are no existing microorganisms in the tissues of health animal (Marmion et al., 2021). According to Marmion et al 2021, microorganisms are found in feathers, skin, feet and interstitial track of the animal. Microorganisms enter digestive track of the poultry by consumption of contaminated feeds (Kariuki et al., 2019). These microorganisms then infect the carcass during slaughter (Mageto et al., 2015). All birds may not be contaminated prior processing but during processing cross contamination is likely to occur and the whole batch ends up contaminated. The amount of contamination depends on the processing environments conditions and the method of processing. Storage condition is also important factor on the level of contamination of the carcass.

The microorganisms and their toxins can at later stage be consumed by human causing poisoning and infection on them. The processing stages of poultry meat include several stages and at each stage the microbial risk is likely to occur (Cunningham, 2016).

To assure food safety of streets vended foods, they ought to be a well-planned urbanization and support facilities. This has not been the case upon rapid growth of this sector and this has lead to numerous challenges and safety concerns associated with these foods.

Consumers of these foods are mostly concerned about convenience rather than food safety (Mensah *et al.*, 2012). In previous studies (Masupye and Von-Holy, 2000, Lues *et al.*, 2006, and Dawson and Canet, 1991), it was observed that hand washing was usually done in one or more pan without use of soap, waste disposal was poorly done along the streets and around the processing environment harbouring a good source of flies and rodents in the processing environment, foods were not fully covered or protected from dust and thus contamination, safe temperature as described in WHO five keys could not be maintained and were greatly violated.

Street processors are capable of producing safe foods with low bacterial counts but the processors are not aware of the training programs and processing procedures they should

embrace (Martins, 2006 and Lues *et al.,* 2006). Some of the processors that are aware of the programs are ignorant of the practices regarding food safety (Lues *et al.,* 2006).

2.9 Hazard Analysis Critical Control Points (HACCP).

The use of the HACCP system as a food safety assurance tool and its short comings are discussed.

2.9.1 HACCP as a food safety assurance tool

HACCP is a cost-effective food safety assurance tool that is preventive in nature. Lack of resources and limitations by traditional processing methods has accentuated the need for HACCP. HACCP is used as a scientific tool that identifies, assess and control hazards along the food chain to ensure food is safe. It terms a safe food as a food that doesn't present an unacceptable risk to health of the consumer (Makita *et al.,* 2012).

HACCP is an online tool that incorporates end product testing into the design of the food chain/processing providing a preventative control approach. HACCP system is based on seven principles:

i. Conducting hazard analysis;
ii. Identifying control critical points (CCPs);
iii. Establishing critical limits for the identified CCPs;
iv. Establishing corrective actions;
v. Establishing verification and monitoring procedures;
vi. Documentation of the process.

When developing HACCP plan, all potential hazards are identified and put to consideration. Then its potential hazards that are essential to control are determined. Here a risk-based hazard assessment, quantitative microbiological risk assessment (QMRA) is adopted for accurate determination (Makita *et al.,* 2012).

2.9.2 HACCP system shortcomings

As already mentioned above the HACCP system doesn't have a good risk assessment tool in the process that requires determination of essential potential hazards and has to incorporate other tools of risk assessment.

HACCP is a cost-effective tool and its implementation is demanding. It's a common-sense approach to food safety. Implementation of HACCP in small and medium sized facility is likely to face insurmountable issues that jeopardize the efficiency and effectiveness of the system (Makita *et al.,* 2012). Lack of expertise for small micro enterprise (SME) is also a bigger challenge.

2.12 Knowledge gaps

The governments in developing countries are increasing their support and funding to widely available farmer's market. This bid aims on improving farmer's market access and increasing direct to customer's sales of the farmed products. Poultry products are among the favoured farm products and their sales have increased and further processing evident along the streets and areas with readily available market. On the other hand, many consumers expect to have higher quality, safe and 'fresh' foods from these markets. Although these developments may have a positive economic impact it is still questionable whether these food increase food safety risks due to the way they are produced and sold.

Food-borne diseases are an important cause of morbidity and mortality, and a significant impediment to socioeconomic development worldwide, but the full extent and burden of food-borne diseases can adequately inform policy-makers, allowing them to allocate appropriate resources for food safety control and interventions efforts.

To prevent food-borne illness, it is necessary to understand how food becomes unsafe and what proactive measures can be taken to ensure food safety. In this context, the study aimed on evaluating the processors' knowledge, attitudes and practices on food safety. Microbial quantification will be done to identify if the microbial interventions in place yield best results.

The numerous knowledge gaps identified in this study and previous study, will offer unique opportunity for extension personnel to offer training and outreach poultry processors. Street poultry processors form a distinct connection among the local consumers, farmers and local governments in a way that generates numerous benefits for each party.

Streets food sector have not been perceived as a major public health risk. Local authorities perceive them as undesirable in most cases and a temporary structure that will disappear after sometimes on the course of development.

This study will contribute to upgrade the quality of poultry products and minimize the microbial risks associated with consumptions of poultry products.

CHAPTER THREE:

FOOD SAFETY KNOWLEDGE, ATTITUDE AND PRACTICES RELATED TO MICROBIAL SAFETY AMONG STREET POULTRY PROCESSORS IN EMBAKASI, NAIROBI COUNTY, KENYA

Abstract

Urbanization and population growth have led to rapid growth of street vended foods especially in areas with low-income status. This field however, due to limited regulation, has led increased the food safety risks associated with the street processed foods. The current study sought to establish the contribution of knowledge, attitudes and practices among poultry processors in Embakasi, Nairobi Kenya towards microbial safety of their products.

An exploratory study consisting of cross-sectional survey in which structured questionnaire (appendix 1) was administered to the poultry processors at Embakasi, Nairobi.

Processors were highly knowledgeable on food safety with an average score of 90.8%. Processors' attitude and practices were lower with an average score of 74.6% and 74.6% respectively.

There are key failures for practices that affect food safety of street poultry products despite having knowledge on what should be done. The attitude of the processors is low hence affecting their practice on food safety. Training should be done with aim of in-depth explanations on importance of each process and notes are available to refer over time for the processors. Care should also be taken to evaluate the external factors affecting the performance of the processors on food safety despite higher knowledge.

3.1 Introduction

Street vended foods are processed and cooked in an open-air environment and that makes them prone to contamination. Predictors of microbial contamination are; presence of flies, litter around the processing environment, unclean working surface and processing equipment, processors hand

washing practice after touching contaminated surfaces during processing, lack of enough clean water and lack of adequate clothing among the processors.

Street vended poultry products are much affordable and therefore high consumption especially in informal settlements (Makita *et al.*, 2012). There are innumerable challenges of microbial safety of these street processed poultry products and therefore their safety assessment should not be overlooked. Poultry products have high water content and thus harbor microorganisms and facilitate rapid multiplication to levels beyond acceptable levels of ready to eat foods which should be less than 5Log CFU/g according to KEBS, FAO and ISO standards (Lues *et al., 2006*).

Unhygienic practices among the poultry processors, lack of food safety knowledge, negative attitude towards food safety and processing parameters can lead to microbial contamination. Street processed poultry products are exposes to food hazards especially microbial according to a study by Oguttu, 2015 in South Africa. Consumers take the ready to eat products without the knowing the fact that the safety of the products has not been guaranteed.

This study determined the real condition among the processors with a goal of identifying the gaps that compromise food safety. This will be a very essential reference to efforts of reversing the current situation.

3.2 Material and methods

3.2.1 Study site

The study was conducted in Embakasi, Nairobi County ($01^0$18'S, $36^0$55'E). It is located at east of central business district as shown in figure 3.1.

It is highly and fast developing area in Nairobi County. It is in Embakasi where the main airport in Kenya; Jomo Kenyatta International Airport which has been operational since 1958 is located. It contains more than a third of the Nairobi industrial area. Embakasi serves as an inland container depot hosting the standard gauge railway and ICD.

It incorporates areas of Dandora, Donholm, Pipeline, Kariobagi, Kayole, Njiru, Ruai, Umoja, and Mukuru kwa Njenga. Embakasi is a sub county in Nairobi that borders Langata, Starehe, Makadara, Kamukunji, Mathare, Ruaraka, Kasarani and parts of Machakos county. It covers

208km^2. It has been split into: Embakasi South, Embakasi North, Embakasi Central and Embakasi West constituencies.

The primarily languages are the Kenya national languages i.e., Swahili and English. Embakasi is a very ethnically diverse city and most of the Kenya's ethnic groups reside here. There is also presence of international communities such as Asian, Somali and Europeans. The large population can be associated with job opportunities which have led to the growth of the area.

The sub county has many learning institutions of primary to tertiary level. It's a home of many national secondary schools and some of Africa best universities according to report by U.S. News and world report. The health sector is very developed with most hospitals.

Below is figure 3.1 showing the map representation of the study site.

Figure 3. 1: A map showing Embakasi, Nairobi County.

3.2.2 Study design

The study was exploratory consisting of cross-sectional survey in which snow balling technique was used to recruit more processors in the study. The data collected included: the demographics of the poultry processors, knowledge, attitudes and practices of the processors.

3.2.3 Study setting

Embakasi represents the study setting in which the survey was carried out. It consists of four constituencies as named in 3.2.1. It is part of Nairobi County that borders areas of Langata, Starehe, Makadara, Kamukunji, Mathare, Ruaraka, Kasarani and parts of Machakos county.

3.2.4 Study population

The study population included street poultry processors in Embakasi, Nairobi County.

3.2.4.1 Sample size determination

A total of 136 street poultry processors were used in the survey part of the study determined from previous similar studies and the number was found to be sufficient to make scientific conclusions.

The sample size was calculated as per Solvin's formula: (Mageto *et al*., 2015)

Sample size = $N/(1+N*e^2)$

Where:

e is the marginal error of 5%

N is the population size 206 obtained from previous study (Mageto *et al*., 2015).

$= 206/ \{1+206*(0.05^2)\}$

=136 Processors

3.2.4.2 Sampling criteria

Embakasi in Nairobi County was purposively selected due to its high population and the high economic growth that has led to rapid expansion of poultry consumptions and business. Poultry processors were randomly selected from all the four sub counties of Embakasi as shown in figure 3.2.

