BACTERIOLOGICAL SAFETY OF STREET FOODS AND FACTORS ASSOCIATED WITH FOOD CONTAMINATION AMONG STREET FOOD VENDORS IN GITHURAI AND GIKOMBA MARKETS.

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Bacteriological Safety of Street Foods and Factors Associated with Food Contamination among Street Food Vendors in Githurai and Gikomba Markets

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University

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DEDICATION

I dedicate this thesis to my dear husband Mr. Samuel Kariuki and our lovely daughter Favor Shantel Kariuki for their love, support and encouragement during the course of this study.

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LIST OF ABBREVIATION AND ACRONYMS

DCA	Deosycholate Citrate Agar
E. Coli	*Escherichia Coli*
FAO	Food Agricultural Organization
ICMSF	International Commission on Microbial Specifications for foods,
KEMRI	Kenya Medical Research Institute
MPN	Most Probable Number
NERC	National Ethical Review Committee
RCM	Robertson Cooked Meat medium
S. aureus	*Staphylococcus aureus*
SBA	Sheep Blood Agar
SIM	Sulfide Indole Motility
Spp	Species
SPSS	Statistical Packages for Social Science
SSC	Scientific Steering Committee
TCBS	Thiosulphate Citrate Bile Salt Agar
TSI	Triple Sugar Iron agar
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate agar
SPC	Standard Plate Count

DEFINITION OF TERMS

Food contamination Presence of unacceptable coliform count, E. coli and or Klebsiella pneumoniae such as in food

Food contamination as a dependent variable Having at least one food sample being contaminated

Street vended foods Foods prepared on the street and are ready to eat, or prepared at home and consumed on the street without further preparation

Environmental contaminants Substances introduced into food as a result of human activities which may have potential to contaminate food

Kachumbari A mixture of raw onions and tomatoes

Chapati A flat thin cake of unleavened wheat bread

Chips French fries

Githeri Meal made of mixed boiled maize and beans

Kangumu A hard deep-fried leavened wheat bread.

Mandazi A deep-fried leavened wheat bread.

Mukimo Meal made of mixed boiled maize, beans and potatoes

Samosa A deep-fried leavened wheat bread filled with minced meat

Smokie A type of sausage often used for hotdogs

Mutura	Large intestines of a cow filled with small pieces of meat commonly referred to as African sausage
Ugali	A dish made of maize flour cooked in boiling water to dough like consistency

ABSTRACT

The World Health Organization have established that poor sanitation and food handling practices may be some of the factors contributing to food related illnesses in developing countries including Kenya. The vending of street foods is a rising occupation in many countries that are developing and its increase is allied to urbanization and the necessity of urban community for both work and food. The vending of street foods is a growing business in Githurai and Gikomba markets in Kenya with most of its inhabitants being low income earners who mostly depend on the low priced foods which are sold on the streets. The safety of these street foods is of great importance as a result of the growth in this trade. The main aim of this study was to determine the bacteriological safety of street vended foods and factors associated with food contamination among street food vendors in Githurai and Gikomba markets. A cross-sectional study with a laboratory component was carried out involving one hundred and forty nine street food vendors who were selected through systematic random sampling. The main method of data collection was a structured questionnaire and an observation check list. Food samples were bought and transported to the laboratory under low temperature in a cooler box for microbial food analysis in order to determine the microbial status of the food. All the samples were analyzed within 24 hours of sampling. Data was first coded then entered into Microsoft Excel database and later analyzed using SPSS Version 20'. Food contamination was assessed by total aerobic plate count (APC), Enumeration of total coliforms and *Escherichia coli*, and presence of *Klebsiella Pneumoniae.* The overall occurrence of food contamination was 34.9%. Using the ICMSF guidelines for the microbial examination of foods that are ready to eat (ICMSF, 2001) all the samples of the baked cake (n=6) were satisfactory (APC= $< 10^4$), 85.7% of the boiled egg samples were also satisfactory (APC = $< 10^6$). On the other hand, 42.9% of boiled beans samples were unsatisfactory (APC= $> 10^5$), "*ugali*" sample was unsatisfactory (APC = $>10^5$) and 33.3% of the "*mutura*" sample was marginal (APC=$< 10^7$). "*Kachumbari*" and salads were not classified as it is anticipated that such foods have a natural raised plate count due to the normal microbial flora. In general, 25.2% of the foods sampled in this study were *E. coli* positive. *Klebsiella pneumoniae* was detected in a sample of boiled egg with *"kachumbari*". *E. coli* pathotyping revealed the presence of two pathogenic strains; *Enteropathogenic E. coli (EPEC) and Enteroaggregative E.coli* (*EAEC*). Among the food handling practices, access to fresh running water while preparing food, hand washing before handling food items, the method of hand washing and use of an apron while vending food were significantly associated with food contamination ($p< 0.05$). Access to a toilet facility, availability of running water around the toilet facility, presence of pests/rodents around the vending site had a significant association with food contamination. The results of this study provide evidence that several practices used while handling food and some factors linked to the environment are associated with food contamination among vendors in Githurai and Gikomba markets. There is need for the Ministry of Health to set effective food safety training requirements before issuing a license to any street food vendor and also carry out regular inspections to ensure compliance.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

The definition of street-vended foods is that they are foods that are prepared on the street which are ready for consumption, or they can be prepared at home then consumed on the street without the requirement of any other form of preparation (Martins & Anelich, 2000). Diseases related to food are shared among most countries that are still developing such as Kenya as a result of the predominant factors as; bad sanitation, poor food handling practices, food safety laws that are inadequate, and lack of basic education on food handling among food-handlers (WHO, 2004). The expansion and growth of the street food trade in most countries that are still developing today has been associated with urbanization and the need of the population in the urban areas for both labour and food. The safety of the street foods is therefore of great significance and deserves attention (WHO, 2004).

One of the major health hazard associated with street foods is microbial contamination (Abdussalam & Kaferstein, 1993; Arambulo *et al*., 1994). Some of the factors involved in causing contamination of food by microbes include poor food handling and preparation practices; insufficient methods that are used to store foods; the personal hygiene of the food vendors; lack of suitable ways for disposing waste and poor sanitation facilities (Abdussalam & Kaferstein, 1993).

Some of the contributing factors to a food related outbreak in Ethiopia were; contaminated food items which were raw, inadequate methods used for storage of food, lack of proper personal hygiene while preparing food, reheating and cooling of food items insufficiently and a long period of time between when the food is prepared and when it is consumed (Linda & Irma, 2005).

Further research done in various places in Ethiopia also demonstrated the poor state of sanitary facilities used in catering premises and occurrence of pathogenic organisms like campylobacter, *Salmonella, Staphylococcus aureus, Bacillus cereus and Escherichia coli,* (Knife & Abera, 2007; Abera *et al*., 2006; Bayleyegn *et al*., 2003; Tefera *et al*., 2009; Mekonnen *et al*., 2013).

Food contamination may also be as a result of the utensils used for serving food (Tomlins & Johnson 2004). Lack of basic facilities necessary to ensure safe food preparation is also a factor that may be responsible for unhygienic food handling practices as shown in one of the surveys conducted in Lusaka and Harare among street food vendors (Graffham *et al*., 2005). In Kenya, observations showed that the surfaces used to prepare food by the food vendors had leftovers of foods which had been prepared earlier. Several types of foods were prepared on the same surface which may increase the likelihood of cross contamination. Observations by Muinde and Kuria (2005) demonstrated that the vendors re-used the oil which was used to deep fry the chips, fish, sausages and *mandazi*, hence the the oil was dark coloured since the vendors did not replace it (Muinde & Kuria, 2005).

1.2 Statement of the problem

Vending of street food is a growing trade in Githurai and Gikomba markets in Kenya which have most of its inhabitants being low income earners who mostly depend on the low priced street foods. This therefore implies that in case of any outbreaks of food-borne diseases, majority of the inhabitants may be affected. Globally, there is scanty data on how foods sold on the street contribute significantly to food poisonings (Lianghui *et al*., 1993). African studies on street foods have shown that the growth of this trade has placed a burden on most of the resources in the city such as sewage and drainage systems, water, and intrusion of the plans of the city due to congestion and littering, hence affecting daily life (Canet & N'diaye, 1996).

According to Mwangi, (2002), food vendors in Kenya have visibly increased and 40% of Nairobi residents consume these foods. Increase in food vending has been prompted by the growth and change in demands of foods together with the need to diversify and/or employ more sources of income in the face of diminishing incomes (Mwangi, 2002). Frequently, vendors of street food are usually not licensed, they are also not trained on food sanitation and hygiene, and they work under makeshift structures where the sanitary conditions are inadequate (FAO, 2003). Globally, in the year 2005, there were 1.8 million deaths from diarrheal diseases and a greater percentage of these cases were ascribed to food contamination (WHO, 2011). Food vendors who sell foods on the streets are thought to be the source of food borne disease outbreaks as a result of inappropriate food handling practices (Jones *et al*., 2006). There is therefore a possible risk of food borne related outbreaks to consumers.

1.3 Justification

According to Gitahi and Njage (2012), research on street foods safety has been done in developing countries though not much has been done in Kenya. The current study was undertaken to develop an understanding of the quality of street vended foods with regards to microbes in Githurai and Gikomba markets and to identify the some of the environmental factors and food handling practices associated with microbial food contamination. Studying the relationship between the occurrence of different microbial pathogens and the food handling practices of street food vendors as well as environmental factors related with food contamination could expose the potential of poisoning as a result of food related outbreaks from consumption of foods sold on the streets. This could in return help to inform policy makers so as they can develop more intervention strategies to mitigate such an outcome. Establishing the quality of the street foods with regards to microbes may serve as a vital factor in understanding the safety issues relating to foods sold on the streets so that the

respective organizations can take suitable actions to improve the safety of the foods and sanitation with respect to street food vending.

1.4 Research Questions

1. What is the bacteriological contamination level of street vended foods by *Escherichia .coli, Salmonella, Shigella, Staphyllococcus aureus and Closrtidium perfringes* at consumption point in Githurai and Gikomba markets?

2. What are the food handling practices of street food vendors associated with food contamination in Githurai and Gikomba markets?

3. What are the sanitation practices of street food vendors associated with food contamination in Githurai and Gikomba markets?

1.5 Objectives

1.5.1 Broad objective

- To establish the bacteriological safety of street foods and factors associated with food contamination among street food vendors in Githurai and Gikomba markets.

1.5.2 Specific objectives

1. To determine the bacteriological contamination level of street vended foods by *Escherichia .coli, Salmonella, Shigella, Staphyllococcus aureus and Closrtidium perfringes* at consumption point in Githurai and Gikomba markets.

2. To determine food handling practices of street food vendors associated with food contamination in Githurai and Gikomba markets.

3. To determine the sanitation practices of street food vendors associated with food contamination in Githurai and Gikomba markets.

CHAPTER TWO

LITERATURE REVIEW

2.1 Street food vending

Foods vended on the streets are foods that are prepared and consumed on the street, or prepared at home then consumed on the street without requiring any further preparation (Martins & Anelich, 2000). The safety of the foods sold on the streets is a very significant aspect in the field of nutrition security. Vending of street foods is a key public health issue which has caused great distress to everybody. This is due to prevalent food borne diseases, due to the escalating of wayside food vendors who have no basic knowledge of food safety issues (Dawson, 1991). The most common source of food contamination is street food handling in unhygienic conditions by the some of the vendors (Dawson, 1991). Pathogens such as *Escherichia coli*, *Shigella*, *Campylobacter*, *Salmonella* and *S. aureus* can be transferred to foods by food vendors if they are carriers hence posing a hazard to consumers.

A study in India showed that 42% of the working women and men in the 25-45 years age group, and 61% of the students in the 14-21 years age group consumed foods from the streets at least once a day. As opposed to carrying food from home to work, about 23% of working women preferred to have food from street vendors. Majority (82%) of people of all age groups preferred street foods against 18% who preferred going to the restaurant in the evening. More than half (57%) of the working men and women were concerned about the hygiene and cleanliness of the vendors while the remaining were not bothered (Sunita Mishra, 2004).