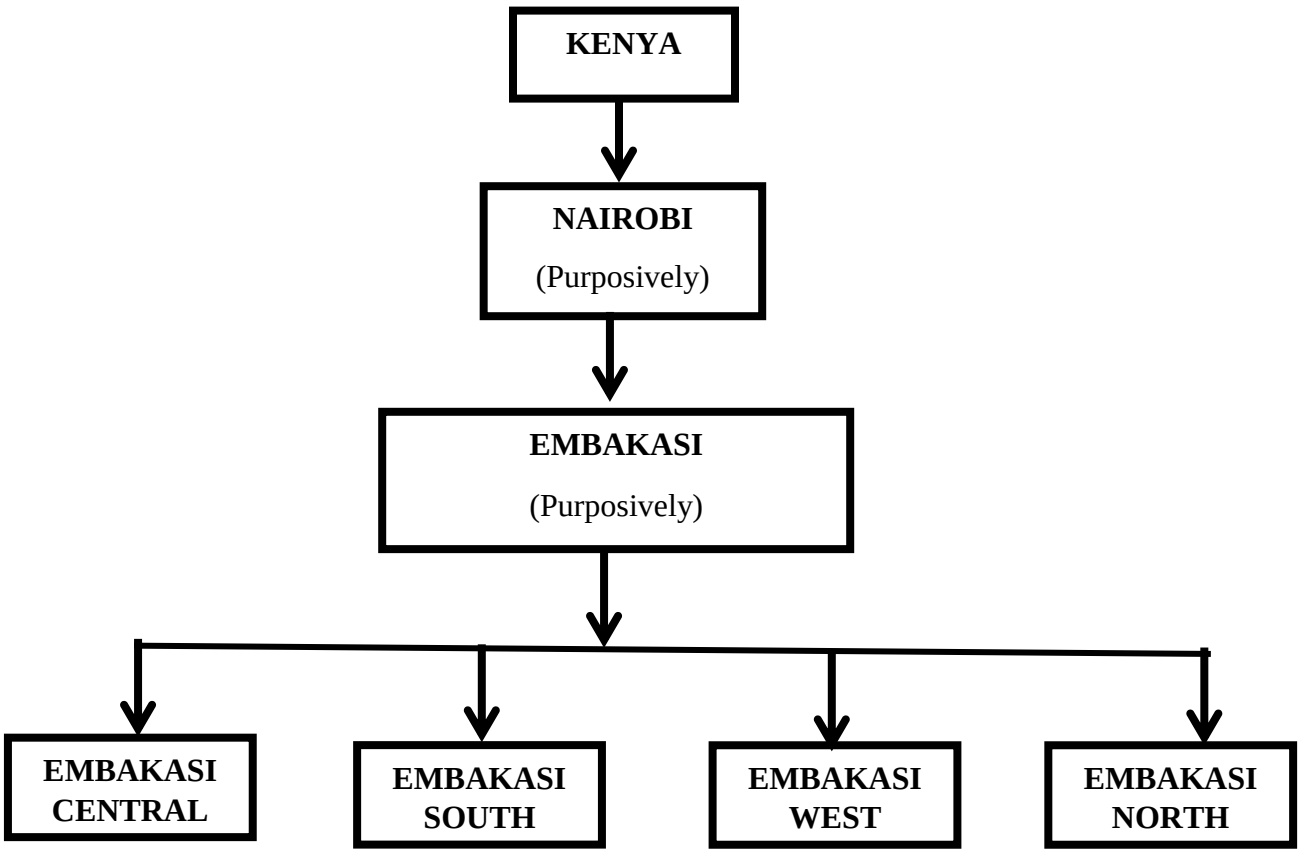


Figure 3. 2: Sampling Schema

3.2.4.3 Inclusion criteria

i. The study only included street chicken processors operating their business in Embakasi, Nairobi County. The processors were sampled no matter the area they reside from as long as they were doing the business within Embakasi, Nairobi County.
ii. The processor had to be of eighteen years of age and above to participate in the study.
iii. The processor had to be Swahili or English literate in order to be able to interpret the questions administered.
iv. The processor had to voluntarily sign an ethical consent form in order to participate in the study.

3.2.4.4 Exclusion Criteria

i. Children, pregnant women, physically impaired and psychologically ill patients.
ii. Those not willing to sign the consent form.
iii. Those not able to understand or comprehend English or Swahili languages.
iv. Anyone who runs the processing facility but doesn't participate on the processing of the products.

3.2.5 Ethical consideration

i. The processors were issued with ethical consideration certificate signed by researcher and the processors read them and signed. The terms included the information provided not to be misused.
ii. Ethical approval was also given by Department of Food Science, Nutrition and Technology in University of Nairobi. Approval was also sort from Director of Veterinary Science to conduct and collect samples for the purposes of study only.
iii. Market county council officials and market chairpersons were also consulted to explain the purpose of the study before sampling commenced.
iv. A pilot study was conducted prior the study to test both the questionnaire and observation checklist. This offered the researcher opportunity to gain experience and skills on how to administer the study and fill the observational checklist without offending the respondents.
v. Throughout the study, researchers committed to treat the processors with respect and dignity and to ensure confidentiality of the information gathered, no names were recorded, instead, a special code was assigned to the processors for purposes of identification. However, the researchers introduced themselves to processors by their names but it wasn’t a requirement that the respondent give names. However, there were cases when the respondent said their names but they were not documented.
vi. The researchers were required to read loud the question on the questions as it was in English and interpret the question to the processors in elaborated explanation or Swahili to the processors.

3.2.6 Data Collection

A structured questionnaire (appendix 1) was used to collect data and was administered in a face-to-face interview with the processors at the processing facility. The questionnaire was polit tested (36 respondents) in the University of Nairobi's Department of Food Science, Nutrition, and Technology Pilot Plant to confirm that the questions were clear and well structured. The final version was validated in same plant and in consultation with research supervisors after the slight modifications adapted from the comments of respondents during pilot testing.

The study data collection was carried out between May 2020 and November 2020. The collection was done using the mobile application: Open Data Kit (ODK) to ensure accuracy of the data. Street poultry processors were selected by researchers placed in highly frequented streets, busy markets and areas around big institutions. The used the studied processors to recruit more processors in the study. The researchers also moved around most of the streets and identified and interviewed more processors. The objective of the study was explained to the processor and how they would benefit from the current study. Researchers used three days to familiarize themselves with the processor before data collection and during this time applied the snowball sampling technique to locate all processors in the study at the specific area. The processors during this time voluntarily signed the ethical consent form.

The study included two different questionnaires in which first questionnaire was administered or filled by the researchers on some points to determine if one is to be included in the study. Inclusion and exclusion questionnaire only served as a director of if to proceed with the study or not with that particular respondent. The second questionnaire was structured on four sections demographics, knowledge, attitudes and practices. Demographics: Section one was to collect data on respondent's demographics characteristics such as name, education level, age, period worked as poultry processor and food trainings participated at. Each of the three sections (knowledge, attitude and practices) had questions of general, waste management, personal hygiene, process control and observational checklist. Typically, it took 15-30 minutes for the researcher and processors to complete an interview.

The section on knowledge comprised 9 questions. The questions were close ended with only three possible answers; 'true', 'false' and 'do not know'. According to Lues *et al., 2006* for the

processors to be considered knowledgeable they should have answered more than two thirds of the questions correctly (i.e., $\geq$ 7 correct answers).

The section on attitudes compromised of questions. This section aimed at testing the complex mental state involving emotions, feelings, beliefs and values to act in a certain way or condition. The questions had five possible choices; 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree'. The processors who score less than 6 questions were considered to have a poor attitude whereas those above six ($\geq$6) were considered to have a good attitude towards food safety (Oguttu, *2015).*

The section on practices had 8 questions. The researcher observed and asked the questions to evaluate the respondent's score. There were 5 possible choices; 'never', 'rarely', 'often', 'sometimes', and 'always.' If during administering the questionnaire or during the study the researchers observed practice that was different from respondent answer, 'sometimes' was used as the choice. For evaluation, 'sometimes' and 'often' were considered to be those who know what should be done but don't always do it. 'Never' and 'rarely' were considered to be bad practices. 'Always' are considered to be those with good practices.

3.2.7 Data management and analysis

3.2.7.1 Quality control

The researcher familiarized themselves with the respondents three days' prior the study. This was to reduce fear and tension during interviews which may have led to falsification of information given. This time was also used to explain to the processor the objective of study and prepare them for participation. More processors in the area were also located.

Respondents were given a time of approximately 2 minutes to think and answer each question asked by the researcher during the study. Further clarification on question was offered to make sure the respondent understood the question.

Answers given by respondents were read out loudly by the researchers to confirm that was their intended answer and also ensure correct entry on the collection tool.

Before analysis data cleaning was employed to ensure the data collected was uniform and without extremes.

3.2.7.2 Data analysis

The survey data was analyzed using SPPS version 20. Frequencies and descriptive statistics such as average, standard deviation, minimum and maximum for the socio-demographics were obtained.

3.3 Results

3.3.1 Demographic characteristics

A summary of socio-demographic profile of the respondents is represented in Table 3.1. Of the 136 processors who participated in this study, the greater proportion of age bracket (15%) of the participants were 27 years old and average age was 29.05 ± 5.3294 years. Similar studies showed that most food handlers are at mid youth stage (Fortune *et al*., 2017). All the participants had attended school and approximately more than half (67.6%) of the participants in this study completed secondary education. Majority of the participants (39%) had 1-2 years of experience working in poultry processing and average length poultry processing experience was 2.28 ± 2.08 years.

Table 3. 1 Socio-demographic characteristics of poultry processors in Embakasi, Nairobi County (n = 136).

Characteristics	Percent %(n)	Mean ± SD	Range
Age in years			
<20	1.47% (2)		
20-25	18.38% (25)		
26-30	42.6% (58)		
31-35	25% (34)		
36-40	10% (14)		
>40	2.2% (3)	29.05±5.3294	28
Number of birds slaughtered in a day			
<50	85.3% (116)		
50-100	5.1% (7)		
>100	9.6% (13)	N/A	N/A
Type of bird slaughtered			
Broiler	38.97% (53)		
Broiler and cross breed	5.15% (7)		
Broiler and indigenous	2.2% (3)		
Broiler, cross breed and indigenous	3.7% (5)		
Cross breed	6.6% (9)		
Cross breed and indigenous	8.8% (12)		
Indigenous	34.6% (47)	N/A	N/A
Education level			
Primary	10.3% (14)		
Secondary	67.6% (92)		
Tertiary	22.1% (30)	N/A	N/A
Experience in poultry processing in years			
<1	26.5% (36)		
1-2	39% (53)		
2.1-3	14% (19)		
>3	20.6% (28)	2.2763±2.0761	12.9
Participation in any food safety training related to job			
No	50% (68)		
Yes	50% (68)	N/A	N/A

Half of the processors (50%) had received training related to food safety. All those who had participated in food training were as a result issued with food handling certificate by the training body. Most of the trainings reported 76% were offered by private and research institutions. Some participants (<3%) reported to have been holding food handlers' certificate without having participated in any food safety training related to the job. Most of the processors reported to be

processing all the types of the birds depending on customer needs however; indigenous birds were the most processed.

3.3.2 Poultry processors' knowledge on food safety

This study assessed processors' knowledge on general questions about food safety, personal hygiene, process control and waste management. Questions 1-3 were on general food safety knowledge, questions 4-5 were on personal hygiene knowledge, questions 6-7 were on knowledge on waste management, and questions 8-9 were on process control knowledge. All the processors were aware that consumption of unsafe food leads to food borne illness. Most of the processors (80.9%) knew that bacteria are naturally occurring in live poultry and it's the processing that determined the safety of meat. Nearly all the respondents (98.5%) were aware that water used during processing of poultry meat can lead to cross contamination. Nine out of ten (89.7%) respondents were aware that they should not have long nails or nail colorings when handling food. Nearly all the respondents (98.5%) knew that washing hands regularly during processing of food is part of personal hygiene. All the respondents were aware that cleanliness of the working environment influences the safety of the products. Eight of ten (80.15%) of the processors were aware that they should separate dirty zones and clean zones during poultry meat processing. About 8 of 10 (83.8%) of the respondents were aware that temperature and time combination are important factors in control of microorganisms. About 9 out of 10 (88.97%) of the respondents were aware of the vital stage during processing that can contaminate the poultry meat with pathogens if not taken care of.

The processors proved to be very knowledgeable on matters of personal hygiene and waste management. The awareness on such important matters is very appropriate this is because poor personal hygiene and poor working conditions can lead to cross contamination and eventually food poisoning (Cunningham, 2016). However, there is a great concern on hygiene as sanitation procedures were not in place for most processors and this could be a bigger threat and a contributing factor to poor hand washing.

On the other hand, the poultry processors were less familiar with process control. Eight of ten participants (83.8%) were aware of time and temperature combination application in control of bacteria during processing. Improper handling of food and the abuse of time temperature

combination, account for most food-borne disease outbreak. In the present study, respondents had insufficient knowledge on contribution of some processing stages on the meat safety and time-temperature controls. Similar results were reported in previous (Jenpanich, 2015) whose results show that knowledge of critical temperatures and holding time was insufficient amongst food-handlers.

Half (50%) of the participants self-reported to have received training lasting more than a week related to their job and food safety. All the training had been offered by private institutions mostly research institutions. Processors who had received food safety related training showed significantly greater ($p<0.05$) level of food safety knowledge. The education level was also significant ($p<0.05$) on the level of food safety knowledge. This may be attributed to the fact that education helps in on comprehending information on food safety, handling and hygiene. Table 3.2 shows a summary of knowledge on the above-named sections.

Table 3. 2Food safety knowledge among poultry processors in Embakasi, Nairobi (n=136)

Statement	**Response % (n)**		
	Correct	**Incorrect**	**Do not know**
Q1. Food-borne illness is caused by consumption of unsafe food.	100% (136)	**0**	**0**
Q2. Bacteria are naturally occurring in live poultry and it's the processing that determines the safety of meat produced.	80.9% (110)	6.6% (9)	12.5% (17)
Q3. Water used during processing can lead to infection.	98.5% (134)	1.47% (2)	0
Q4. Employee should not have long nail or nail colorings at work.	89.7% (122)	5.15% (7)	5.15% (7)
Q5. Washing hands regularly with soap is part of personal hygiene.	98.5% (134)	1.47% (2)	0
Q6. Cleanliness of the working environment determines the safety of the meat produced.	100% (136)	0	0
Q7. Processing line should separate clean zones from clean zones.	80.15% (109)	0	19.9% (27)
Q8. Time and temperature are important factor in control of bacteria during processing.	83.8% (114)	3.68% (5)	12.5% (17)
Q.9 Are there stages that can contaminate meat with pathogens.	88.97% (121)	6.62% (9)	4.41% (6)

Overall, the mean percentage of correct entries among the processors on knowledge of food safety was 91.17% (± 8.3), whereas the mean percentage of incorrect entries was found to be 2.8% (± 2.7). The overall mean of those who did not know/remember was 6.1% (±6.3). The figure below: figure 3.3 shows the overall summary of the processors' knowledge.

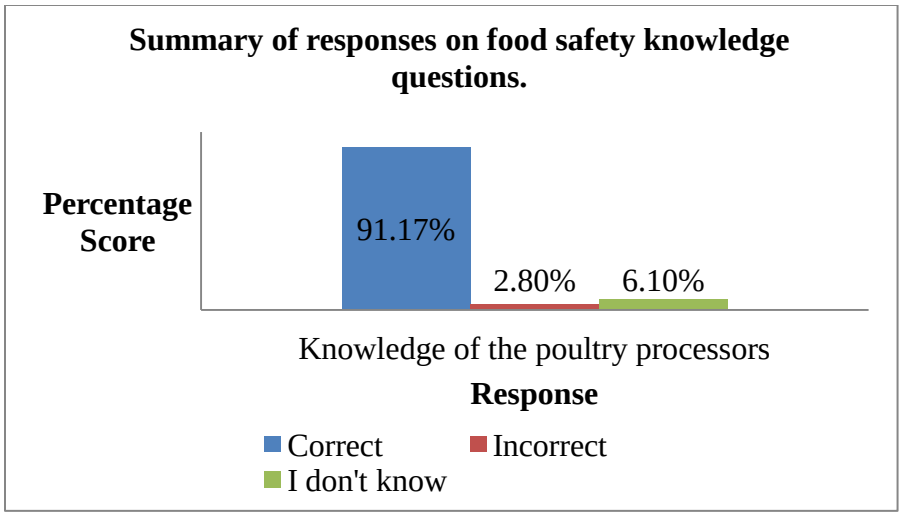


Figure 3. 3: Summarized processors' knowledge on food safety

This sheds light on the fact that the poultry processors of Embakasi, Nairobi County are knowledgeable about the facts related to food safety and hygiene. However, there is a red flag on key areas of knowledge that are very vital on processing such as time and temperature combination contribution towards killing of micro-organisms and the separation of clean and dirt zones.

3.6.3 Poultry processors' attitude on food safety

In order to maintain safe food handling practices there is a strong relation between the knowledge of food handlers, how they feel or what the value and their practices. For a positive change the processors should have a positive attitude towards prevention and control of food borne diseases (Kariuki *et al*., 2019.). The questions on attitude were formatted using a five-point Likert scale, in which a response of 5 indicated agreed, 3 as a neutral and 1 as disagree.

Majority of the processors (92.65%) agreed they will change their meat handling practices if they found out that it facilitates meat contamination. To most of processors (89.7%), producing safe meat is more important to them than producing tasty meat. Nearly all (99.22%) of the respondents believe good personal hygiene prevents food borne illness. A whole 96.32% of the respondents agreed that safe meat handling is part of their job responsibility. Nearly half (48.53%) of the respondents agreed that food processing facilities should be hiring cleaners and not use those handling products as cleaners. Although these workers still maintain cleanliness in the processing plant according to their response, they do it reluctantly and with no other option

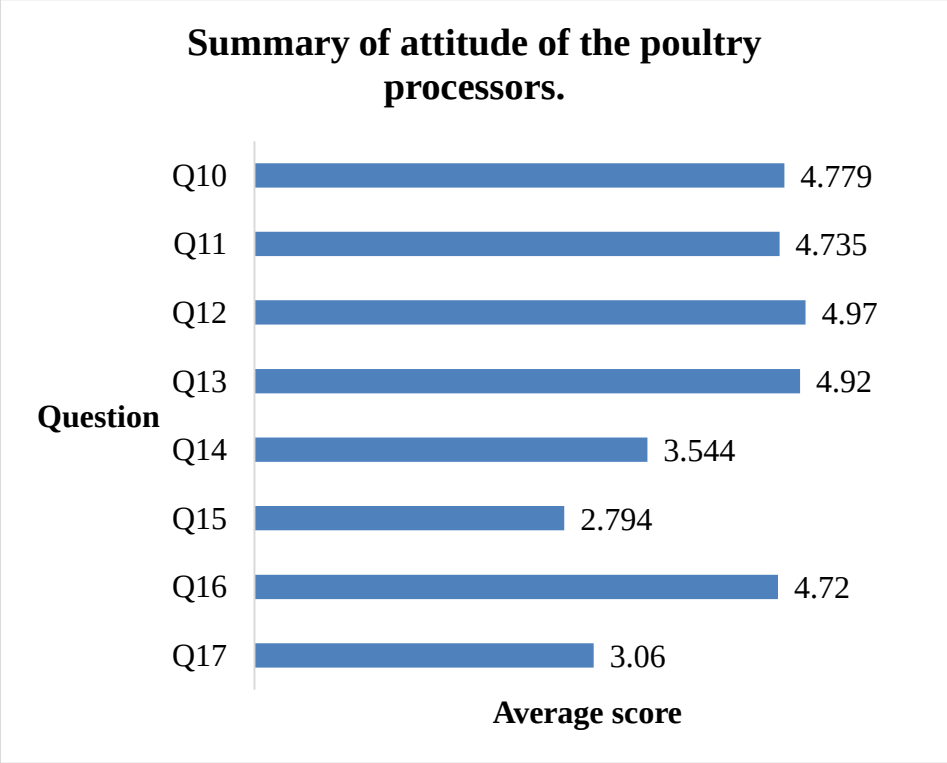
as due to cost saving. Some 46.32% of the respondents disagreed that it is only supervisors' responsibility to ensure that there is no litter in the processing floor. They believe it is everyone's responsibility to ensure clean working environment not wait for the bosses to direct. Most of those who agreed to this were the primary owners of the business and would not risk untidy working environment to lose customers. Most of the respondents (87.5%) believed that examination of flock prior slaughter reduces chances of contamination. They believed some birds may be sick and processing them with healthy ones would transfer microorganisms. They also described to separate any sick bird observed in the cages immediately the notice it to avoid transfer of disease to healthy birds. Examination of flock was reported to be useful in preventing outbreaks of bird diseases that would lead to high losses among the processors. The birds with observed abnormalities were kept separate under close monitoring and in some cases, medication given until the gain full healthy and later slaughtered. There were cases in which such birds would die. Less than half of the respondents (36.75%) disagreed that quality control is a simple job and does not require any expertise. This means they value the process control and would like it to be handled by professional experts. However, among all street processors there was no quality control personal specifically for that role. The processors were their own quality control and would seek some advice from other processors in case of unknown abnormalities. Table 3.3 shows the summary of the responses on attitude statements.

Table 3. 3Poultry processors' attitude towards food safety in Embakasi, Nairobi (n=136)

Statement	Response % (n)		
	Agree	Neutral	Disagree
Q10. I will change my meat handling practices if I find that they facilitate contamination of the products.	92.65% (126)	3.68% (5)	3.68% (5)
Q11. Producing safe meat is more important than producing tasty meat.	89.7% (122)	7.35% (10)	2.94% (4)
Q12. I believe good personal hygiene can prevent food borne illness.	99.26% (135)	0	1.36% (1)
Q13. Safe meat handling is part of my job responsibility.	96.32% (131)	3.68% (5)	0
Q14. The facility should hire external cleaners and not use workers as cleaners.	48.53% (66)	30.1% (41)	21.32% (29)
Q15. It is only supervisors' responsibility to ensure there is no litter in the processing flow.	36.02% (49)	17.6% (24)	46.32% (63)
Q16. I believe prior examination of flock reduces chances of contamination.	87.5% (119)	11% (15)	1.47% (2)
Q17. Quality control is a simple job and does not require expertise.	39.7% (54)	23.5% (32)	36.75% (50)

As far as attitude of poultry processors on food safety is concerned, the respondents had an average score of 74.6% of positive attitude towards food safety. The statements which recorded low positive attitudes are; company should not be using workers as cleaners they should be external cleaners hired (21.32%) this could be because most of the processors consider cost of the production and reported the profits to be low for sustainability of extra manpower. Also, there was negative attitude on it is only supervisors' responsibility to ensure no litter is in processing flow (36.02%) and upon further scrutiny those with the negative attitude were not primary owners of the business and did not consider it's a loss if business failed due to poor supervision.

Figure 3.4 below show the summarized processors attitudes towards food safety.



Q10: I will change my meat handling practices if I find that they facilitate contamination of the products. (N-136)

Q11: Producing safe meat is more important than producing tasty meat.

Q12: I believe that good personal hygiene can prevent food borne illness. (N-136)

Q13: Safe meat handling is part of my responsibility. (N-136)

Q14: The facility should hire external cleaners and not use workers as cleaners. (N-136)

Q15: It is only supervisors' responsibility to ensure that there is no litter on the processing floor. (N-136)

Q16: I believe that prior examination of flock reduces chances of contamination. (N-136)

Q17: Quality is a simple job and does not require expertise. (N-136)

Figure 3. 4: Summarized processors' attitude on food safety

3.3.3 Poultry processors' practices regarding food safety

Processors were interviewed on their practices regarding personal hygiene, food borne disease transmission, waste management and process control. The average score of those who always followed the right practices during processing was 74.6%. Getting medical examination as a requirement of food handling had the least score with only 47.8% of processors reporting to have always observed that. Most of the processors consider visiting hospital facility when sick but not for medical examination requirement for food handling.

It was observed more than half (52.94%) processors displayed their products open to areas which are prone to dust contamination. Dust serves as a vector in transfer of micro-organisms. Flies could also be observed in the processing site increasing chances of contamination of uncovered product. Some 9.8% of the processors did not cover dustbins with lids and kept them open through attracting more flies to the site.

Eight out of ten processors (84.6%) would report any abnormalities in the meat to other processors, farmer, supplier, their boss and regulatory bodies. What they considered abnormality was foul smell, discolorations, lesions or visible organisms. Three of ten of these processors had never encountered any abnormality in meat and hence never reported a case. Seven of the ten processors who reported any case to their bosses took advice/directives as given to them on the action taken on the meat.