2.2 Food contamination

Pathogenic bacteria, viruses, and parasites are the main microbiological hazards with regards to food safety. Problems that result in the contamination of food with

these microorganisms at the processor level can be easily alleviated with improved training of employees training and effective hygienic practices.

The hygiene of employees is vital to food sanitation and is one of the leading causes of food contamination (Higgins, 2002). Due to the change in lifestyle of the consumer, there is a requirement for more operational and enhanced ways of controlling food hygiene. Statistical evidence shows that the incidence of food poisoning initiating from caterers accounts for 70% of all bacterial food poisoning outbreaks which is higher than in any other food sector (Wilson, 1997). Insufficient control of temperature of food accounts for seventy per cent of outbreaks of food poisoning while the remaining 30% are due to cross-contamination (Wilson, 1997).

The hands of some of the employees in the food service can serve as a transmission route in the spread of food borne diseases either as a result of poor personal hygiene or cross-contamination. Such a food handler may contaminate his hands when using the toilet, or bacteria might be spread from raw meat to green salads by the hands of the food handler. Available data on risk factors for food borne diseases infer that most outbreaks are as a result of inappropriate food handling practices (Ehiri & Morris 1996). A USA study made suggestions that 97% of food borne illnesses in food service establishments and homes were due to unsuitable handling of food (Howes *et al*., 1996).

2.3 Microbiological standards of foods

The, aerobic plate count (APC) which is also known as the standard plate count (SPC) or the total viable count (TVC) is a test commonly applied to indicate the bacteriological quality of food. The importance of APC depends on the type of food product and the treatment it has received. When one applies the aerobic plate count test regularly, it can be a suitable means of observing trends by comparing the aerobic plate count results over time. There are three levels of aerobic plate count which depend on

the type of food and the handling or treatment the food has gone through. Level 1 is applied to ready-to-eat foods whereby every constituent of the food has been cooked in the process of manufacturing/preparation of the final food product and, as such, the number of microbes should be low.

Level 2 is applied to ready-to-eat foods which comprise some constituents which are already cooked then further handled either through slicing or mixing prior to preparation of the final outcome or where the cooking process is not used. Level 3 is applied to ready to eat foods whereby the aerobic plate count is not applied. This is applied to foods such as fresh fruits and vegetables such as vegetable salads, foods that are fermented foods and those which incorporate the vegetable salads like sandwiches. Such foods are expected to have a naturally raised plate count due to the presence of normal microbial flora (ICMSF, 2001).

2.4 Categorization of the microbiological quality of foods.

Depending on the microbiological quality, foods are categorized into four based on the level of indicator organisms, the aerobic plate counts, and the number or the presence of pathogens. Food can either be categorized as satisfactory, marginal, unsatisfactory and potentially hazardous. Satisfactory results show that the foods have a good microbiological quality and therefore one does not need to take any action. Marginal results shows that the foods are at the borderline meaning that they are within acceptable limits of microbiological quality but may indicate possible problems of hygiene especially during the preparation of the food. In this case, re-sampling of the foods may be applicable. If a food premise regularly yields borderline results, then its food handling controls should be investigated. When foods yield unsatisfactory results, it shows that the foods have microbes that are outside of acceptable microbiological limits and this may imply that the food handlers have poor food handling and personal hygienic practices. The action required is more sampling of additional foods from the food outlet for investigation to establish whether the hygienic practices and food

handling controls sufficient. Potentially Hazardous results suggest that the microbial levels in this category may result in food borne illness and instantaneous counteractive measures should be started. Withdrawing any of the food that is still available for distribution or sale should be considered and if valid, one may direct a recall action.

There should be an initiation of an investigation of the food handling practices or the production methods so as to identify the origin of the problem in order to start the corrective actions. The three levels of SPC depending on the food type and the handling or the processing the food has gone through are listed below (ICMSF, 2001).

Microbiological Quality (CFU per gram)

Test	Satisfactory	Marginal	Unsatisfactory	Potentially Hazardous
Standard Plate Count				
Level 1.	$<10^4$	$<10^5$	$\geq 10^5$	
Level 2.	$<10^6$	$<10^7$	$\geq 10^7$	
Level 3.	N/A	N/A	N/A	

2.5 Personal hygiene of the street food vendors

Food handlers play a very significant role in making sure that food is safe throughout the chain of food production, processing, storage and preparation. If food handlers mishandle and disregard hygienic measures, this may introduce pathogens to food and in some cases the pathogens may survive and proliferate in adequate numbers to cause infection in the consumer (WHO, 2011). Buying ingredients and foods which are ready for consumption from the street or the market vendors poses a substantial risk to the health of the public. This is so because of the poor hygienic practices that have been

observed. In most instances where research on street food vending has been done, the vendors lack adequate facilities for washing, and some vendors start their daily activities without taking a proper bath since they spend the night at the vending sites so as to protect their commodities (Ehiri *et al*., 2001).

The foods and their ingredients may also be exposed to repeated contamination as a result of using unwashed hands and also from the materials that are used for wrapping, such as old newspapers, leaves, and reusable plastic bags (Ehiri *et al*., 2001). Handling of raw materials by food handlers when they are suffering from specific diseases may introduce biological hazards through cross contamination (Ohiokpehai, 2003; Mensah *et al*., 2002). A majority of the food vendors use plastic bags to pack foods for their customers whereby in order to open them, they blow air inside and in this process a significant number of pathogens may be passed on to the consumer. A research carried out in Colombia discovered that greater than 30% of a group of food handlers examined were carriers of pathogenic microorganisms, including *Salmonella typhi*, *Staphylococcus aureus*, *Salmonella enteritidis*, and *Shigella* (Buchanan *et al*., 1998).

2.6 Environmental hygiene of street food vendors

Some vendors position themselves in overcrowded areas in order to reach out to the extraordinary numbers of likely potential customers hence leading to limited access to some of the basic sanitary facilities. Therefore, the contamination of street vended foods is often allied to the waste that is generated by food processing, which in most instances is dumped near the vending site. The lack of adequate sanitary facilities for wastewater and liquid drainage as well as garbage disposal promotes the disposal of wastes into nearby streets and gutters. Such areas act as breeding points for flies, dwelling places for rodents, and media for growth of microorganisms.

In an African study, 85% of the vendors prepared foods like fruit salads, roasted maize, fish, and chips in conditions that were unhygienic, given that dirty waste and garbage

were evidently adjacent to the stalls (Muinde & Kuria, 2005). African studies on street foods have shown that the tremendous growth of the street food trade has resulted in a strain on city resources, such as water, the drainage and sewage systems.

The growth has also interfered with the plan of the city through littering and congestion undesirably affecting our daily life (Muinde & Kuria, 2005). Several researchers have stipulated that foods sold on the streets raises fears in regards to their likelihood to cause serious food poisoning outbreak as a result of pathogenic bacteria that may be present in the foods either from environmental contamination or from improper food handling and hygienic practices (Muinde & Kuria, 2005.). Barro *et al.,* established that most food vendors have a very low level of education, are untrained and work under unhygienic conditions (Barro *et al*., 2006). According to Patience *et al*. (2002), the state of hygiene of vending establishments is a major source of alarm for food control officers. Often, food vending stalls are structures which are not finished and with no available running tap water. Washing facilities and Toilets are rarely adequate and hand washing as well as washing of dishes is mostly done in bowls or buckets. Rarely is disinfection done, and improper sewage disposal may attract rodents and insects to such sites. Finally, refrigeration is usually unavailable and food is not sufficiently protected from flies and (Patience *et al*., 2002).

According to Mwangi, (2002), there is a visible increase in the number of street food vendors in Kenya. This is more apparent in Nairobi, whereby the vendors sell both cooked and raw food items along the streets. Increase in food vending has been prompted by the rapid growth and change in food demands alongside the need to expand and/or employ more income sources in the face of diminishing incomes (Mwangi, 2002)**.** Observations made from a study in Kenya showed that about 85% of the vendors interviewed prepared foods in conditions that were not hygienic given that garbage and dirty waste were noticeably close to the stalls. Among the vendors interviewed, 92.5% disposed their garbage near the food stalls as they did not have

garbage receptacles. As a result of such practices, the surrounding environment was quite filthy (Muinde & Kuria, 2005).

2.7 Acquisition of knowledge on food preparation among food handlers

A study carried out in Ethiopia established that majority (83.9%) of the food vendors acquired cooking skills from observing others, 7.8% from being taught by parents while 8.3% were formally trained. Obtaining the necessary training on food hygiene standards to employ when handling and cooking food items is very imperative. Food handlers should have the skills and knowledge necessary to enable them to handle food hygienically (Mekonnen, 2013).

2.8 Vendors and consumers of street foods

In Africa, every age group consumes street vended foods. However, differences may be in the type of clients depending on the neighbourhood. While it is regularly thought that children under five are fed from home, Mensah *et al*. (2002) observed that many mothers working at the markets in Accra sometimes fed their babies on food items from vendors. In a study in West Africa, a majority of those who consume street foods were found to be male. While a majority of the consumers were from the middle or low income group, a substantial number were professionals and represent the diverse ethnic groups in the countries concerned.

The consumers also included people who have achieved a variety of educational levels and the illiterate (Nago, 2005). According to findings of research in Nairobi, Kenya, greater than thirty-five percent of the vendors were between 20-25 years, 40% were female, and sixty percent were male while; slightly over half of the vendors (57.5%) were married. Only 1.3% of the vendors interviewed had college education, 36.3% had secondary education while Sixty-two percent of the vendors interviewed had primary education and below (Muinde & Kuria, 2005).

2.9 Food poisoning due to street foods

There is inadequate epidemiological data to suggest that street foods contribute to a substantial number of food poisonings; however, there have been several cases documented on food poisoning outbreaks due to street foods. Street foods were accountable for 691 food poisoning outbreaks and 49 deaths from 1983 to 1992 in Shangdong Province (China) (Lianghui *et al*., 1993). Some of the common food borne bacterial pathogens detected in street vended foods are *Bacillus cereus*, *Clostridium perfringens*, *Staphylococcus aureus* and *Salmonella* spp (Muleta & Ashnafi, 2001).People who frequently consume street food have been reported to suffer from food borne diseases like, diarrhea, cholera, typhoid fever and food poisoning (Todd, 1992). Food borne and waterborne diarrheal diseases are the major leading causes of illness and globally kill an estimated 2.1 million people annually, most of whom are children in developing countries (WHO, 2001). The high prevalence of diarrheal diseases in most countries that are still developing suggests major underlying food and water safety problems (WHO, 2011).

Food-borne pathogens are identified as a major health hazard associated with street foods, the risk being primarily dependent on the type of food and the method used for preparation and conservation (FAO, 1998 & FAO/WHO, 2005). In a study carried out in Accra, Ghana that involved 951 mothers, about 60% of them supplemented their children's diet with street food. This posed an increase in the risk for both acute and persistent diarrhoea to the children. Higher contamination levels were observed in the street food given to these children than in food cooked at home (Mensah *et al*., 2002). According to WHO (2004), many factors have contributed to the dramatic increase in food borne incidents. Historically, most foods were prepared and consumed at home, but urbanization has revolutionized the food chain, resulting in an explosive increase in food service establishments. Food borne diseases outbreaks involving street foods have been reported from several African countries.

There is scientific evidence demonstrating the poor microbial quality of street foods in the African region (Mensah *et al*., 2002; Garin, 2002; Muleta & Ashnafi, 2001; Aidara, 2000). Agents such as *Escherichia coli* and *Salmonella* have caused food borne disease epidemics hence highlighting problems with safety of food. This has also raised public anxiety that food processing, modern farming systems, and marketing do not provide adequate safety measures for public health. Factors which contribute to potential hazards in foods include; poor hygiene, improper agricultural practices at all stages of the food chain, lack of preventive controls in food processing and preparation operations, contaminated raw materials and insufficient or unsuitable storage among others (WHO, 2002a). Foods borne illnesses originating from microbes are a major cause of death in developing countries and a significant international health problem associated with food safety (WHO, 2002a; WHO, 2002b).