Half of the processors (53.7%) kept their nails short and would remove any adjournment when handling meat as per of safety practice requirement of the job. Nails can harbor bacteria and facilitate contamination during handling of the meat. Seven out of ten (71.15%) of the processors who admitted never kept their nails short of removed adjournment when handling meat were ladies. The highlighted beauty as the main reason and defended their action by saying they kept their hand clean despite the long nails and adjournments. Three out of ten of those who never kept their nails short were men and the reported ignorance as the cause though most of them understood the needs for having short nails.

Hand washing with was reported to be nine out of ten processors (91.2%). There was number of processors who reported not to wash their hands regularly with soap during processing. Some of these processors considered wiping their hand with clean cloths, was on basin water without soap and with hot water. Most of these processors considered soap would easily interfere with the taste of the poultry product as there were likely to be transferred to the product.

Table 3.4 shows distribution among poultry processors on various practices.

Table 3. 4 Food safety practices exhibited by poultry processors (n=136).

No	Question	Always	Often	Sometimes	Rarely	Never
Q18	I get medical examination yearly as part of my job requirement	47.8% (65)	32.4% (44)	3.7% (5)	5.9% (8)	10.3% (14)
Q19	I report any abnormalities during processing that would render meat unsafe.	84.6% (115)	1.5% (2)	3.7% (5)	2.2% (3)	8.1% (11)
Q20	I keep my nails short and remove any adjournment before starting work.	53.7% (73)	2.2.% (3)	1.5% (2)	4.4% (6)	38.2% (52)
Q21	I was my hands with soap regularly during work.	91.2% (124)	1.5% (2)	1.5% (2)	0	5.9% (8)
Q22	I throw my litter in the dustbin and cover it.	94.1% (128)	0	5.1% (7)	0	0.7% (1)
Q23	I point out at any unclean behavior by my fellow workmate.	76.5% (104)	4.4% (6)	7.4% (10)	1.5% (2)	10.3% (14)
Q24	I ensure time and temperature combination are attained at my processing point.	81.6% (111)	0	14% (19)	1.5% (2)	10.3% (14)
Q25	In case of contamination, I stop the process and check the previous batch.	67.6% (92)	26% (19.1)	7.4% (10)	1.5% (2)	4.4% (6)

On an average, considering all the eight items, seven out of ten (74.6%) processors always do the right practices during processing. The remaining 25.4% processors are only “sometimes”, “never”, “often” or “rarely” considerate over good practice.

The environment in which processing was done was not conducive for production of safe food. This violates the Key 1 of the five keys WHO that requires to keep clean. Contamination of the poultry products was also associated with water supplied to the processing facilities violating WHO key 5 that requires food to use safe raw material. For the 5 raw processing water samples, two of them showed CFU beyond the acceptable limits.

3.4 Discussion

3.4.1 Processors' knowledge

The level of knowledge on food safety among street poultry processors in this study was relatively high at a percentage mean of 91.17. Among the nine knowledge questions included in this study, two questions (Q1 and Q6) resulted in all correct responses (Table 3.2). Responses to these questions do appear to suggest that there are apparent processors' knowledge on impact of cleanliness of the processing environment and causes of food borne illnesses.
The responses on the general questions (Q1 and Q2) were relatively high with an overall score of 90.45%, however there was a low performance on the response of Q2. Several processors 19.1% were not aware the bacterial are naturally occurring on life poultry. This could lower the cautious approach that would have been exercised if the processors knew from the beginning of processing they are dealing with carriers of pathogens.

The overall score on the knowledge questions related to personal hygiene (Q3, Q4 and Q5) was relatively high; 95.6%. The question on having short nails among the processors Q4, had a relatively low score compared to that of Q3 and Q5. This could be attributed to negative attitude of the processors of keeping nails short especially women. Most processors with long nails explained that is not the size of nails that mattered but their cleanliness.

The overall score on the knowledge questions related to waste management (Q6 and Q7) was relatively high; 90.1%. However, several processors 19.85% could not differentiate on what were the dirty zones and clean processing zones. However, this observation may reflect difficulty of the question and format.

The processors' knowledge of process control was the lowest performed on the parts for knowledge of this study. On average the score for this part (Q8 and Q9) was 86.4%. This finding is critical as it translates that the processors don't know impact of the various processing stages and conditions on the microbial safety of the product. Several processors do not understand that those processes require strict temperature-time combination controls.

3.4.2 Processors' attitude.

The eight questions were administered on processors' attitude towards food safety (Q10-Q17). Five of these questions had a very positive attitude among the processors (Q10, Q11, Q12, Q13 and Q16). These relatively well performed questions were those on general attitude, personal hygiene and on process control.

All though most of the processors believed that they practiced best process for assuring quality and safe product, most of them (96.65%) were willing to change any practices that they would find led to production of unsafe product. The response to this statement suggests that processors believed their products were safe using their current practices, although they may not have been unaware that they were using processes that do not address pathogen control.

Most processors had negative attitude on waste management with more than half stating they would only wait for instructions by their supervisors to collect garbage and still most believed they should be independent employees to work as cleaners only. These results appear to be conflicting with the output on personal hygiene, but may demonstrate that processors would not be very corporative on facility cleanliness as it seemed extra work that should have be done by other independent workers.

3.4.3 Processors' practices

3.4.3.1 Processors' practices (self-reported)

Personal hygienic practices are extremely important to ensure that the food produced is safe for the consumer. In the present study, it was found that processors have good hand hygiene. Most the processors (91.2%) always wash their hands with detergent before processing meat. According to the Codex Alimentarius Commission (2003), improper food handling was a major cause of food borne diseases and poor hand hygiene was an important risk factor in the occurrence of food contamination. Food handlers should always wash their hands at every stage of food production, particularly before handling foods, after eating, after touching contaminated materials, after using the washroom, etc.

More than half (53.7%) of the processors remove the personal stuff such as watches, ring and jewelry that can contaminate foods while working. A previous study demonstrated by Çakıroğlu and Uçar (2008), 84.2% indicated that they did not wear jewelry during food production. Dora-

Liyana *et al*., (2018) showed high practice levels of general sanitation measures. Codex Alimentarius Commission (2003) stated that sick food handlers who are known or suspected of having any disease that might be transmitted by food are not allowed to work nor handle foods. In this study, slightly less than half (47.8%) of the processors get medical examination every year in relation to the requirement by their business. The rest of the processors either did not take the examination at all nor did it irregularly. Results from demographics data showed that (100%) of those with more than two years' experience always had their medical examination. The percentage of those not getting medical examination at all (10.3%) was very high that should consider contamination with food.

Most of the processors' (84.6%) would report or act on any abnormalities noted during poultry meat processing. However, half of them (48.6%) have never encountered any abnormalities hence they did have a practical experience on the matter. The examples of abnormalities termed by the processors included; color lesions on meat, bad/foul smell of the meat, skin damage, and poor general health of the bird to be slaughtered. In the current study it was found that the processors did not have a safe procedure of disposing condemned meat.

Practices on waste control and process control were relatively good and most of the processors always did what was required by them.

3.4.3.2 Processors' practices (observed)

Most of the processors' (91.2%) reported that they washed hand before, during and after poultry meat processing; none of these processors washed their hand according the seven steps of hand washing. The findings are similar to those of a similar study by Tan *et al.,* 2013 where 100% of the food handlers did not wash hand using the proper technique.

The aim of this part of questionnaire was to point out if the self-reported practices have been adopted. The study established that the self-reported practices were overstated and the processors responded what is probable and not what the truly do with the facility. A similar finding was also established in a previous study (Soares *et al.,* 2012).

3.5 Conclusions

The results obtained from the survey show that the level of processor's knowledge was generally sufficient. It was however inferior on further comparison of the result obtained through the

attitudes and practices questionnaire. The overall KAP score indicate the need for a training program for the processors. The training program should take into account mainly the importance in changing attitudes, practices and understanding the role of the processors towards food safety. In as much as the street poultry processors displayed a sufficient knowledge on food safety, the attitude and practices of the processors are questionable.

The needs of training should be evaluated to obtain the areas to be properly addressed during the training. Also, after the training the effectiveness of the training should be assessed to ensure that it has well addressed the expected needs and it's fully effective.

3.6 Recommendations

The study recommends a training schedule for streets poultry processors to guarantee their continued training on food safety matters. The intervention activities in place should be constantly monitored to timely identify any failures and corrective actions to be timely implemented.

It is critical to highlight that within food processing facilities it is necessary to seek continuous improvement.

CHAPTER FOUR:

THE EFFECT OF PROCESSING PARAMETERS AND CONDITIONS AT THE DIFFERENT PROCESSING STAGES AMONG STREET POULTRY PROCESSORS IN EMBAKASI, NAIROBI COUNTY.

Abstract

To evaluate the efficiency of the processing conditions on ensuring product safety, all the stages of processed poultry meat were considered. The temperature, ph of the water and any antimicrobial added to the water were considered.

An exploratory study consisting of cross-sectional survey in which structured questionnaire (appendix 1) and observation checklist were administered to the poultry processors at Embakasi, Nairobi.

The origin of the birds was critical in ensuring the produced product was safe. Simple techniques of time temperature combination were sufficient to ensure the safety of produced products. The conformity lasted long with the right storage temperatures after processing.

Among all the stages of processing, two stages were accepted as critical control points because after them there were no other control points for microbial hazards. These stages are de-feathering and manual pluck picking stage.

4.1 Introduction

In poultry processing, the entire carcass can be processed as a whole or cut into pieces. The cuts include; wings, legs, and breasts. The primary objective of poultry meat processing is to inhibit microbial growth and to stop quality deteriorations of the meat. With a primary goal of producing safe meat there are other activities that come up during processing such as waste management.

The study focused on assessing the different processing procedures and parameters among the processors so as to instruct why things are done in certain ways and hence evaluate problem situations and develop possible solutions

4.2 Materials and methods

4.2.1 Study site

The study was carried out in Embakasi, Nairobi County as described in 3.2.1.

4.2.2 Study Design

The study was exploratory consisting of cross-sectional survey in which snow balling technique was used to recruit more processors in the study was carried out on the selected samples depending on the choice of the researchers. The data collected included: the processing flow charts, temperature and time combination of critical stages of processing and the ph of the effluent water.

4.2.3 Study setting

The study setting was poultry processors in Embakasi, Nairobi County as described in 3.2.3.

4.2.4 Study population

4.2.4.1 Sample size determination

Sample size was determined as described in 3.2.4.1.

4.2.4.2 Sampling criteria

Sampling criteria was as per that described in 3.2.4.2.

4.2.4.3 Inclusion criteria

Inclusion criteria were as per that described in 3.2.4.3.

4.2.4.4 Exclusion Criteria

Exclusion criteria were as per that described in 3.2.4.4.

4.2.5 Ethical consideration

Ethical considerations were as per described in 3.3.

4.2.6 Data Collection

The last section of the structured questionnaire (appendix 1) was observation checklist for time taken during processing, initial water temperature, final water temperature, monitoring equipment used, any antimicrobials added, and ph. of the processing water and flow chart of the processing stages.

This section was filled by the researcher with minimum assistance from the processor for any clarifications needed. The researcher also utilized this section to assess the knowledge of the processors on importance of each processing stage or condition and clarification on why the processors did things in a certain manner. Typically, it took 15-30 minutes for the researcher and processors to complete an interview.

In this study, in-depth interviews were used for issue identification, assessment and strategic planning. It gave the researcher a chance to get detailed information and a chance to observe the behavior of the individuals interviewed. It was an open ended and discovery orientated tool of data collection which allowed the researcher to explore individual perspective and feelings about a particular subject. The researchers were familiarized with the method and had thoroughly explored possible outcome during discussions to ensure accurate data was gathered.

4.2.7 Data management and analysis

4.2.7.1 Quality control

The researcher familiarized themselves with the respondents three days' prior the study. This was to reduce fear and tension during interviews which may have led to falsification of information given. This time was also used to explain to the processor the objective of study and prepare them for participation. More processors in the area were also located.

Respondents were given a time of approximately 2 minutes to think and answer each question asked by the researcher during the study. Further clarification on question was offered to make sure the respondent understood the question.

Answers given by respondents were read out loudly by the researchers to confirm that was their intended answer and also ensure correct entry on the collection tool.

Before analysis data cleaning was employed to ensure the data collected was uniform and without extremes

4.2.7.2 Data analysis

The survey data was analyzed using SPPS version 20. Frequencies and descriptive statistics such as average, standard deviation, minimum and maximum for the processing parameters were obtained.

4.3 Results

4.3.1 The general food chain of farm to fork of poultry products

From the current study it was noted most of the poultry products take approximately five to twelve months from farm to fork. The food chain involves a numerous people namely; farmer, transporters, veterinary officers, processors, vendors and consumers.

4.3.2 Equipment Cleaning

4.3.2.1 Dish washing activities

The study found out that seven out of ten new processors (79.4%) had been tasked with the activity in first three months of employment and without proper guidelines of the activity. Nine out of ten of the processors 91.1% reported that dish washing as an obvious activity and all processors are automatically aware of it without training. Despite having reported dish washing as an obvious activity, amongst those processors it was observed that more than half (58.28%) of the processors were doing it wrong. It was also noted that most of these personnel don't know the importance of right concentrations of detergent, water and time taken. It was noted that most of the processors used processes similar to three bucket methods but omitted very essential steps.

4.3.2.3 Stunning and bleeding

Street's poultry processors combined these two stages and were observed as the first processing steps. Most of the processors (94.8%) reported to be using knife to cut the throat of the birds and allow bleeding until blood stopped coming out. In this process the head is fully cut out after the bird dies.

It was a critical process and was likely to cause bird stress through struggle from the observations by the researcher. The struggle led to contamination of working surface and the processors hands due to blood spillage and holding of the bird. Slightly less than half of the processors (43%) could not give a clear description on how to determine when stunning process was complete before cutting off the head. Approximately the stage was noted to take a time of 10-30 seconds among the processors.

4.3.2.4 Scalding and de-feathering

This is the process of treating the carcass with hot water to loosen the feathers and paws skin. After all the movement of carcass ceased the processors would dip the carcass on water at boiling temperature for approximately 5-10 seconds before starting to plug the feathers out.

Eight out of ten (86.8%) of the processors would plug the feathers from the carcass while still dipped in water. The remaining 13.2% of the processors would leave the carcass in the hot water for approximately 30-45 seconds before taking it out and unplugging the feathers on a working surface. The process of unplugging would take 2-3 minutes. At the end of de-feathering water temperature was 50-65^{0}C for most of the processors 98.5%. Nearly four of ten processors (38.2%) placed the picked feathers on working surface before discarding them and on same surface the placed carcass without cleaning for next step processing.

4.3.2.5 Evisceration

This is a process in which intestinal organs of the bird were removed first followed by contents of chest cavity. All the processors in the study cut the carcass either from neck area or bottom belly while lying on a surface to carry out the process. Most of the processors (98.5%) would pull out the internal contents downwards away from carcass through the bottom belly. Although they were not aware of the importance of the process it was a positive observation to prevent

cross contamination. Of these processors who pulled the organs downwards away from carcass (98.5%), 13.23% of them were aware that pulling downwards reduced chances of cross contamination and all of these processors had undergone prior training on food safety especially on poultry processing.

Nearly half of the processors (46.32%) reported that sometimes when pulling the internal organs, they would break and faecal matter spill inside the carcass upon which they would pull the remaining parts and wash the carcass on running water.

This process would take place on a working surface at room temperature approximately 10-20 minutes among the processors.

4.3.2.6 Carcass review

This was carried out by most of the processors (86.02%) and involved the act of inspecting the carcass after de-feathering and evisceration. The processors reported to be checking for remains of feathers, faecal matter, internal organs and lesions. Most of the processors (95.6%) reported it as an important process that is useful in assessing out abnormality inspection. A few processors (9.6%) who termed it as an important process but did not execute it had reported attitude less than half (<46.23%) towards food safety on the survey part of the study.

4.3.2.7 Paw removal

All the processors reported to cut out the paws at this stage. The paws were cut off the carcass then washed on tap water at room temperature then placed aside. A few processors (8.1%) reported some customers would require the paws and thus they were packed with raw meat for consumption. The rest of the processors reported that they would collect all the daily paws and further sell to other processors who would cook and sell to customers along the streets and hotels.

4.3.2.8 Washing of the carcass

All the processors reported to wash the carcass after processing and ready for dispatch. Nearly four out of ten (36.02%) processors reported to be using clean running water from taps to wash the carcass. The rest of the processors (63.9%) of the processors would use water in a basin and rinse with clean water two times after first washing.

All the processors reported that they would rewash the product after the routine washing if they noted any contamination had occurred. Nearly most of the processors (95.6%) reported that the water used for final rinsing and the washing process was chlorinated.

The temperature of rinsing/washing water was found to be 20-27^{0}C and Ph of 5.46-8.32 among the processors.

4.3.2.9 Cooking

This was for those processors who sold ready to eat meat to the consumers. Cooking was done at uncontrolled environment and only checked if the product was ready after some time of cooking by visual and taste sense.

Cooking time was on average observed to be 20-45 minutes and temperatures as high as 90^{0}C. These temperatures were sufficient to kill all pathogenic micro-organisms. More than half (55.9%) processors reported to be reusing oil that remained on previous day during cooking on next day's up to one week's time.

4.4 Discussion

According to Food Standards Agency, 2020, it is a requirement that food chain information be provided for any poultry intended for human consumption 24 hours before arrival of the birds. This information would inform decisions on how the slaughter is to be carried out. The information serves as a certificate of analysis and in that context, it helps on making the right decision and risk assessment. A detailed information including all activities carried out on the bird and all those handled it is very important. The information would also serve as a traceability basis. In the current study the information was provided verbally but not very detailed. Importantly all the processors in the obtained information vaccination activities of the birds.

Most of the processors had established networks along the food chain in which they would go back up-to the farm level in case of anything.

Dish washing is a very important task on food establishment but highly neglected. It is mostly tasked to unskilled and newly employed personnel according to the findings of this study. The three-bucket method incorporates: wash, rinse and sanitize. 1st bucket should use warm water and detergent and the dish should be scrubbed to remove dirt. 2nd bucket should use warm water and wipe with sponge to remove the loosened dirt. 3rd bucket should have warm chlorinated water and the dish should be wiped clean sponge to air dry. During cooking, it was risky for the processors to determine if the product was ready by tasting as this could happen before the product was heated enough to kill micro-organism hence causing harm to the processor.

Dish washing isn't much followed up among the processors in this study. The importance of the activity hasn't been considered despite its impact on food safety. This implies that probability of holding or eating equipment/utensils spreading bacteria to the products they come in conduct with. The processors expressed high confidence on the activity that it was well done but there were no verification activities for the process. What was observed in some facilities by the researchers was also not conforming to sanitary conditions after the dish wash activity.

Throughout the processing steps all those handling the birds should maintain hygienic conditions. Stunning is the process in which live birds are rendered unconscious before bleeding to death to during slaughter. Bleeding is the process by which the carotid arteries and jugular veins are cut during slaughter to ensure the animal dies out of loss of blood. During bleeding, the birds should be well contained or kept in place to avoid flapping that would lead to splashing of blood. The blood may contain pathogens and should be collected beneath when the bird is placed in upside down position. The quality and temperature of scalding water is critical in determining chances of contamination. Temperatures of 50-58^{0}C are termed optimal for 4 minutes (Kerschgens *et al.,* 2016). Under-scalded birds will have difficulty feathers to remove and over scalding may damage the skin (Kerschgens *et al.,* 2016). The water used during scalding should be frequently replaced. When de-feathering and evisceration is done by hand as the case among the streets poultry processors there is high risk of contamination by *Staphylococcus aureus.* Hand washing will exacerbate the problem. This bacterium is of great concern and should be prevented as it produces toxins which are heat resistant if the storage temperatures permit its growth and

multiplication. The toxins will not be denatured in the normal cooking temperature and that mean the consumer will get sick even after cooking the processed poultry meat (Maharjan *et al*., 2019).

After evisceration, the birds should be washed with cold water by spray or shower. The water used should be potable. The water should be sufficient and from a dependable supply so as to reduce quantities of micro-organisms. Cross contamination may happen after rinsing the carcass and it's important to prevent contamination from working tables by hanging the birds and working on them in those hangs. Figure 4.2 shows the changes of bacterial contamination during the processing stages of slaughter as sourced from: Logue and Nde, 2007.

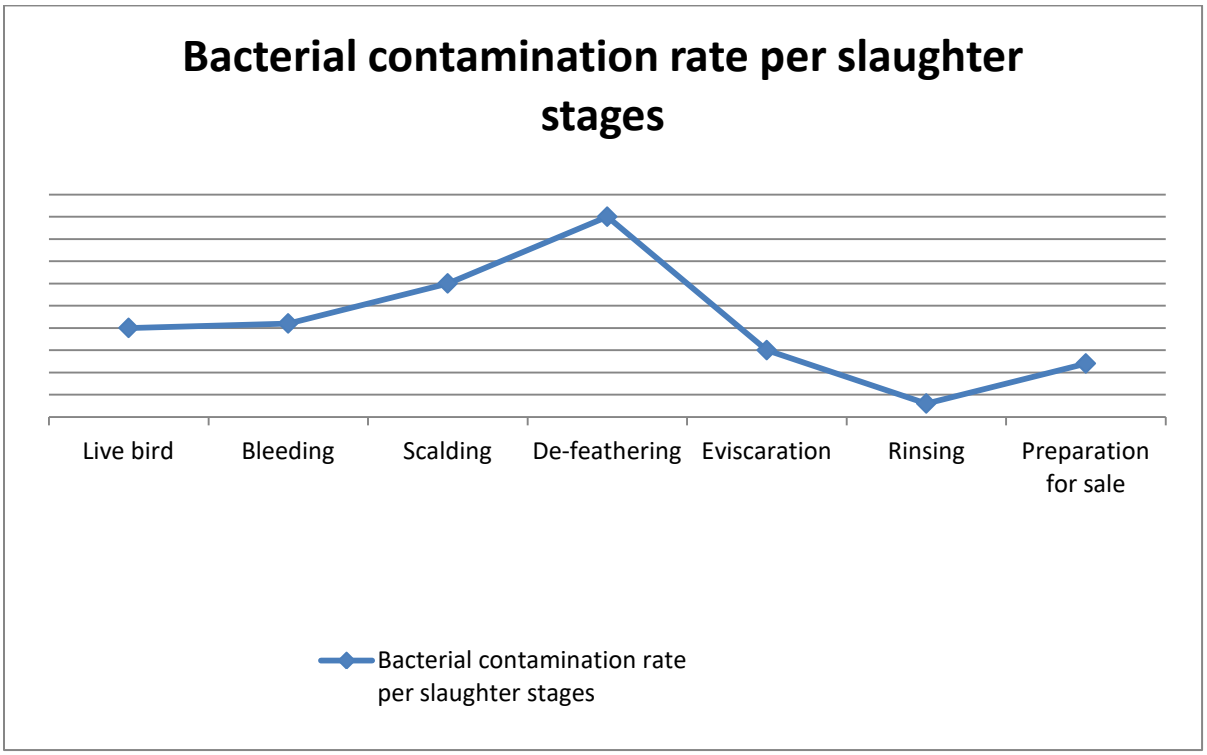


Figure 4. 1: Bacteria contamination rate per processing stages.