2.10 Global food safety issues

According to the World Health Organization, urbanization, food trade globalization, changes in lifestyle, international travel and advances in food technology have made the food production and distribution chain more complex, providing greater opportunities for food contamination from more diverse sources. Consequently, food safety is an increasingly important public health issue with governments all over the world intensifying their efforts in this area. These efforts are in response to an increasing number of food safety problems and rising consumer concerns (WHO, 2001).

Food safety is the guarantee that food will not cause harm to the consumer when it is prepared and consumed (FAO/WHO, 1997). Millions of people fall ill and many suffer from serious disorders, long-term complications or die as a result of eating unsafe food (FAO, 2007). The heavy burden of food borne diseases imposes substantial economic losses to individuals, households, health systems and entire nations. Economic losses as a result of rejected food exports due to shortcomings in food safety are often very significant (WHO, 2004).

The frequency of reported outbreaks of food poisoning incidents have risen substantially in most countries, and have become an important topic of concern among consumers and governments. Outbreaks of microbial and chemical food poisoning cases have been continuously increasing within the African region in recent years (WHO, 2004).

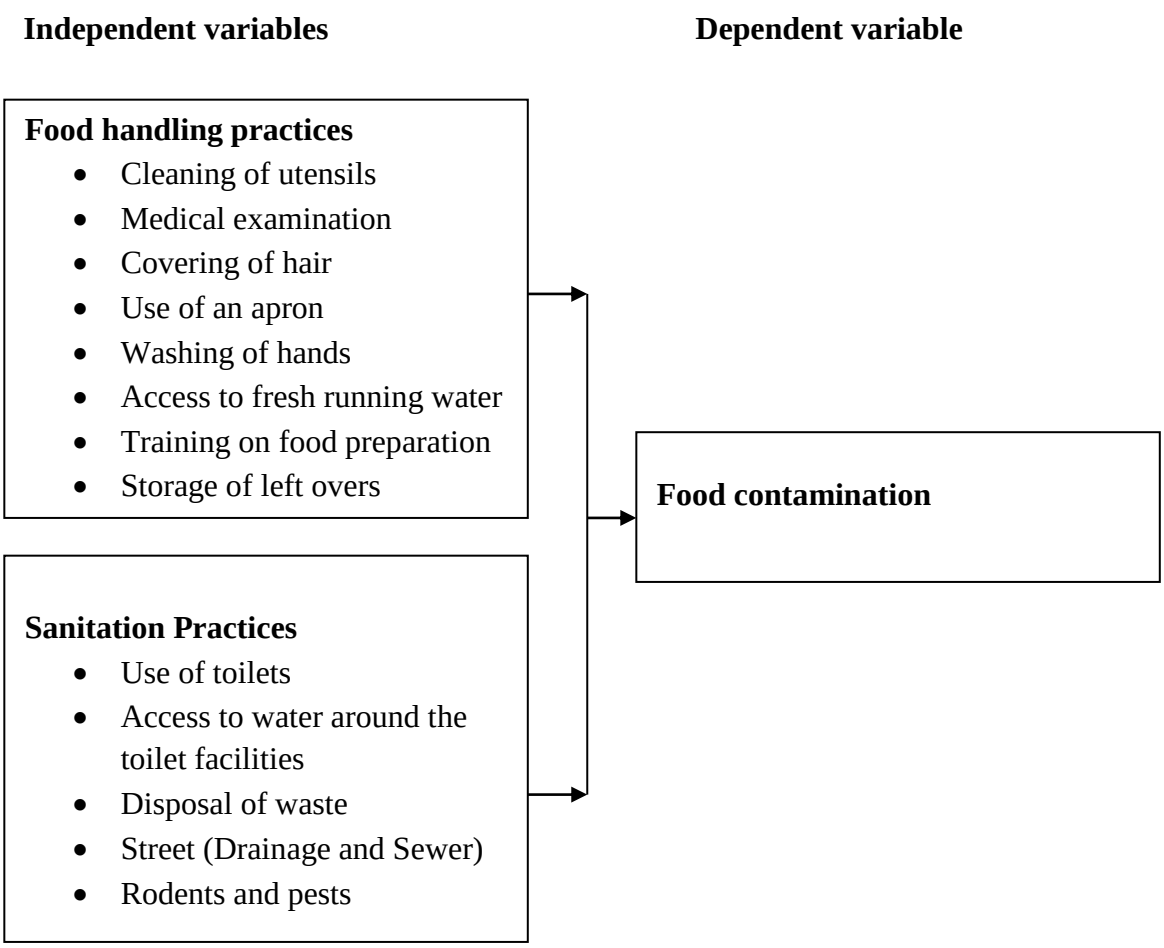

Figure 2.1: Conceptual framework

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study area

The study area was Githurai and Gikomba markets. Today there are more than 4000 traders in Gikomba. Gikomba is a market located about 800 metres from the Nairobi town centre in kamukunji constituency and is famous for the sale of second hand clothes but there are other products which are sold including food. It is a very busy market where there are various businesses and activities such as hand carts (mukokoteni's) who ferry goods across the market, and the surrounding communities are mainly low income earners who largely consume street vended foods. Githurai on the other hand is located on the Eastern part of Nairobi, about 12km from the city centre in Kasarani constituency. Githurai's population likely exceeds 300,000 persons and has a busy market which is famous for the sale of second hand goods as well as food. The Githurai market is very congested and movement within it is severely hampered as every trader tries to display his/her goods for passersby to buy. The surrounding communities widely depend on the market for buying cheaply priced goods including street vended foods, since majority of them are low income earners. There was therefore a need to carry out this study on food safety in these two areas as any contamination may imply a possible food borne disease outbreak in the offing, that may affect a large population in Nairobi who may not only be residents but also those visiting the markets.

Figure 3.1: Map showing the Location of Githurai market

Figure 3.2: Map showing the Location of Gikomba market

3.2 Study design

The study employed a descriptive cross-sectional study design with a laboratory component so as to establish the bacteriological safety of the street foods and asses the food handling and sanitation practices associated with food contamination at consumption point.

3.3 Study population

The study population comprised of street food vendors who were selling ready to eat foods in Githurai and Gikomba markets. The food vendors were sampled as described in the sampling procedures and interviewed after which a food sample was purchased from them for microbial analysis.

3.3.1 Inclusion criteria

Street food vendors aged 18 years and above and consented

3.3.2 Exclusion criteria

Food handlers selling food in well-structured permanent food establishments other than the temporary makeshift structures.

3.4 Sample size determination

The total sample size was determined by the formula of Fisher et al. (1998) .Where; N = the desired sample size for target population > 10,000, Z = normal standard deviation corresponding to 95% confidence interval, that is 1.96, P = Proportion of the population estimated to have desired characteristics, q = 1-p , d = degrees of accuracy desired (0.05), hence; this study employed a prevalence value of 20% as used in a similar study in Ethiopia (Mekonnen *et al.*, 2013).

The sample size was therefore calculated as follows:

$$n = \frac{Z^2 1-\infty/2\ P\ (1-P)}{d^2}$$

Description:

n= required sample size

z= confidence level at 95% (standard value of 1.96)

p= estimated prevalence (0.20)

d= level of precision at 5 %(0.05) (Fisher et al., 1998).

n= 245.86

However, the population under study was <10,000 and hence the Cochran 2000 formula (Solomon, 2007) was further employed to calculate the actual sample size. A preliminary survey revealed the population of interest was a total of 380 street food vendors:

Actual sample size therefore was:

$n_f = n/1+n/N$

Where N= population size

n= Sample size if N is infinite (N> 10,000)

nf= Sample size if N is finite (N< 10,000)

=245.86/1+245.86/380

= 149

Then sharing the sample proportionate to size= Gikomba = 197/380* 149= 77; Githurai= 183/380* 149= 72

Sampling interval (K) = N_1/n_1

= 380/149

= 2.55

$\approx$ 2

3.5 Sampling

Random sampling was used to sample the first street food vendor specifically preparing and selling the foods on site within the two study areas; Githurai and Gikomba after which systematic random sampling using a sampling interval of 2 as calculated above was used to sample the rest of the food vendors. Food samples were then bought and collected aseptically from the same street food vendors who were already sampled for the purpose of microbial analysis.

3.6 Data collection

An Informed consent form was first issued to the street food vendors for the purpose of obtaining permission to interview them after which a structured questionnaire (Appendix II) was administered to gather relevant information from the street food vendors. The information that was sought was on food handling practices (such as washing of hands before handling food, method of hand washing, , storage of leftover, training on food handling, frequency of medical examination among others), environmental factors such as availability of toilet facilities, availability of clean water and disposal of solid waste. Observations were also done using an observation checklist (Appendix III). Food samples were then bought and collected in sterile universal bags, transported to the National Public Health Laboratories under low temperature in an ice

cooler box and stored at 4°C until testing. All the samples were analyzed within 24 h of sampling. Standard methods were used for enumeration, isolation and identification of bacteria as described below.

3.7 Standard operating procedure for food bacteriology (WHO, 2000 on Food bacteriology)

Procedure for microbial analysis of food samples

After transporting the food samples to the laboratory, the following procedures will be followed for microbial analysis;

Preparation of the Food Homogenate

Using a sterile scalpel and forceps 25 grams of sample was transferred into a previously sterilized sample container. 250 ml of buffered peptone water was added to make 1:10 dilution. After preparing the food homogenate, aerobic count of viable organisms was carried out on each sample as follows;

Aerobic count of viable organisms in food.

This test is a useful indicator of microbiological status of food. A high count often indicates contaminated raw materials, unsatisfactory sanitation or unsuitable time/temperature condition during production or storage or a combination of both. In addition high counts foretell the likelihood of spoilage.

Procedure

A serial dilution was prepared from the 1:10 dispersion by pipetting 1ml of the dispersion into a universal bottle containing 9ml of buffered peptone water to make 1:100 dilutions. This procedure was repeated until a dilution of 1 part of sample in 1,000,000 volume of diluent was obtained; the bottle was then mixed thoroughly at each dilution before preparing a further dilution, by inverting and righting the bottle by hand

ten times. From each dilution of the sample starting at the 1:100 dilution two ml volumes was taken and each volume transferred to a plate (Petri dish).

For each separate Petri dish one 15 ml volume of plate count agar was taken, melted, tempered to 45^{o}c then added to the plate and mixed well to ensure even distribution of colony forming units after incubation. The agar was allowed to set the plates then inverted and transferred into an incubator at 30^{o}c for 72 hrs. The plates were suitably labeled as per every dilution. After incubation period the plates were removed and colonies counted on dishes containing 30 -300 colonies. The total count of viable organisms was then calculated by averaging the count on each plate of a given dilution and multiplying the average count by the factor involved. When the dishes examined contain no colonies, the result were to be expressed as $1x10^{1}$ bacteria per gram or ml and when the dishes (dilution 1 in 10) contain less than 30 colonies, the result were to be expressed as less than $3x10^{2}$ .When the colonies were more than 30, the colonies in both plates of the dilution were counted and the average calculated, retaining only two significant digits and multiplying by the inverse of the corresponding dilution to obtain the number of bacteria per gram or ml.

Enumeration of Coli form Bacteria

Inoculation

From the 1:10 dilution three 1 ml I volume was pipetted into three bottles containing Mac conkey broth. The same procedure was repeated for the 1:100 dilutions and also 1:1000 dilutions ensuring that the Durham tube inside the bottles containing Mac conkey broth was filled before incubation. Incubation was then done at 37 C for 48 hours. From the Mac conkey broth previously incubated fermentation and gas production was checked.