Stunning and bleeding of the birds was in almost cases used as one processing stage accommodating the two activities together. Bleeding was done on approximated time of around 10 seconds for all the processors. The bleeding time wasn't determined by carcass weight or their blood volumes. The only processing parameter considered in this stage was the time factor.

Scalding was the next processing among the street processors and time and temperature combination parameters were considered. In some cases, the processors also considered the

chlorine levels of the water used in the process. Temperature of the water to be used for scalding was determined by boiling in some cases and other cases processors used a finger to feel the temperature for 2 seconds and when 'burned' the temperature was termed as sufficient to determine readiness for use for scalding. There is no provision on temperature controls as the processors don't have thermometers. Upon determining that the water was ready the carcass was inserted on the hot water and feathers plucking started by hand. The process would last for less than 2 minutes as the heat loss was high and the feathers would be hard to pluck. If water of temperature higher than 75^0 C was used skin damage was evident and this would lower market value of the meat and also increase chances of contamination in the proceeding stages.

Poor evisceration techniques may increase carcass contamination with bacteria from intestinal track of the birds processed. The risk is higher for the processors in this study as there wasn't much consideration of feed withdrawal before bird slaughter. Torn intestines may leak into inside of the bird during drawing or during the processing. The carcasses were inspected during the processing by the researcher and it was visible in 56% cases that there was contamination.

4.5 Conclusions

Along the food chain the poultry products follow specific steps in order to reach the final customer. They include primary production, transport, processing and retailing. Each of these steps has inputs and increases value of the poultry products. To develop a sustainable food chain of poultry products in ensuring food safety is important to understand the role each step plays in value addition according to Food Standards Agency, 2020. Challenges such as remoteness of the production sites, poor infrastructure and cool system transportation capacity effect of safety of the poultry products.

Dish cleaning process is mainly influenced by temperature, time, chemistry and mechanics. The main principle is to chemo-thermal inactivation and mechanically removing the microorganisms. The main conclusions drawn from this study on dish washing are; temperatures greater than 60^0C for two minutes are effective to achieve sufficient hygiene similar results. The higher the temperature the more effective the program will be. Increasing cleaning temperatures has higher impact on microbial rather than increasing rinsing temperatures. Temperature greater than 60^0C, and chlorine concentration greater than 10ppm achieves sufficient antimicrobial effect. Longer

contact time during cleaning and more changes on the water increases microbial reduction. Higher mechanical action has impact on the removal of micro-organisms, thermal inactivation isn't solely enough.

The microbial hazards in the processing of poultry products are well known but often difficult to control effectively due to the technological limitations for the processing of this products. Scalding and final rinse stages have been identified as important CCPs in poultry processing. Implementation of the HACCP system has clear benefits of:

i. Ensuring regular monitoring of the whole processing.
ii. Hygienic optimization of the processes and personnel.
iii. Check of the controlling processing parameters in the CCPs and a well outlined procedure in case of non-conformance.
iv. Staff awareness on food safety requirements.

4.6 Recommendations

Application of HACCP system in which the identified CCPs will be monitored and controlled. HACCP has a benefit for the street's poultry processors in that its approach is preventive based. The processors would not have to reject a whole lot which is still uneconomical during the processing rather than have well stipulated procedures and strategies for preventing contamination.

Birds to be slaughtered should be clean and dry; the cleaner the bird the less contamination that may happen during processing. During transportation care should be taken not to soil the bird's feathers with faecal matter so that there is no contamination of the feathers. To avoid these solid portions should be placed on the top of the crates if the birds are to be stacked.

The processors should implement HACCP system and allocate resources for monitoring equipment such as thermometer and ph meter.

After processing the finished product should be kept on the right keeping conditions so as not to support increase of microbial load before time of consumption.

All consumers should be educated on their responsibility especially on raw meat to ensure that the products are well prepared to eliminate any hazard that would have cause harm

Training should be carried out for the processors in order to facilitate the implementation of HACCP system.

CHAPTER FIVE:

MICROBIAL SAFETY OF STREET PROCESSED POULTRY PRODUCTS IN EMBAKASI, NAIROBI COUNTY

Abstract

Microbial contamination on poultry meat poses safety concerns to consumers and on commercial view, spoilage bacteria also play a bigger role towards economic losses. Control may depend on the awareness and behavioral traits of the processors. This study aimed at relating knowledge, attitudes and practices to microbial contamination among poultry processors in Embakasi, Nairobi County, Kenya.

This study provides information about knowledge, attitude and practices regarding microbial safety among poultry processors in Embakasi, Nairobi. It is clearly evident in this study that level of knowledge has positive impact on the practices, attitude of processors and eventually microbial contamination. It highlights the importance of targeting lack of knowledge for improving on food safety caution among the processors. The results of this study will form a useful base of training for poultry processors.

30 processors were randomly selected from which microbial samples were taken. Among them 15 processors were those ranked to have had a satisfactory performance on KAP study and the later 15 processors were those ranked to have had unsatisfactory performance on the KAP study.

The null hypothesis was significant as $P<0.05\%$. This implies that KAP score of the processors influenced the total viable count results of the collected microbial samples.

5.1 Introduction

Poultry meat may be contaminated by different types of micro-organisms during processing. The microbial quality of the samples taken was analysed for the selected poultry processors in the study. Selected samples were based on KAP study score in which highest scoring and lowest scoring were considered. After processing facility in which samples were to be taken different stages with impact on microbial contamination was also considered.

5.2 Material and methods

5.2.1 Study site

The study was carried out in Embakasi, Nairobi County as described in 3.2.1.

Microbial sample analysis was carried out at food microbiology lab in the Department of Food Science, Nutrition and Technology, University of Nairobi.

5.2.2 Study Design

A cross-sectional study was used. Laboratory microbial analyses were carried out on the selected samples. The data collected included total viable count and process parameters.

5.2.3 Study setting

5.2.4 Study population

5.2.4.1 Sample size determination

A total of 30 microbial samples were analyzed from the 136 processors who participated on the survey study. The sample size was calculated as per Solvin's formula: (Mageto *et al*., 2015) from a population of 136 processors as used in the survey pat of the study.

Sample size = $N/(1+N*e^2)$

Where:

e is the marginal error of 16%

N is the population size 136 obtained from previous study (Mageto *et al*., 2015).

= $136/ \{1+136*(0.1.6^2)\}$

=30 samples

5.2.4.2 Sampling criteria

Sampling criteria was as per that described in 3.2.4.2.

5.2.4.3 Inclusion criteria

Microbial samples were taken from specific points, facilities and processor depending on observations and the score on administered questions.

5.2.4.4 Exclusion Criteria

Exclusion criteria were as per that described in 3.2.4.4.

5.2.5 Ethical consideration

Ethical considerations were as per described in 3.3.

5.2.4 Data Collection

From the selected 136 processors for Chapter 3(KAP survey); 30 processors were randomly selected from which microbial samples were taken. Among them 15 processors were those ranked to have had a satisfactory performance on KAP study and the later 15 processors were those ranked to have had unsatisfactory performance on the KAP study. A minimum of 150gms poultry product sample was collected in a sterile polythene bag and well labeled its particulars. Samples from satisfaction performance processors were labeled with word "A" and those with unsatisfactory performance were labeled with a word "Z". In total 96 samples were collected on different processing stages among the 30 processors selected. The collected sample were stored in dry ice less than 4^0C and transported within 12 hours of collection to the laboratory of the Department of Food Science and Technology of the University of Nairobi. In the laboratory the samples were stored in freezer and analyses within two days of delivery.

The samples were analyzed for total plate count as per the ISO 4833-1:2013(E) guidelines. Culture media (plate count agar) was dissolved in water and heated to dissolve with though mixing. Total viable count was determined using Luria Bertabi (LB) media which contained 10g Tryptone, 5g yeast, 5g NaCl and 15g Agar per liter of the media. The medium together with equipment to be used during the analysis and serial dilutions were autoclaved at 121^0C for 15 minutes (ISO 11133 and ISO 11.080.01). The medium was then placed in a water bath at 45^0C to cool and maintain the temperature before used.

Serial dilutions (ISO 20776) were carried out up to 12th dilution under aseptic conditions in a bio safe cabinet. Distilled water was used as the diluents as per the guidelines by ISO 6887. The samples of each serial dilution were then inoculated under aseptic conditions in sterile Petri dish and incubated at 30^0C for 72hrs under aerobic conditions until the results were read. The number

of aerobic microorganisms was calculated per gram of the test sample from plate counting less than 300 colonies and more than 30 colonies according to ISO 4833 -1:2013(E).

The Total viable count (TVC) was done according to the following formula:

$$N = \frac{\sum C}{[(n1 \times 1) + (n2 \times 0.1)] \times (d)}$$

Where:

N = Number of colonies per ml or gram of product

$\sum C$ = Sum of all colonies on all plates counted

n1= Number of plates in first dilution counted

n2 = Number of plates in second dilution counted

d= Dilution from which the first counts were obtained

5.2.5 Data management and analysis

5.2.5.1 Quality control

All the equipment used during the study was up to date calibrated by authorized calibration agents to ensure precise measurements. Standards mass was also used for scales to confirm they took accurate reading of the weights taken.

Before collection of microbial samples, the researcher ensured aseptic conditions for the tool and equipment to be used.

Microbial samples were delivered to lab for analysis under low temperature in 12 hours to ensure no build up or growth before or during analysis.

Each serial dilution there was two samples inoculated to ensure precise results of the count.

Only the plates with 30 to 300 colonies were used to calculate the microbial load per the sample.

ISO standards procedures were used for all microbial tests and procedures to ensure standard harmonic results.

5.2.5.2 Data analysis

Microbial results were analyzed in duplicate and results transformed into log CFU/g. ANOVA tests were used to determine the statistical difference in microbial counts with statistically different averages using the Tukey's test. Statistical significance was testes at p is less than 0.05. Least significant difference was used to separate the means that were significantly different.

5.3 Results

Five processors were picked for microbial analysis after evaluation of the KAP study results. The processors were further grouped depending on their processing product; those dealing with finished products that are raw and those vending ready to eat poultry products. The processors picked for collection of microbiological samples were selected on the top three best performers and bottom two performers for the KAP study. The study picked top two performers of finished raw products, one poorest performer for finished raw products, one top performer for finished ready to eat product and one poorest performer of finished ready to eat poultry products in the KAP study. In the processors code for the picked processors in the microbial analysis, top performers have been indicated with a superscript “a” and bottom performers have been indicated with a superscript “z”.

A total of 30 microbial samples were collected from the selected processors. 24/30 samples were from the raw poultry processors and 6/30 of the samples were from finished ready to eat poultry processors. The collected samples were finished products, food contact surfaces including processors hands, raw water used in the processing and samples of the products after some critical stages of processing. The table 5.1 shows how the processors were selected for microbial safety study.

Table 5. 1 Processors' grouping and KAP results considered in microbial samples collection.

Processor's Naming Code	Type of finished product (raw/ready to eat)	KAP study Score (%)
13[a]	Raw	80.12
82[a]	Raw	77.23
90[a]	Ready to eat	73.26
29[z]	Raw	58.18
67[z]	Ready to eat	53.26

Highlighted in yellow color shows the processors considered for microbial study.

[a] is the best performing processors in the KAP study

[z] is the poor performing processors in the KAP study

Table 5.2 below show the microbial results of the analyzed samples.