Those which showed fermentation and gas production in the Durham tubes a loopful {0.02ml} was transferred into fresh Peptone broth and Mac conkey broth. All of them were incubated at 44 ^{o}C + 0.25 ^{o}C water bath for 48 hours. At this stage the results of those that were positive for coliforms were tabulated and the most probable number indicated using the MPN chart. After incubation, fermentation and gas production was checked then kovacs reagent added to its corresponding peptone water.

The presence of *E. coli* is indicated by a. red ring at the surface of the medium. The number of E. coli was then tabulated using the MPN chart.

Examination for Thermotolerant (faecal) coliform bacteria

The food samples were also tested for faecal coliforms using the multiple tube fermentation technique (MPN) (UNEP/WHO, 1996). The first step of the MPN procedure for fecal coliform testing is called the presumptive test. MacConkey broth was used in this study for the purpose of isolation of total coliforms, then after the incubation process, any tube showing gas production with fermentation indicated the possible presence of coliform bacteria and was recorded as positive presumptive tube. All positive presumptive tubes were transferred to Tryptone water media and incubated after which KOVACS' reagent was added. Presence of a red ring on the surface of the tube with gas production denoted presence of indole hence confirming the presence of *E. coli*. The presence of *E. coli* in food almost always indicates recent fecal contamination. Fecal coliforms appear in great quantities in the intestines and feces of people and animals hence their presence in a food sample often indicates recent fecal contamination, meaning there is a greater risk that pathogens may be present.

Examination for presence of Salmonella /Shigella.

100 ml of Tetrathinate broth was pipetted into a sterile container, 3 ml of iodine added and 0.2 ml of brilliant green before adding the food sample. 100 ml of Selenite cysteine then pipetted into a sterile container. 10 ml volume of the previously incubated 1:10 dilution of the food sample was then pipetted into each of the bottles containing Tetrathionate and Selnite cystine. Incubation done at 43^{o}C for 48 hrs then Sub cultured into X.L.D, D.C.A. and Mac conkey agar. Incubation was again done at 37^{o}C for 18-24hrs. Characteristic colonies of salmonella and Shigella were then checked for so as to determine if inoculation on T.S.I. could be done as well as incubation at 37^{o}C for 18-24 hrs. Examination of the T.S.I. reactions was to be done as follows;

Shigella

Yellow (acid) –butt

Alkaline –slant

No gas

No hydrogen sulphite

Salmonella

Yellow (acid) - butt

Alkaline- slant

Gas- present

Hydrogen sulphite produced

Examination for presence of staphylococcus aureus

1 ml of the 1:10, 1:100 and 1:1000 was pipetted into a bottle containing Robertson cooked meat medium of single strength concentration of sodium chloride then 10 ml of the 1:10 dilution of the food sample pipetted into RCM containing 10 ml with double strength of sodium chloride. Incubation was then done at 37 ^{o}C for 18-24 hrs, Sub culture carried out into SBA plates and incubation done at 37^{o}C for 18-24 hrs. Characteristic colonies of staphylococcus aureus were then checked for so as coagulase test would be performed.

Examination for Presence of Clostridium Perfringens

1 ml of 1:10 dilution was pipetted into a bottle containing plain RCM, incubation done at 37^{o}C for 48 hrs. Secondly, boiling was done for ten minutes and sub culture done into SBA both aerobically and anerobically at 37 ^{o}C for 24 hrs.

On blood agar plates, *C. perfringens* grown anaerobically produces β- haemolytic, flat, spreading, rough, translucent colonies with irregular margins. A distinguishing characteristic of *C. perfringens* is a zone of double beta haemolysis.

Polymerase Chain Reaction (PCR)

(*E.Coli* pathotyping)

DNA was extracted from 24 hour old colonies. Bacterial cells were emulsified in 250 µl lysis buffer containing 0.5 % (w/v) sodium dodecyl sulfate, proteinase K (0.5 mg/ml), and RNase (0.8 mg/ml) and incubated in a water bath at 60°C for 5 min followed by centrifugation at 1000 X g for 60 seconds. Two hundred microlitres of the supernatant were placed in a new eppendorf tube and overlaid with 30 µl of 6 M NaCl and 2 volumes of room temperature 70 % ethanol. The tube was then kept at room temperature for five minutes before centrifugation at 1000 X g for three minutes. The

supernatant was discarded and the crude DNA rinsed with 70 % ethanol and dried out by leaving the eppendorf tubes open for a few minutes in the clean bench. Finally the DNA was suspended in 200 µl of sterile water. Two hundred microlitre (200µl) tubes containing PuReTaq ready-to-go PCR beads (GE Healthcare UK limited, UK) were used to set the polymerase chain reaction. Each reaction contained 2.5 units of PuReTaq DNA polymerase, 10 mM Tris-HCl (pH 9.0), 50 mM KCl, 1.5 mM MgCl2, 200 µM dATP, dCTP, dGTP and dTTP, stabilizers, BSA, 1µl each of forward and reverse primers, 2µl of template DNA, and Milli-Q water added to a final volume of 25µl. The PCR amplifications of the target regions were carried out in a thermal cycler (Bio-Rad, USA). Oligonucleotide primers that were used in the PCR assays, their sequences and the amplicon sizes are described in APPENDIX V. Multiplex-PCR was carried out by the method described by Toma (Toma *et al.,* 2003). A multiplex reaction that constituted the genes for detection of EAEC, EIEC, EPEC and EHEC was carried out. Genes for detection of ETEC were amplified in a separate reaction.

The PCR products were analyzed by electrophoresis in 2% agarose gels, stained with ethidium bromide (2µg/ml in 1% TBE buffer), visualized under UV light and recorded with the aid of a gel documentation system (Bio-Rad iCycler, USA).

Primers used in multiplex PCR

Primers, Genes and Sequence (5'- 3')	**Reference**	**Band size (bp)**
SK, eae gene, enterotoxin or shiga toxin producing *E. coli*, EPEC or EHEC SK1 CCCGAATTCGGCACAAGCATAAGC SK2 CCCGGATCCGTCTCGCCAGTATTCG	Oswald *et al.*,2000	881
VTcom, stx1 and stx2 genes, shiga toxin producing *E. coli*, STEC VTcom-u: GAGCGAAATAATTTATTATGTG VTcom-d: TGATGATGGCAATTCAGTAT	Yamasaki *et al.*,1996	518
AL, est gene, enterotoxigenic*E. coli*, having shiga-like toxin, ETEC AL65: TTAATAGCACCCGGTACAAGCAGG AL125: CCTGACTCTTCAAAAGAGAAAATTAC	Homes *et al.*,1991	147
LT, eltB gene, heat labile enterotoxin, ETEC LT1: TCTCTATGTGCATACGGAGC LTr: CCATACTGATTGCCCGCAAT	Tamanai *et al.*,1994	322
Ipa gene, EIEC ipaIII: GTTCCCTTGACCGCCTTTCCGATACCGTC ipaIV: GCCGGTCAGCCACCCTCTGAGAGTAC	Sethabutr *et al.*,1993	600
aggR, aggR gene, aggregate-R, EAEC aggRks1: GTATACACAAAAGAAGGAAGC aggRks2: ACAGAATCGTCAGCATCAGC	Ratchtrachenchai *et al.*,1997	254
Eagg, Pcvd432 (EaggEC) gene, Enteroaggregative *E. coli* Eaggfp: AGACTCTGGCGAAAGACTGTATC Eaggbp: ATGGCTGTCTGTAATAGATGAGAAC	Pass *et al.*,2001	194
AspU, aspU gene, EAEC aspU-3: GCCTTTGCGGGTGGTAGCGG aspU-2: AACCCATTCGGTTAGAGCAC	Toma *et al.*,2003	282

3.8 Data management and analysis

Data from the study was first coded. Double entry was then done using Ms Excel for comparison purposes. Errors were minimized by cleaning and rechecking all the entries with the original data forms. Data analysis was done using SPSS software version 20 where; descriptive statistics like mean, frequencies and percentages were used to describe the data and presentation done through tables, pie charts, and graphs. Bivariate analysis on categorical variables was first performed to determine variables that would be included in the binary logistic regression. Multivariate analysis was then performed to calculate the adjusted odds ratio for the independent association between food contamination and the predictive variables. Food contamination will be based on the ICMSF standards on microbial quality of ready to eat foods as described in section 2.3 and 2.4.

3.9 Ethical Considerations

Approval to conduct this study was obtained from the Scientific Steering Committee (SSC) at the Kenya Medical Research Institute (KEMRI) and Scientific Ethical Review Union (SERU) for scientific and ethical approvals respectively. Consent was also sought from the respondents through the attached consent form (Appendix I). Respondents were assured that no person-identifiers were to be used for publication. Codes were assigned on all information about the participants and handled with utmost confidentiality making it difficult to relate the data to respondents and only used for assessing associations with food contaminations.

3.10 Study limitations

The main limitation of this study was the inability to collect data from more than two study sites. This would have been useful in generalizing the findings to a larger population in Kenya. The population under study was also a very complex population that included very busy traders and hence data collection was challenging in terms of

time spared to answer the questionnaire. However, through reassuring and convincing the street food vendors it was possible to overcome the challenge.

CHAPTER FOUR

RESULTS

4.1 Socio- demographic characteristics of respondents

A total of 149 street food vendors with a mean age of 28.8 years (SE=0.41) ranging between 20-60 years were interviewed. The majority (82) of the respondents were between 20-29 years with the 60-69 year age group having the least (1) respondent. The gender of the respondents was almost equally distributed with 49.7% female, while 50.3% were male. Majority (55.7%) of the respondents were married, 39.6% were single, 3.4% were divorced/separated while 1.3% were widowed. In terms of their level of education, 36.9% of the respondents had acquired up to primary education while 34.9% had secondary education. Only 4.7% had acquired university education while 23.5% of the respondents had no formal education **(Table 4.1).**

Table 4.1 Socio-demographic characteristics of respondents

Variable	Frequency(n=149)	Percentage
Gender		
Female	74	49.7
Male	75	50.3
Total	149	100.0
Age		
20-29	82	55
30-39	63	42.3
40-49	3	2.0
50-59	0	0
60-69	1	0.7
Total	149	100.0
Marital status		
Married	83	55.7
Single	59	39.6
Divorced/Separated	5	3.4
Widowed	2	1.3
Total	149	100.0
Education level		
No formal training	35	23.5
Primary	55	36.9
Secondary	52	34.9
University/College	7	4.7
Total	149	100.0

4.2 Food handling practices of street food vendors

The food handling practices of the street food vendors were also explored. The majority (63.8%) acquired food preparation skills through observation, and only 3.4% were formally trained. In terms of medical examination for the purpose of certification as a food handler, a majority (53.7%) reported to have never gone for medical examination, 24.2% had regular check-ups more than 3months apart, 15.4% after every 3 months while 6.7% had regular check-ups less than 3 months apart. On whether one had a health certificate, 46.3% reported having had one while 53.7% did not have it. Verification was done of which of the 69 respondents who reported to have a health certificate, only 23 were valid, 5 were expired and 41 claimed to have left at home and hence it was not possible to verify. Among those who did not have the health certificate (80), one of them had no clue of what a health certificate was.

A majority (53%) of the respondents had access to fresh running water while 47% did not. Through observation, some of the areas especially within Gikomba market had several taps with running water although most vendors preferred fetching water in containers for use, instead of making trips to the tap. Washing of hands before handling food items was practiced by 68.5% (102) of the respondents; however, a majority (86.6%) of the vendors did not wash their hands after handling raw food items. Among vendors who washed their hands either before handling food items or after handling raw food items, only 1.8% used soap and running water. In terms of use of protective clothing, 56.4% of the respondents always wore an apron while handling food but only 38.3% covered their hair while handling food. A majority (59%) of the vendors stored leftover foods in a cupboard, 18.1% stored it in a refrigerator at home while 11.4% claimed that no food was left. Others consumed it with family (7.4%), discarded it as waste (3.4%) or gave it out to people (0.7%). A majority (85.9%) of the street food vendors sold ‘take away’ foods, with the rest (14.1%) either selling it as ‘take away’ or having the customer consume the food on site. Since a majority of the vendors sold ‘take away’ food, the food was mainly served using plastic bags (67.8%),

while 14.1% used either a plastic bag or a plate, 18.1% used paper bags or maize cob leaves for some maize vendors (**Table 4.2**).

Table 4.2 Food handling practices of the street food vendors

	Frequency	**Percentage**
Medical examination		
Less than 3months	10	6.7
After every 3months	23	15.4
After more than 3months	36	24.2
Never	80	53.7
Total	149	100.0
Access to fresh running water		
Yes	79	53
No	70	47
Total	149	100.0
Always wash your hands before handling food items on site		
Yes	102	68.5
No	47	31.5
Total	149	100.0
Always wash hands after handling raw food items		
Yes	20	13.4
No	129	86.6
Total	149	100.0
Way of Hand washing whether before or after		
Soap and running water	2	1.3
Water in a container and soap	78	52.3
Water in a container only	29	19.5
Do not wash hands (N/A)	40	26.8
Total	149	100.0
Always wear the apron		
Yes	84	56.4
No	65	43.6
Total	149	100.0
Always cover hair		
Yes	57	38.3
No	92	61.7
Total	149	100.0

Variable	Frequency	Percentage
Leftover food storage		
In a refrigerator	27	18.1
In a cupboard	88	59.0
Consume it with family	11	7.4
Give out to people	1	0.7
No food left	17	11.4
Discards as waste	5	3.4
Total	149	100.0
Serving of food		
Plastic bag	101	67.8
Paper bag or maize cob leaves	27	18.1
Plastic bag or plates	21	14.1
Total	149	100.0

4.3 Sanitation practices of the street food vendors

The sanitation practices of the street food vendors were also assessed; a majority (75.8%) had access to a toilet facility with 46.3% using a modern toilet while 29.5% used a latrine. On the other hand, it was also observed that some vendors especially the men urinated on the open on walls. Of those who had access to a toilet facility, 42.3% had fresh running water for hand washing either within the toilet or outside the toilet, while 33.5% said they did not have access to fresh running water. In terms of waste disposal, a majority (62.4%) practiced open area dumping, 31.5% used waste bins while 6.1% were either burning waste in the evening or using it for pig feeding. Presence of pests/rodents in the surrounding environment was reported by 36.9% of the respondents with 26.2% reporting presence of rats. For pest/rodent control, 22.1% of the respondents reported using pesticides/rodenticides with others either using pesticides, rodenticides, and traps (8.7%) or not controlling at all (6%) (Table 4.3). On what they thought about their surrounding environment, a majority (88.6%) thought that their environment was full of contaminants. These contaminants included pollution from sewers, dust, and vehicle fumes among others.

Table4.3 Sanitation Practices of the street food vendors

Variable	Frequency	Percentage
Use of a toilet		
Yes	113	75.8
No	36	24.2
Total	149	100.0
Type of toilet used		
Latrine	44	29.5
Modern toilet	69	46.3
N/A	36	24.2
Total	149	100.0
Hand washing after toilet use		
Yes	63	42.3
No	50	33.5
N/A	36	24.2
Total	149	100.0
Waste disposal		
Open area dumping	93	62.4
Dust bin for municipal to collect	47	31.5
Others(Burning, pig feeding)	9	6.1
Total	149	100.0
Presence of Pests and Rodent s on site		
Yes	55	36.9
No	94	63.1
Total	149	100.0
Type of pests		
Rats	39	26.2
Rats and Moles	16	10.7
N/A	94	63.1
Total	149	100.0
Pest control		
Pesticides/rodenticides	33	22.1
Pesticides/rodenticides/traps	13	8.7
Not controlled	9	6.0
N/A	94	63.1
Total	149	100.0

4.4 Food samples collected

A total number of 218 food samples were sampled from the 149 street food vendors. Twenty two different kinds of foods were sampled from the food vendors **(Fig 4.1).**

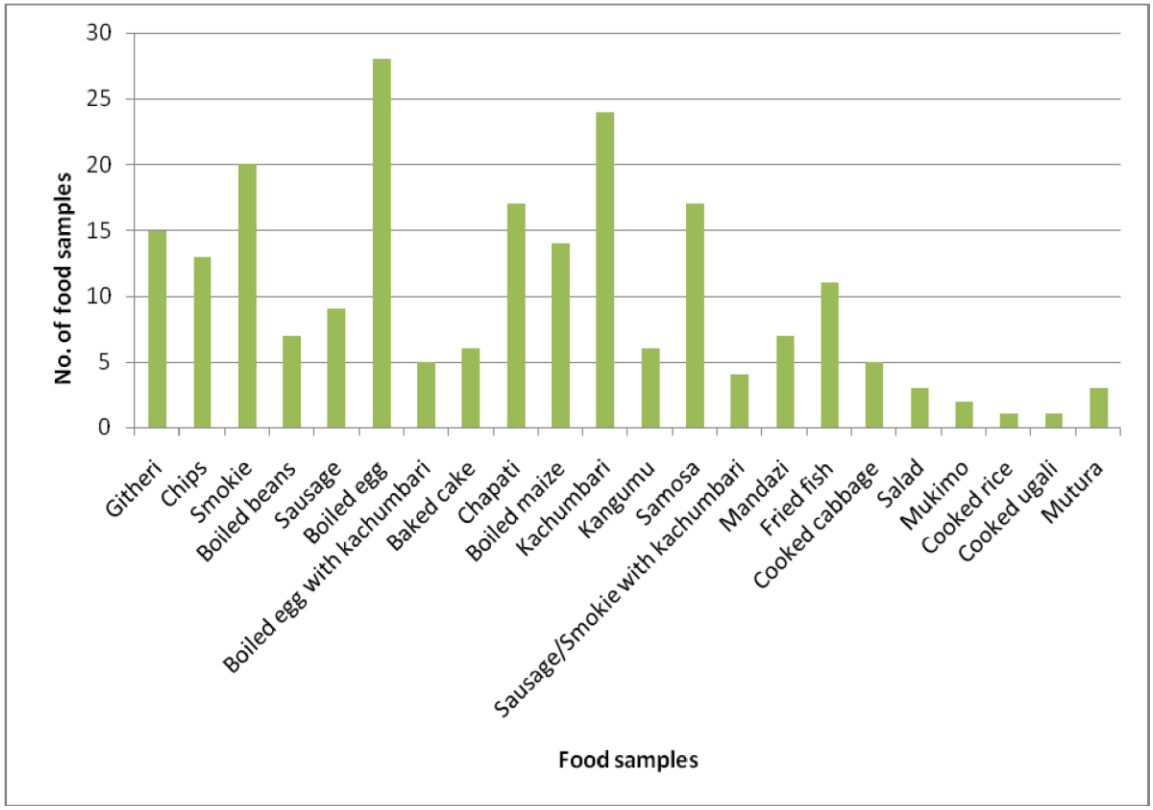

Figure 4.1: Number and type of food sampled in each category.

4.5 Microbial quality of food samples

The aerobic plate count (APC) also referred to as the total viable count or the standard plate count was performed to indicate the microbial quality of the various food samples. The range and the mean bacteria count was then calculated for the various kinds of food. The mean bacteria count ranged between 10×10^0 cfu/g (baked cake, '*mukimo*', and cooked rice) and 3.72×10^6 cfu/g (sausage/smokie with '*kachumbari*') **(Table 4.4).** In terms of microbial quality, food samples were categorized into three, depending on the number of colony forming units obtained after the APC and the levels (ICMSF, 2001). Based on these three categories, all the samples of the baked cake (n=6) were satisfactory (APC= $< 10^4$), 42.9% of the proportion of boiled beans was unsatisfactory (APC= $> 10^5$). Majority (85.7%) of the boiled egg samples were satisfactory (APC = $< 10^6$). On the other hand, "*ugali*" sample was unsatisfactory (APC = $>10^5$) and 33.3% of the "*mutura*" sample was marginal (APC=> 10^7). All the other kinds of food were satisfactory. Nevertheless, "*kachumbari*" and salads were not classified as they fall under level three whereby it would be expected that these foods would have an inherent high plate count because of the normal microbial flora present **(Table 4.5).**

Table 4.4: The mean log_{10} bacteria count for the various food types

Food type	**Mean log_{10} cfu/g**
Boiled beans (n=7)	4.13501×10^5
Boiled eggs (n=28)	7.15855×10^5
Boiled egg & *kachumbari* (n=5)	$0.1968 \times 10_5$
Boiled maize (n=14)	$0.05822 \times 10_5$
"*Chapati*" (n=17)	0.16637×10^5
"*Chips"* (n=13)	0.16346×10^5
Cooked cabbage (n=5)	0.62364×10^5
Fried fish (n=11)	0.26133×10^5
"*Githeri*" (n=15)	0.25852×10^5
"*Kachumbari*" (n=24)	1.14892×10^5
"*Kangumu*" (n=6)	0.00048×10^5
"Mandazi" (n=7)	0.00391×10^5
Salad (n=3)	0.04803×10^5
"*Samosa*" (n=17)	0.00992×10^5
Sausages (n=9)	0.02117×10^5
Sausage/Smokie with "*kachumbari*" (n=4)	37.18425×10^5
"*Mutura*" (n=3)	6.13333×10^5
Baked Cake (n=6)	10×10^0
"Mukimo" (n=2)	10×10^0
Rice (n=1)	10×10^0
"*Ugali"* (n=1)	10×10^0

Table 4.5: Classification of the various food samples as per their Aerobic Plate Count

Food type	No. of Satisfactory samples	No. of Marginal samples	No. of Unsatisfactory samples	APC,N/A
Baked cake(n=6)	6	0	0	-
Boiled beans (n=7)	3	1	3	-
Boiled eggs (n=28)	24		3	-
Boiled egg with *kachumbari*(n=5)	5	0	0	-
Boiled maize(n=14)	11	2	1	-
Chapati (n=17)	15	1	1	-
Chips(n=13)	12	0	1	-
Cooked cabbage(n=5)	3	1	1	-
Fried fish(n=11)	8	2	1	-
Githeri(n=15)	12	2	1	-
Kachumbari(n=24)	-	-	-	24
Kangumu(n=6)	6	0	0	-
Mandazi(n=7)	7	0	0	-
Mukimo(n=2)	2	0	0	-
Salad(n=3)	-	-	-	3
Samosa(n=17)	17	0	0	-
Sausages(n=9)	8	1	0	-
Smokies (n=20)	20	0	0	-
Sausage/*Smokie* with *kachumbari*(n=4)	3	0	1	-
Rice(n=1)	1	0	0	-
Ugali(n=1)	0	0	1	-
Mutura (n=3)	2	1	0	-
Total	165(75.7%)	12(5.5%)	14(6.4%)	27(12.4%)

KEY: *APC, N/A- Aerobic Plate Count is not applicable due to the normal microbial flora in the food.

4.6 Thermotolerant (faecal) coliform bacteria

According to the presumptive test results, there were four kinds of foods in which all the samples were coliform positive. These were, boiled eggs with '*kachumbari'* (5/5) (100%), sausage or "*smokie*" with "*kachumbari*" (4/4) (100%), "*mutura*" (3/3) (100%) and cooked *ugali* (1/1) (100%). On the other hand there were other kinds of foods in which all the samples tested negative for coliforms namely; baked cake, "*mukimo*", and cooked rice. In general a total of 99 samples of different foods, were coliform positive which represented nearly half (45.4%) of the food sampled **(Table 4.6)** in this study.