Table 5. 2 Microbial total viable results as related to the various processors sampled.

Sample description	**Processor identification code**	**TVC RESULTS (Log $_{10}$ CFU/g)**
Raw processing water used in the facility	Facility 13[a]	3.51,
	Facility 82[a]	2.298
	Facility 29[z]	3.861
	Facility 90[a]	3.526
	Facility 67[z]	4.346
Processors hand swabs before commencing the product handling	Facility 13[a]	2.246
	Facility 82[a]	1.851
	Facility 29[z]	4.431
	Facility 90[a]	4.17
	Facility 67[z]	5.865
Food contact surfaces	Facility 13[a]	2.27
	Facility 82[a]	3.127
	Facility 29[z]	4.342
	Facility 90[a]	4.33
	Facility 67[z]	4.537
Finished raw poultry product	Facility 13[a]	2.513
	Facility 82[a]	1.493
	Facility 29[z]	8.836
Ready to eat poultry product served for the consumers	Facility 90[a]	2.476
	Facility 67[z]	4.677
Final product rinse water	Facility 13[a]	2.77
	Facility 82[a]	4.124
	Facility 29[z]	8.7
	Facility 67[z]	7.28
Poultry sample after evisceration	Facility 13[a]	3.633
	Facility 82[a]	4.76
	Facility 29[z]	6.161
Water discarded after use in scalding and de-feathering stages	Facility 13[a]	3.3
	Facility 82[a]	3.778
	Facility 29[z]	6.81

5.4 Discussion

Table 5.1 (processors' grouping according to KAP score) shows that processors dealing with raw processed poultry products performed better compared to those dealing with ready to eat products. There is a greater risk on food safety for ready to eat products as compared to raw

products. Similar results were also observed on a previous study (Beatrice *et al.*, 2020). This is because raw products will be processed further before consumption while ready to eat may be eaten in that state.

The results show that the TVC of the raw and ready to eat to eat samples are beyond the acceptable limits and the pose a risk to the consumer. In total 30 samples from different processing stages among the selected processors were analyzed. Slightly more than half 53.3% (16/30) of the collected samples had TVC beyond satisfactory levels (>10^5 CFU/g).

The table 5.3 is derived from Kenya standard KS 2455:2013 and shows specifications and sampling plan guidelines as for poultry products and water to be used for processing.

Table 5. 3 Kenya Standard: Food Safety-General standard (KS 2455:2013) showing Total viable count criterion in foods.

Food category	**Sampling plan**		**Limits**		**Analytical method**
	N	**c**	**m (CFU/g)**	**M(CFU/g)**	
Raw poultry meat	5	3	10^4	10^5	ISO 4833
Cooked poultry products	5	2	10^4	10^5	ISO 4833
Raw Processing water	5	1	10^4	10^5	ISO 4833

N - Minimum number of sample units to be taken from the lot.

C - Maximum allowable number of defective samples.

m - Acceptable microbial level in a sample unit.

M - The level which when exceeded in one or more sample would cause the lot to be rejected.

Table 5.4 below show the microbial results for Total viable count (cfu/g) of the analyzed samples related to the acceptance level.

Table 5. 4 Microbial total viable results of the various samples collected.

Sample description	Acceptable level ($<10^4$)	Marginal level (10^4-10^5)	Unacceptable level ($>10^5$)
Total Sample (n=30).	46.6% (14)	33.3% (10)	20% (6)
Finished raw poultry meat (n=3).	$3.26*10^2$, 3.11*10	-	$6.86*10^8$
Finished ready to eat poultry products (n=2).	$2.99*10^2$	$4.76*10^4$	-
Raw processing water (n=5).	$3.24*10^3$, $1.99*10^2$ $7.26*10^3$	$3.36*10^4$ $2.22*10^4$	-
Hand Swabs (n=5)	$1.76*10^2$, 7.1*10	$2.7*10^4$, $1.48*10^4$	$7.32*10^5$
Food contact surfaces (n=5)	$1.88*10^2$, $1.34*10^3$	$2.2*10^4$ $2.14*10^4$ $3.44*10^4$	-
After scalding and de-feathering stages (n=3)	$1.99*10^3$, $6*10^3$	-	$6.44*10^6$
After evisceration (n=3)	$4.3*10^3$	$5.71*10^4$	$1.45*10^6$
Final product rinse water (n=4)	$5.89*10^2$	$1.33*10^4$	$5.02*10^8$, $1.89*10^7$

The mean TVC of ready to eat poultry products was $2.4*10^4$ CFU/g

The mean TVC of raw poultry products was $2.29*10^8$ CFU/g,

Figure 4.2 below shows the TVC results on the collected samples

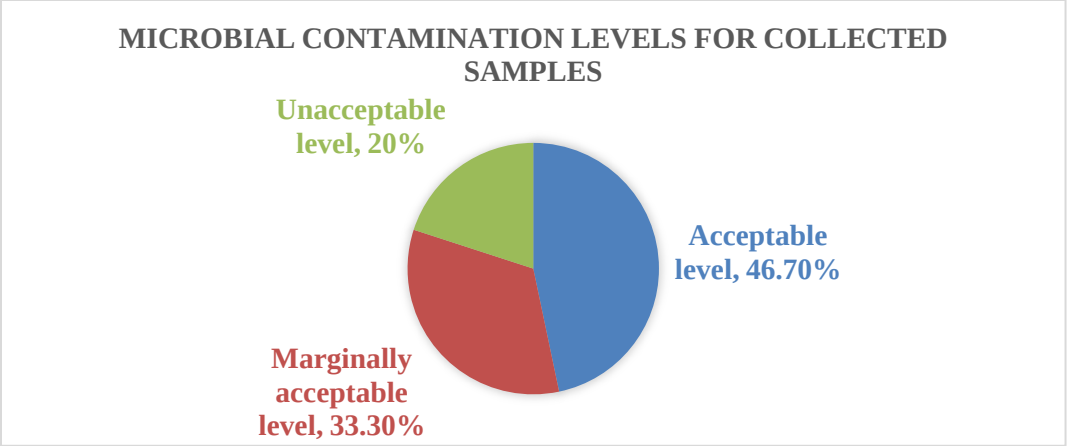


Figure 4. 2: TVC results on the collected samples (n=30).

The results pertaining TVC were nearly agreed in the findings of a similar study by Maharjan *et al*., 2019 in Kathmandu valley, which reported higher mean of log 10^7CFU/g. Another similar study conducted in Morocco by Cohen *et al*., 2007 showed aerobic plate count of 5.9-6.6 log $_{10}$CFU/g in got season and 4.5-5.9 log $_{10}$CFU/g in cold season.

For poultry products to be entirely safe from microbial point of view, it would need to be free from all pathogenic bacteria. This goal is widely recognized to be unrealistic for all raw products but can be achieved in cooked poultry products. For raw poultry products use of ionized radiations would enable the processors achieve microbial safety but would render the products unacceptable for many customers. The later would still be uneconomically viable among the street poultry processors. This has allowed for a provision of acceptable limits for the raw poultry products in which the limits should not be exceeded.

Table 5.5 below show the relationship analysis of the KAP score to that of the TVC results.

Table 5. 5: Relationship between processors' KAP score and TVC

	Processors' KAP score	TVC (LOG10)
Mean	68.9	4.3
Variance	119.7	3.3
Observations	30.0	30.0
Pearson Correlation	-0.7	
Hypothesized Mean Difference	0.0	
df	29.0	
t Stat	28.8	
P(T<=t) one-tail	0.0	
t Critical one-tail	1.7	
P(T<=t) two-tail	0.0	
t Critical two-tail	2.0	

From Table 4.9, the null hypothesis is significant as P<0.05%. This implies that KAP score of the processors influenced the total viable count results of the collected microbial samples.

5.5Conclusions

The findings of the study demonstrated that for poultry processors who have high score in KAP score the microbial risk is low contrary to those with low KAP score. Presence of pathogenic bacteria on ready to eat poultry products is a great risk and renders the meat unfit for human consumption. The public health and local authorities should play a role in creating awareness among the street processors through trainings on food safety and hygienic food handling practices. The government should also work towards improvement of infrastructure and accessibility of basic resources required for safe production.

5.6 Recommendations

After processing the finished product should be kept on the right keeping conditions so as not to support increase of microbial load before time of consumption.

All consumers should be educated on their responsibility especially on raw meat to ensure that the products are well prepared to eliminate any hazard that would have cause harm

Training should be done to address the knowledge gaps, bad attitude and practices among the processors in order to ensure safe production of poultry meat.

CHAPTER SIX

6.0 GENERAL CONCLUSIONS AND RECCOMENDATIONS

6.1 Conclusions

The study provides information about knowledge, attitude and practices regarding microbial safety among poultry processors in Embakasi, Nairobi. It is clearly evident in this study that level of knowledge has positive impact on the practices, attitude of processors and eventually microbial contamination. The results obtained from the survey show that the level of processor's knowledge was generally sufficient. It was however inferior on further comparison of the result obtained through the attitudes and practices questionnaire. The attitude and practices score is approximately the same and lower than the knowledge score. This implies that most of the processors are aware of the factors affecting food safety but poor attitude impacts to poor practices. Poor performance on practices isn't mainly contributed by lack of knowledge but there a mix up of other factors.

The study has found that different processing conditions and parameters have impact on microbial level. Parameters work better on optimum conditions with a link to each other. Time temperature combinations are dependant factors that affect level of micro-organism during processing.

Temperatures of 65-75^{0}C with a time range of 15 minutes to 12 seconds were found to be effective. The temperature however was found to be critical as it also affected the quality of the raw poultry product during processing. Temperatures of less than 70^{0}C for less than 12 seconds are recommendable for control of micro-organisms.

Antimicrobial agents such as chlorine used in the processing water were found to be very effective in control of micro-organisms. A concentration of 4 ppm was found to be optimal.

Along the food chain the poultry products follow specific steps in order to reach the final customer. They include primary production, transport, processing and retailing. Each of these steps has inputs and increases value of the poultry products. To develop a sustainable food chain of poultry products in ensuring food safety is important to understand the role each step plays in

value addition. Challenges such as remoteness of the production sites, poor infrastructure and cool system transportation capacity effect of safety of the poultry products.

The findings of the study demonstrated that for poultry processors who have high score in KAP score the microbial risk is low contrary to those with low KAP score. Presence of pathogenic bacteria on ready to eat poultry products is a great risk and renders the meat unfit for human consumption.

6.2 Recommendations

The overall KAP score indicate the need for a training program for the processors. The training program should take into account mainly the importance in changing attitudes, practices and understanding the role of the processors towards food safety.

The needs of training should be evaluated to obtain the areas to be properly addressed during the training. Also, after the training the effectiveness of the training should be assessed to ensure that it has well addressed the expected needs and it's fully effective.

Due to the high Total Viable Count, study should be done to determine the specific micro-organisms contaminating the product in order to specifically control the loop holes leading to the increased chances of contamination.

Realizing the potential of street poultry vending business and the potential health hazards, the relevant regulatory authorities should take action to ensure implementation of policies and measures to curb any potential outbreaks. They should also ensure availability of essential resources and services to the processors such as potable water and waste management.

Stringent measures should be put in place all along the food chain to ensure all the stakeholders understand and play their role towards food safety.

There is need of to create awareness on good manufacturing and good hygiene practices along the poultry food chain by organised trainings.

There should be an improvement of facilities in which vending business is carried out and the environment to minimize risk of contamination by the environmental sources.

REFERENCES

Bolder N. M., (2007). Microbial challenges of poultry meat production. *World's Poultry Science Journal.* 63:401-411.

Cakiroglu F., and Ucar A. (2008). Employees' perception of hygiene in the catering industry in Ankara (Turkey). *Semantic Scholar Organization.* D01:10.1016.