The samples that had positive presumptive results were then subjected to further tests to detect the presence of fecal coliforms, mainly *E. coli*. 62.5% of the boiled egg samples tested positive for fecal coliforms. Half (50%) of the Boiled beans, sausage/*smokie* with "*kachumbari*" and "*samosa* samples were also positive for fecal coliforms. A proportion of 40% of the boiled egg with "*kachumbari*" sample was fecally contaminated where as 33.3% of the "*chapati*", Salad, sausage and "*mutura*" samples also tested positive. In general, 25.2% of the food sampled in this study tested positive for *E. coli* **(Table 4.7).**

Table 4.6: Isolation of total coliforms using the MPN technique (presumptive test)

Food type	**Frequency of food samples that tested positive for total coliforms**	**Percentage of food samples that tested positive for total coliforms**
Baked cake **(**n=6**)**	0	0
Boiled beans (n=7)	6	85.7
Boiled egg (n=28)	8	28.6
Boiled egg with *kachumbari*(n=5)	5	100
Boiled maize (n=14)	8	57.1
Chapati (n=17)	9	52.9
Chips (n=13)	4	30.8
Cooked cabbage (n=5)	3	60
Fried fish (n=11)	9	81.8
Githeri (n=15)	8	53.3
Kachumbari (n=24)	14	58.3
Kangumu (n=6)	2	33.3
Mandazi (n=7)	2	28.6
Mukimo (n=2)	0	0
Salad (n=3)	3	100
Samosa (n=17)	4	23.5
Sausage (n=9)	3	33.3
Sausage/*smokie* with *kachumbari* (n=4)	4	100
Smokie (n=20)	3	15
Mutura (n=3)	3	100
Cooked *Ugali* (n=1)	1	100
Cooked rice (n=1)	0	0
Total(n= 218)	99	**45.4**

Key: ***MPN**- Most Probable Number

Table 4.7: Confirmatory test results for fecal coliform bacteria *(E.coli)*

Food type	**Range of MPN fecal coliforms /g of food**	**Frequency (fecal coliform+)**	**Percentage (fecal coliform+)**
Baked cake **(n=0)**	0	0	0
Boiled beans (n=6)	154	3	50
Boiled egg (n=8)	154	5	62.5
Boiled egg with *kachumbari*(n=5)	26	2	40
Boiled maize (n=8)	17	2	25
Chapati (n=9)	150	3	33.3
Chips (n=4)	0	0	0
Cooked cabbage (n=3)	0	0	0
Fried fish (n=9)	0	0	0
Githeri (n=8)	240	1	12.8
Kachumbari (n=14)	9	2	14.3
Kangumu (n=2)	0	0	0
Mandazi (n=2)	0	0	0
Mukimo (n=0)	0	0	0
Salad (n=3)	7	1	33.3
Samosa (n=4)	4	2	50
Sausage (n=3)	19	1	33.3
Sausage/*smokie* with *kachumbari* (n=4)	210	2	50
Smokie (n=3)	0	0	0
Mutura (n=3)	150	1	33.3
Ugali (n=1)	0	0	0
Rice (n=0)	0	0	0
Total (N=99)		25	25.2
*N in this case represents no. of coliform positive samples as per the presumptive test			

4.7 Testing for pathogens

All the samples tested negative for *Salmonella, Shigella, Clostridium Perfringes and Staphylococcus aureus*. *E. coli* was however confirmed because of its ability to ferment lactose on XLD and MacConkey agar **(Fig 4.2)** after which sub culturing was done on Triple Sugar Iron (TSI) and Sulfide Indole Motility (SIM) and the reactions observed **(Fig 4.3).** *Klebsiella pneumoniae* was also detected in a sample of boiled egg with "kachumbari" though this microorganism was not among the pathogens to be tested in this study **(Fig 4.4).** This was detected through the use of the Vitek machine (**Appendix VI**). *E. coli* pathotyping was carried out using Multiplex-PCR method described by Toma (Toma *et al.,* 2003) (**Appendix IV**) on samples that tested positive for *E.coli* to determine presence or absence of toxigenic strains. As shown in the plate below in well number 8 and 9, two *E .coli isolates* from food samples (Chips salad and '*samosa*') tested positive for Enteropathogenic *E. Coli (EPEC)* **(Plate I)** and one sample (sausage) as illustrated in well 15 tested positive for Enteroaggregative *E. Coli* **(Plate II)**. The other pathogenic strains of *E. coli* {Enteroinvasive *E. coli* **(**EIEC), Enterohaemoragic *E. coli* (*EHEC*), Shiga toxin producing *E. coli* (*STEC*)} and Enterotoxigenic *E. coli* (ETEC) were not detected.

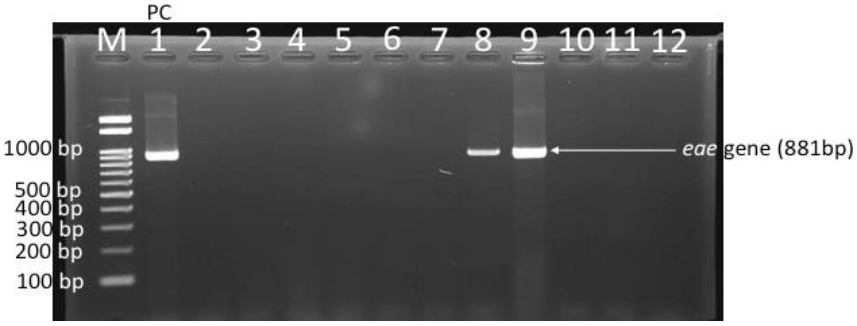

Plate 4.I: Image showing the two samples (Well 8 and 9) that tested positive for Enteropathogenic *E. coli*

Well 1: Positive for *eae* gene (EPEC) **Positive control** for *eae* gene (EPEC). MDH/321

Wells 8 & 9: (Positive for *eae* gene (EPEC)

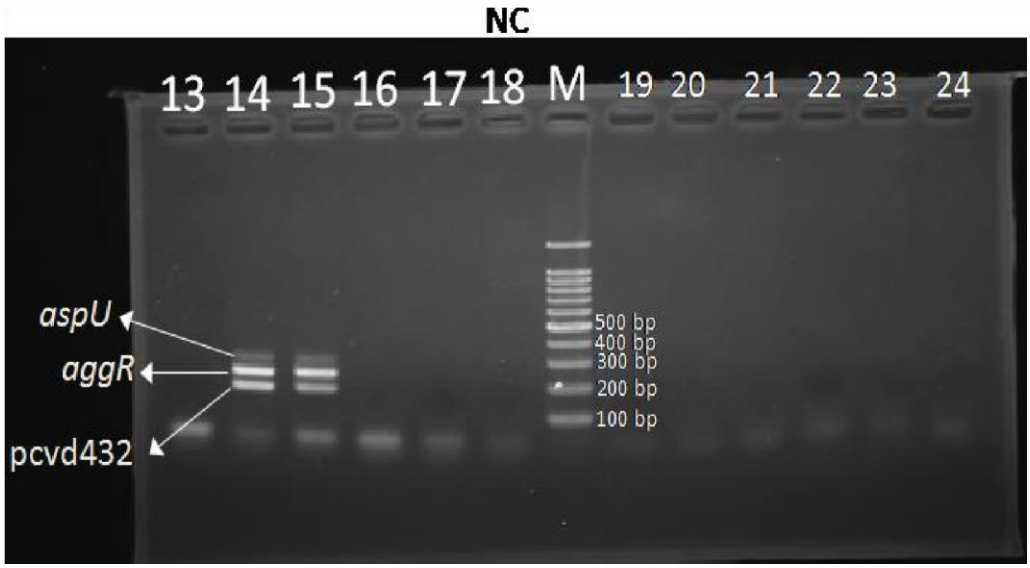

Plate 4.2: Image showing the sample (Well 15) that tested positive for Enteroaggregative *E.coli*

Well 14: Positive for *aspU/aggR/cvd432* genes (EAEC). **Positive control** for *aspU/aggR/cvd432* genes (EAEC). MDH/352

Well 15: Positive for *aspU/aggR/Pcvd432* genes (EAEC)

Wells 18: Negative Control

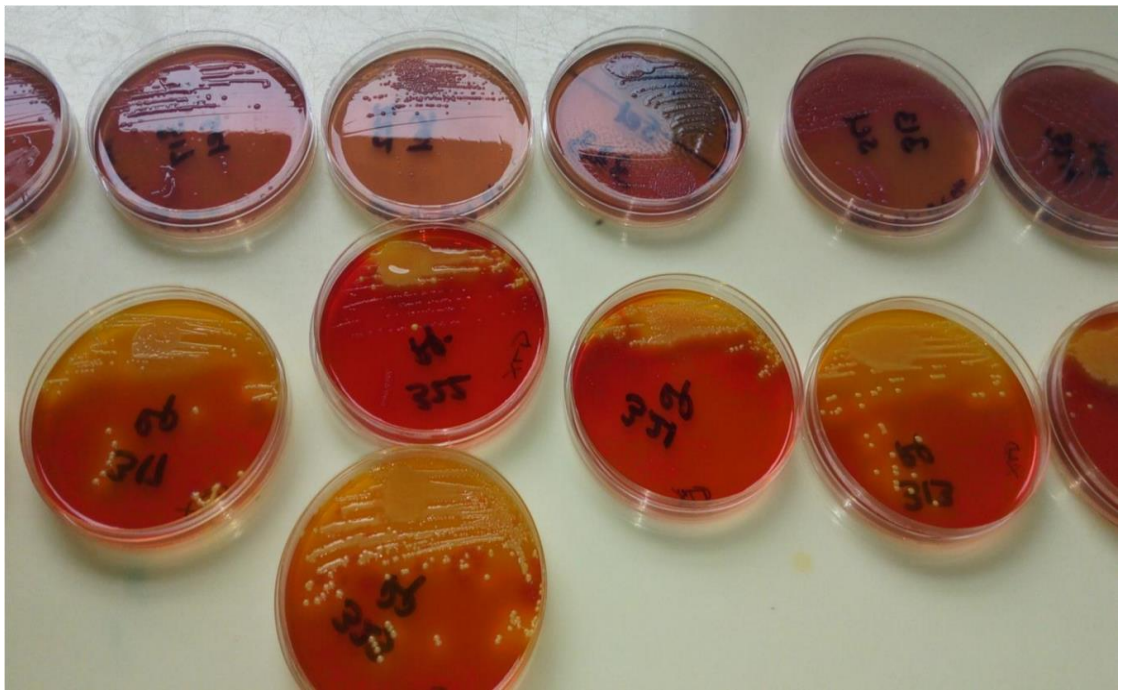

Figure 4.2: Growth on MacConkey agar and Xylose Lysine Deoxycholate Agar

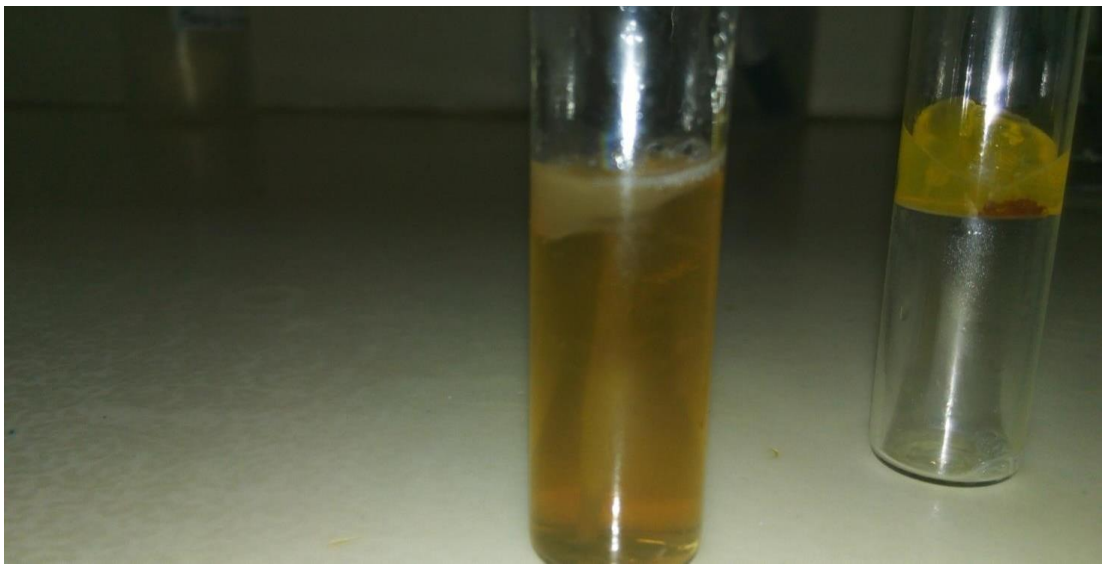

Figure 4.3: Reaction on SIM and TSI confirming an E. coli positive food sample (Completed test).

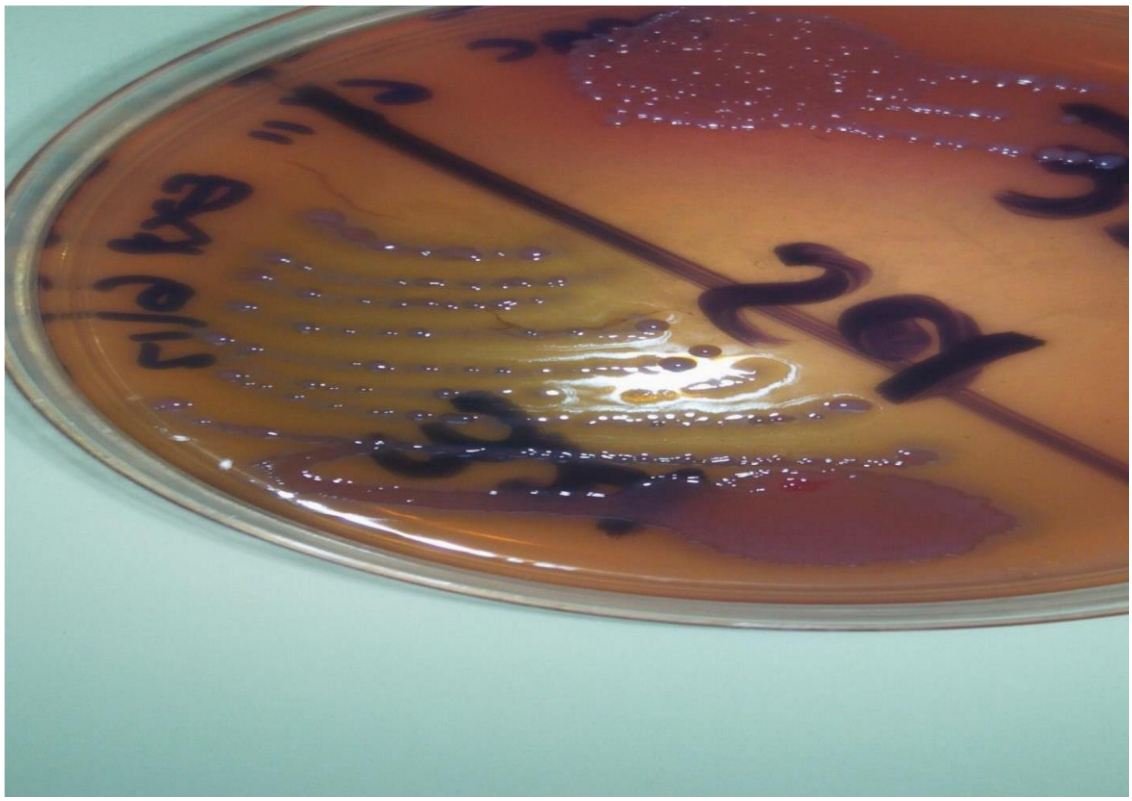

Figure4.4: Sample 321(boiled egg with "*kachumbari*") on MacCkonkey agar that tested positive for *Klebsiella Pneumoniae*

4.8 Occurrence of coliforms and *E.Coli* in relation to the type of food.

The overall level of occurrence of coliforms in food was 45.4% (99/218). This occurrence was based on whether the food was coliform positive or coliform negative. The food was regrouped into protein rich and non-protein rich and then examined in relation to occurrence of coliforms. Though there was no significant [OR= 0.859, (CI= 0.503-1.467), p=0.577)] association between the type of food and the occurrence of coliforms. Protein rich foods had a higher (54.5%) proportion being coliform positive compared to non-protein rich foods (45.5%) **(Fig 4.5).**

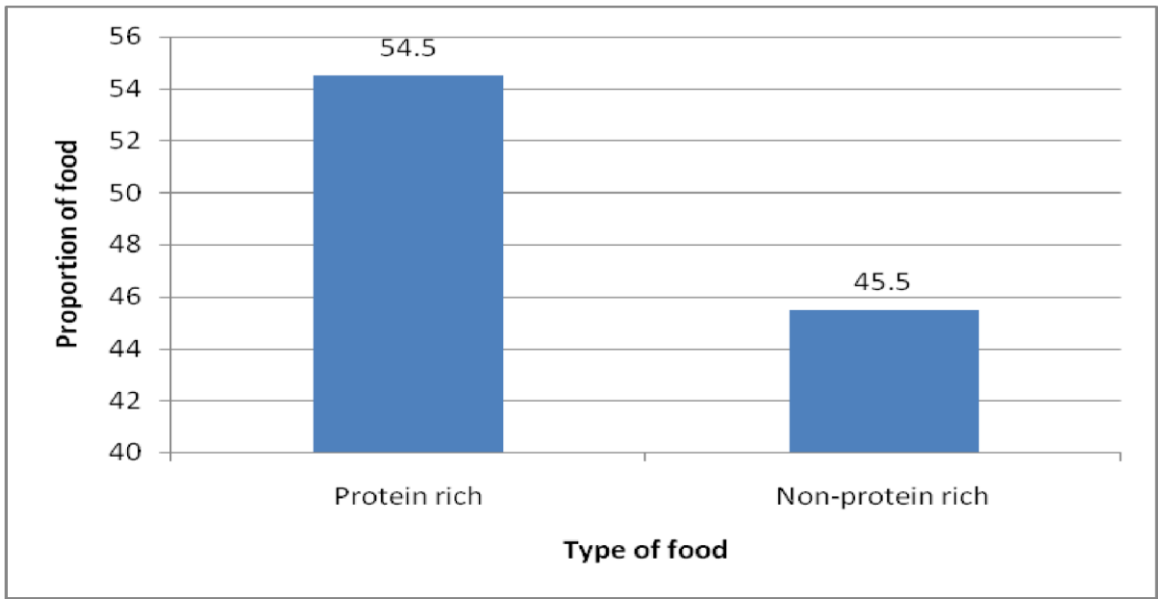

Figure 4.5: Occurrence of coliforms by type of food

The level of occurrence of *E.coli* was 25.2 %(25/99). This was based on whether after a positive presumptive test, the food also tested positive in the confirmatory test for fecal coliforms. The relationship between the type of food to occurrence of *E.coli* was also not significant [OR= 1.896, (CI= 0.781-4.601), p=0.152)]. However, the protein rich food had a higher proportion (68%) (CI= 0.797- 3.922) being *E.coli* positive compared to the non-protein rich foods (32%) (CI= 0.849-1.024) **(Fig 4.6).**

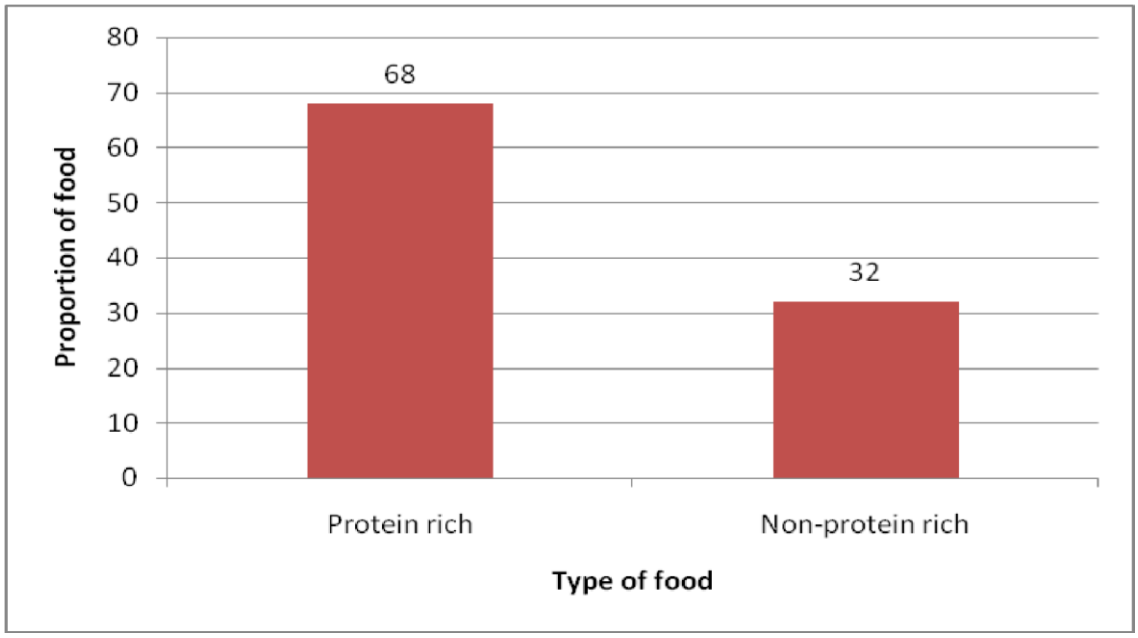

Figure4.6: Occurrence of *E.coli* in relation to the type of food

4.9 Occurrence of food contamination in relation to various food handling practices

Some food handling practices were significantly associated with food contamination. Access to fresh running water was significantly ($p<0.005$) associated with food contamination whereby a decreased risk [(OR= 0.355; 95% CI= 0.177 – 0.713)] of having contaminated food was observed if one had access to fresh running water (**Table 4.9**). The occurrence of food contamination was lower (24.1%) among those who had access to fresh running water compared to those who did not (47.1%) (**Table 4.8**).

Hand washing before handling food items was also significantly ($p<0.005$) associated with food contamination whereby there was a decreased risk [(OR= 0.018; 95% CI= 0.006 – 0.051)] of having contaminated food if one was washing hands before handling food items (**Table 4.9**). There was a lower occurrence (10.8%) of food contamination among those who washed hands before handling food items compared to those who did not (87.2%) (**Table 4.8**). Hand washing after handling raw food items was only practiced by 13.4% (20) of the respondents with the rest (86.6%) (129) not washing their hands. This variable was however not significantly [(OR= 1.288; 95% CI= 0.490 – 3.383), p=0.607)] associated with food contamination (**Table 4.9**).

The method of hand washing was also assessed in relation to food contamination. The highest (85%) occurrence of food contamination was among vendors who did not wash their hands at all, either before handling food items or after handling raw food items. There was no occurrence of food contamination among vendors who used soap and running water to wash their hands. Nonetheless, an occurrence of 17.2% of food contamination was observed among vendors who washed hands using water placed in a container. This variable was significantly ($x^2_{3,\ 0.05\ =}$ 60.657, $p< 0.001$) associated with food contamination **(Table 4.9).** In terms of acquisition of knowledge on food preparation, majority (63.8%) had acquired cooking skills through observation while only 3.4% had been formally trained. On examining this variable in relation to food contamination, there was no significant ($x^2_{3,\ 0.05}$= 1.371, p= 0.725) association (**Table 4.9)**.