Codex Alimentarius Comission (2003). Food Hygiene Basic texts. Fourth edition.

Cohen N., Ennaji H., Bouchrif B., Hassar M., and Karib H. (2007). Comparative study of microbiological quality of raw poultry meat at various seasons and for different slaughtering processes in Casablanca (Morocco). *J. Appl. Poult. Res*.16(4): 502-508

Cunningham F. E. (2016). Microbiological Aspects of Poultry and Poultry Products - An Update. *Journal of Food Protection*. Vol 2., pp 12.

Dawson R.J., and Canet C., (1991). Internatio activities in street foods. *Food control.* Vol.2, no.3, pp. 135-139.

Dias M.R.I., Dianin L.S., Bersot L.A.I., and Nero. (2017). Self-Monitoring Microbiological Criteria for the Assessment of Hygienic Procedures During Chicken Slaughtering. *Brazilian Journal of Poultry Science.* S1516-635X2017000200317

Dora-Liyana, Mahyudin A.L., Ismail-Fitry N.A., Ahmad-Zaki M.R., and Rasiyuddin H. (2018). Food safety and hygiene knowlegde, Attitude and Practices amog Food Handlers at Boarding Schools in the Northern Region of Malaysia. *International Journal of Academic Research in Business and Social Sciences.*(8)17, 238-266.

FAO 2012. Street food vending in West African cities: Potential challenges.*FAO regional office for Africa, Accra, Ghana.*Vol 2., pp 6.

Fortune A., Hlortsi H.E., and Owusu-Kwarteng J., (2017). Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC Public Health.*

Frings M.L., Tobia M., Khan D.,, Epprecht M.H., Kipruto M., Galea S., and Gruebner S., (2018). Modeling and mapping the burden of disease in Kenya OPEN. *Scientific reports*.

Jay L.S., Comar D., and Govenlock L.D. A video study of Australian domestic food handling practices. *J Food Prot.* 1999;62(11):1285–96.

Jenpanich C. (2015). Knowledge, attitudes and practices study on pig meat hygiene at slaughterhouses and markets in chiang mai province, Thailand. *Masters thesis, Chiang Mai University and Freie Universität Berlin.*

Kamau C. N., (2018). Impact of improved poultry production technologies among small holder indigenous chicken farmers in Kakamega and Makueni-Kenya. *Thesis Kenyatta University Agribusinnes Management.*

Kariuki E., Onsare S., Mwituiria R., Ng'etich J., Nafula R., Karimi C., Karimi K., Njeruh P., Irungu F., and Mitema P. (2019). Improving food safety in meat value chain, Nairobi.

Kassa H., Silverman G.S., and Baroudi K. (2010). Effect of a Manager Training and Certification Program on Food Safety and Hygiene in Food Service Operations. *Environ. Health Insights* 4, 13–20

Keerthirathne H., Piushani T.R., Fallowfield K., and Whiley H., (2016). A Review of Temperature , pH , and Other Factors that Influence the Survival of Salmonella in Mayonnaise and Other Raw Egg Products' *Multidispinary Digital Publishing Institute*.

Kenya Bureau of Standards. (2013). Kenya Standard KS 2455:2013 Food safety – General standard. ICS 67 020.

Koutsianos D., Athanasiou L., Chotinun K., and Koutoulis K. (2021). Colibacillosis in poultry: A disease overview and the new perspectives for its control and prevention. *Journal of the Hellenic Veterinary Medical Society.* 71(4)2425-2436.

Lazarov I., Zhelev G., Lytzkanov M., Koev K., and Petrov V. (2018). Dynamic of microbial contamination in a poultry hatchery. *ResearchGate.* Vol 11,No. 1, 37-44.

Logue C.M., & Nde C.W. (2007). Salmonella contamination of Tukey from processing to final product – A process to product perspective. *Foodborne Pathogens and Disease,* 4(4):491-504.

Lues J.F.R., M.R., Venter P and Theron M.M., (2006). Assessing food safety and associated food handling practices in street vending. *International Journal of Environmental Health Research.* vol. 16, no. 5, pp.319-328.

Mageto L. M., Ombui J. N. and Mutua F. K. (2015). Prevalence and risk factors for Campylobacter infection of chicken in peri-urban areas of Nairobi, Kenya. *Journal of Dairy, Veterinary & Animal Research Research.*

Maharjan S., Rayamajhee B., Chhetri V.S., Sherchan P.S., Panta P.O., and Karki T.B. (2019). Microbial quality of poultry meat in an ISO 22000:2005 certified poultry processing plant at Kathmandu valley.

Makita K., Desissa F., Teklu A., Zewde G., and Grace D. (2012). Risk assesment of staphlococcal poisoning due to consumption of informally-marketed milk and home made yoghurt in Debre Zeit, Ethiopia. *International Journal of Food Microbiology,* vol 153, pp. 135-141.

Marmion M., Ferone M.T., Whyte P., and Scannell A.G.M. (2021). The changing microbiome of poultry meat; from farm to fridge. *Food microbiology.* 99(103823).

Martins J.H., (2006). Socialeconomic and hygiene features of street vendering in Gauteng. *South African Journal of Clinical Nutrition.* Vol.19 no. 1, pp. 18-25.

Masupye F.M. and Von Holy A.(1999). Microbiological quality and safety of ready to eat street vended foods in Johannesburg, South Africa. *Journal of Food Protection.* Vol. 62, no.11, pp. 1278-1284 (7).

Mensah P., Mwamakamba L., Mohamed C., and Nsue-Milang D. (2012). Public health anf food safety in WHO Africa region. *African Journal of Food, Agriculture, Nutrition and Development.* Vol 12., no. 4, pp. 6317-6335.

Oguttu J.W. (2015). Participatory risk analysis of street vended chicken meat sold in the informal market of Pretoria, South Africa. *University of Pretoria.*

Reich F., Schill J., Bungenstock L., Klein P., and Reich F. (2018). Characterisation of Campylobacter contamination in broilers and assessment of microbiological criteria for the pathogen in broiler slaughterhouses. *Food Control Journal*.

Scheinberg J., Radhakrishna R., and Cutter C.N., (2013). Food safety knowledge , behaviour, attitudes of vendors of poultry products sold at Pennsylania farmers' market. *Journal of Extension.* Vol 51-6/6FEA4.

Shange N. (2015). Contamination of game carcasses during harvesting and slaughter operations at a South African abattoir. *Google Scholar.*

Shibia, M., Rahman, S. M. and Chidmi, B. (2017). Consumer demand for meat in kenya: An examination of the linear approximate almost ideal demand system. *Universitas Nusantara PGRI Kediri.*

Soares L.S., Almeida R.C.C., Cerqueira E.S., Carvalho J.S., Nunes I.L., Knowledge, attitudes and practices in food safety and the presence of coagulase positive staphylococci on hands of food handlers in schools of Camacari (2012). *Brazil Food Control*.;21:206-13.

Ştiinłifice I., Lucrări V., Medicină M., Adriana M., and Sala G. (2011) Establishing the bacterial control points in poultry slaughterhouse. *Faculty of Veterinary Medicine Timişoara Summary.*

Trampel D. W., Holder T. G., and Gast R. K. (2014). Integrated farm management to prevent Salmonella Enteritidis contamination of eggs. *Poultry Science Association.* 23/2/353/762531.

Ontario Foodland (2021). Implementing microbial control interventions on beef and veal in provincially licenced plants. *Ministry of Agriculture, Food and Rural Affairs.*

APPENDIX 1

POULTRY PROCESSORS QUESTIONNAIRE

1. Name …… ……. ……

2. Ages in years

<20 [ ] 20-25 [ ] 25-30 [ ] 30-35 [ ] >40 [ ]

3. Educational level

No school [ ] Primary school [ ] High school [ ] Tertiary [ ]

4. birds slaughtered in a day

<50 [ ] 50-100 [ ] >100 [ ]

5. Types of birds slaughtered

Indigenous [ ] Broiler [ ] Cross breed [ ]

4. Working experiences in chicken slaughter in years

<1 [ ] 1-2[ ] 2-3 [ ] <4 [ ]

5. Participation in food safety training or other training that is related with their jobs

Yes [ ] No [ ]

Part 1: General questions

	Knowledge	**Yes**	**No**	**Don't know**
1	Food borne illness is caused by consumption of unsafe food?			
2	Bacteria are naturally occurring in live poultry and it's the processing that determines the			

	safety of poultry meat?					
3	Water used during processing can lead to infection					
	Attitude	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
3	I will change my meat handling techniques if I know they facilitate meat contamination.					
4	Producing safe meat is more important than tasty meat.					
	Practices	**Always**	**Often**	**Sometimes**	**Rarely**	**Never**
5	I get medical health examination yearly as part of requirement of my job.					
6	I report and act to any abnormality during poultry processing that would render meat unsafe.					

Part 2: Personal hygiene

	Knowledge	**Yes**	**No**	**Don't know**
1	Employees should not have long nails or nail colorings at work?			
2	Washing hands with soap before and regularly during work is part of personal hygiene?			

	Attitude	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
3	I believe that good personal hygiene can prevent food borne illness.					
z4	Safe meat handling is part of my job responsibility.					
	Practices	**Always**	**Often**	**Sometimes**	**Rarely**	**Never**
5	I keep my nails short and remove any adornments before starting my activities.					
6	I wash my hands with soap regularly during work.					

Part 3: Waste management

	Knowledge	Yes	No	Don't know
1	Cleanliness of the working environment determines the safety of meat produced?			
2	Processing line should separate between dirty zones and clean zones?			

	Attitude	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
3	The company should have hire cleaners and not use workers as cleaners.					
4	I don't wait for supervisors to instruct me to collect any litter in processing floor.					
	Practices	**Always**	**Often**	**Sometimes**	**Rarely**	**Never**
5	I throw my litter in the dustbin.					
6	I point out to any unclean behaviour by my fellow workmates.					

Part 4: Process control

	Knowledge	Yes	No	Don't know
1	Time and temperature are important factors to control growth of bacteria?			
2	Are there processing stages that can contaminate meat with pathogen?			

	Attitude	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
3	I believe examination of the flock prior processing reduces					

chances of contamination.

4 Quality control is a simple task and doesn't require expertise.

	Practices	Always	Often	Sometimes	Rarely	Never
5	I ensure time and temperature factors are attained at my processing point.					
6	In event of contamination, I stop the process and check the previous batch.					

Part 5: Observation checklist.

1. Toilets inside the facility
   Yes [ ] No [ ]
2. Water treated
   Yes [ ] No [ ]
3. Antimicrobials used
   Yes [ ] No [ ]
4. Pest control program
   Available [ ] Not available [ ]
5. Cleaning and sanitization procedures
   Available [ ] Not available [ ]
6. Food monitoring devices.
   Available [ ] Not available [ ]

APPENDIX 2: INFORMED CONSENT FORM

Consent Form

Researcher Name: ARON KING'UYU KITONYI **Contact:** 0706946905

KNOWLEDGE, ATTITUDE AND PRACTICES RELATED TO MICROBIAL SAFETY AMONG STREET POULTRY PROCESSORS IN EMBAKASI, NAIROBI, KENYA.

1. I confirm that I have read (or have been read to) and completely understood the information from the above study. I have been given an opportunity to consider the information, ask questions and have had the questions answered satisfactorily.
2. I understand that I have voluntarily participated and am free to withdraw at any moment without giving any reason, without my legal rights being affected.
3. I understand that important sections of the data and information collected during the study may be looked at by other members of this research team. I give my permission for these individuals to have access to these records
4. I agree to take part in the study on my own free will without any demands

Name of Respondent: ……

Date: …… Signature: ……