Though the relationship between having a medical examination for certification as a food handler and food contamination was not significant ($x^2_{3,\ 0.05}$= 4.216 p= 0.239) (**Table 4.9)**, occurrence of food contamination was highest (47.2%) among vendors who claimed to have had a medical examination after a period of more than 3 months and least (20%) among those who were medically examined after a period of less than 3months (**Table 4.8**). Use of an apron while vending food was also assessed in relation to food contamination, and a significant ($p<0.001$) association was observed.

There was a decreased risk [(OR= 0.190; 95% CI= 0.091 – 0.394)] of having contaminated food among vendors who wore an apron while vending food (**Table 4.9**). On the other hand, use of a head cover while vending food was not significantly [(OR= 0.531; 95% CI= 0.258 – 1.093), p=0.084)] associated with food contamination. However, a higher occurrence (40.2%) of food contamination was observed among the vendors who did not cover hair compared to 26.3% among those who used a head cover while vending food (**Table 4.8**). Storage of leftover food was also assessed in relation to food contamination. It was observed that majority (59.7%) stored leftover food in a cupboard and only 18.1% stored it in a refrigerator. Although this variable was not significantly ($x^2_{2,\ 0.05}$= 4.431 p=0.109) associated with food contamination, there was a higher occurrence (40.4%) of food contamination among respondents who stored leftover food in a cupboard compared to 18.5% among those who stored it in a refrigerator (18.5%) (**Table 4.8**).

In terms of serving food, majority (67.8%) used a plastic bag since they sold "take away" food. There was no significant ($x^2_{3,\ 0.05}$= 0.755 p=0.860) association between the way food was served and food contamination. However, the highest (42.9%) occurrence of food contamination was observed among vendors who used a plastic bag or plates and least (30.8%) among 'others' who either used manufactured paper bags (sausage/smokie bags) or maize cob leaves (**Table 4.8**).

Table 4.8 Occurrence of food contamination in relation to food handling practices.

		Food contamination		
		Yes	No	
Food handling practices		n (%)	n (%)	Total
ccess to fresh running water	Yes	19(24.1)	60(75.9)	79(100)
	No	33(47.1)	37(52.9)	70(100)
	Total	52(34.9)	97(65.1)	149(100)
Hand washing before handling food items	Yes	11(10.8)	91(89.2)	102(100)
	No	41(87.2)	6(12.8)	47(100)
	Total	52(34.9)	97(65.1)	149(100)
Hand washing after handling raw food items	Yes	8(40)	12(60)	20(100)
	No	44(34.1)	85(65.9)	129(100)
	Total	52(34.9)	97(65.1)	149(100)
Medical check up	<3m	2(20)	8(80)	10(100)
	After 3m	6(26.1)	17(73.9)	23(100)
	After>3m	17(47.2)	19(52.8)	36(100)
	Never	27(33.8)	53(66.2)	80(100)
	Total	52(34.9)	97(65.1)	149(100)
Cover hair	Yes	15(26.3)	42(73.7)	57(100)
	No	37(40.2)	55(59.8)	92(100)
	Total	52(34.9)	97(65.1)	149(100)
Storage of leftover food	Fridge	5(18.5)	22(81.5)	27(100)
	Cupboard	36(40.4)	53(59.6)	89(100)
	Others	11(33.3)	22(66.7)	33(100)
	Total	52(34.9)	97(65.1)	149(100)
Serving of food	Plastic bag	34(33.7)	67(66.3)	101(100)
	Paper bag	5(35.7)	9(64.3)	14(100)
	Plastic/ Plates	4(42.9)	9(69.2)	13(100)
	Others	9(30.8)	12(57.1)	21(100)
	Total	52(34.9)	97(65.1)	149(100)

Table 4.9: Bivariate analysis of food handling practices in relation to occurrence of food contamination

Variables	Chi-square	df	p value	OR	Lower CI	Upper CI
Food handling practices						
Access to fresh running water	8.711	1	***0.003**	0.355	0.177	0.713
Hand washing before handling food items	82.768	1	***<0.001**	0.018	0.006	0.051
Hand washing after handling raw food items	0.265	1	0.607	1.288	0.490	3.383
Method of hand washing	60.657	3	***<0.001**			
Medical check up	4.216	3	0.239			
Wear apron	21.296	1	***<0.001**	0.190	0.091	0.394
Cover hair	2.994	1	0.084	0.531	0.258	1.093
Storage of leftover food	4.431	2	0.109			
Serving of food	0.755	3	0.860			

Note * Variables significant at the 95%level

4.10 Occurrence of food contamination in relation to various sanitation practices

Several sanitation practices were significantly associated with food contamination. A significant association ($p<0.001$) was observed between use of a toilet facility and food contamination whereby, a decreased risk [(OR= 0.095; 95% CI= 0.039 – 0.227)] of occurrence of food contamination was observed if one had access to a toilet facility **(Table 4.11).** Vendors who used a toilet had a lower occurrence (22.1%) of food contamination compared to those who did not (75%) (**Table 4.10**). The vendors were further probed on the type of toilet facility they had used, of which 46.3% of the vendors had used a modern toilet while 29.5% used a latrine. This variable was assessed in relation to food contamination and a significant ($x^2_{2,\ 0.05}$= 37.270 $p<0.001$) association was observed. Those who had access to a modern toilet had a higher occurrence (29%) of food contamination compared to those who had access to a latrine (11.4%) (**Table 4.10**).

Availability of running water around the toilet facility was significantly($x^2_{2,\ 0.05}$= 36.046 $p<0.001$) associated with food contamination. A higher occurrence (30%) of food contamination was observed among vendors who did not have access to running water compared to those who did (15.9%) (**Table 4.10**). Majority (62.4%) of the vendors practiced open area dumping in terms of waste disposal. The relationship between waste disposal and food contamination was however not statistically significant ($x^2_{2,\ 0.05}$= 1.369 $p=0.504$) **(Table 4.11).**

Presence of pests/rodents was significantly ($p<0.001$) associated with food contamination, with vendors who reported presence of pests/rodents having a 5.9-fold risk [(OR= 5.921; 95% CI= 2.831 – 12.383)] of having contaminated food **(Table 4.11).** Some (26.2%) vendors reported rats as the main rodent around the vending site, others (10.7%) reported both rats and moles with the rest (63.1%) reporting no pests or rodents on site.

This variable was observed to have a significant ($x^2_{2,\ 0.05}$= 35.489, p<0.001) association with food contamination, with those who reported presence of both rats and moles having the highest (93.8%) occurrence of food contamination compared to those who reported rats only (46.2%) (**Table 4.10**). Raw sewage lines, dust, flies and vehicle fumes were some of the potential environmental contaminants reported by the vendors. The relationship between environmental contaminants and food contamination was however not statistically significant [(OR= 0.363; (95% CI= 0.099 – 1.327), p= 0.113)]. Nevertheless, those reporting presence of such contaminants around the vending sites had a higher occurrence (37.1%) of food contamination compared to those who did not (17.6%) (**Table 4.10**).

Table 4.10: Occurrence of food contamination in relation to sanitation practices

		Food contamination		
		Yes	No	
Environmental factors		n (%)	n (%)	Total
Use of a toilet facility	Yes	25(22.1)	88(77.9)	113(100)
	No	27(75)	9(25)	36(100)
	Total	52(34.9)	97(65.1)	149(100)
Type of toilet facility	Latrine	5(11.4)	39(88.6)	44(100)
	Modern	20(29)	49(71)	69(100)
	N/A	27(75)	9(25)	36(100)
	Total	52(34.9)	97(65.1)	149(100)
Running water around the toilet	Yes	10(15.9)	53(84.1)	63(100)
	No	15(30)	35(89.5)	50(100)
	N/A	27(75)	9(25)	36(100)
	Total	52(34.9)	97(65.1)	149(100)
Waste disposal	Open area	31(33.3)	62(66.7)	93(100)
	Dust bin	19(40.4)	28(59.6)	47(100)
	Others	2(22.2)	7(77.8)	9(100)
	Total	52(34.9)	97(65.1)	149(100)
Pests/Rodents	Yes	33(60)	22(40)	55(100)
	No	19(20.2)	75(79.8)	94(100)
	Total	52(34.9)	97(65.1)	149(100)
Type of pests/rodents	Rats	18(46.2)	21(53.8)	39(100)
	Rats&Moles	15(93.8)	1(6.2)	16(100)
	N/A	19(20.2)	75(79.8)	94(100)
	Total	52(34.9)	97(65.1)	149(100)

Table 4.11: Bivariate analysis of the sanitation practices in relation to occurrence of food contamination

Variables	Chi-square	df	p value	OR	Lower CI	Upper CI
Environmental factors						
Use of a toilet facility	33.598	1	***<0.001**	0.095	0.039	0.227
Type of toilet facility	37.270	2	***<0.001**			
Running water within or outside the toilet	36.046	2	***<0.001**			
Waste disposal	1.369	2	0.504			
Pests/Rodents	24.176	1	***<0.001**	5.921	2.831	12.383
Type of pests/rodents	35.489	2	***<0.001**			

4.11 Multivariate analysis

In order to establish the variables that were associated with food contamination, a multivariate logistic regression analysis was carried out. The optimal number of variables that were identified to be associated with food contamination was: hand washing before handling food items ($p<0.001$), Use of an apron ($p< 0.016$) and the type of toilet facility ($p< 0.010$).

Table 4.12: Variables that were significantly associated with food contamination at p<0.05

Variables	**B**	**S.E**	**df**	**Sig**	**Adjusted OR (Exp(B))**	**95% C.I for Adjusted OR(Exp(B)** **Lower**	**Upper**
Hand washing before handling food items	-5.163	1.195	1	p<0.001	0.004	0.000	0.038
Using an Apron	-2.393	0.992	1	p<0.016	0.091	.013	0.638
Type of toilet facility	-3.919	1.526	1	p<0.010	0.020	0.001	0.395

The variables observed to be predictors of food contamination all had a negative association whereby a decreased risk of food contamination was observed. These were: hand washing before handling food items [(OR= 0.004; (95% CI= 0.000 – 0.038), p<0.001)]; use of an apron [(OR= 0.091; (95% CI= 0.013 – 0.638), p<0.016)] and the type of toilet facility [(OR= 0.020; (95% CI= 0.001 – 0.395), p<0.010)] **(Table 4.12).**

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Bacteriological safety of street foods

The overall occurrence of food contamination in this study was 34.9%. This was based on the total aerobic plate count (APC), Enumeration of total coliforms, *Escherichia coli*, and/ or presence of *Klebsiella Pneumoniae.* Comparable findings were observed in a study carried out in Malawi whereby 35% of the street food samples were inappropriate for consumption (Steven *et al*., 2008). Similar findings were also observed in Brazil whereby 35% of the food samples were considered unsuitable for consumption according to the microbiological criteria (Hanashiro *et al*., 2005). On the other hand, a low occurrence (3%) of food contamination was observed in a study carried out in Doha, Qatar. Tahra *et al*., (2014) attributed this low occurrence to the food safety training requirement set by the regulatory authorities before issuing any license to food handlers as well as the inspection carried out by food health inspectors on a regular basis (Tahra *et al*., 2014). This may imply that, developing countries like Kenya are in need of more stringent measures such as those applied in Qatar as this may lower occurrence of food contamination.

Total viable count in all samples varied between 10.0 - 1.7×10^7 cfu/g. Comparable findings were observed in a study carried out in Tirumala with the total viable count of the food samples ranging between 12.16 - $25.81\text{x}10^5$cfu/g (Suneetha *et al*., 2011). The findings of this study however differed from findings of a study in Ethiopia whereby the total aerobic plate count ranged between $1.10 – 3.61\times 10^5$ cfu/g (Getu *et al*., 2013). In terms of the total coliforms, 45.4% of the food samples tested positive for coliforms. These findings are comparable with those of a study carried out in Bangkok, whereby it was observed that 41.3% of the food samples collected was contaminated with total coliform bacteria (Cuprasitrut *et al*., 2011). In this study, sausage/"smokie" with "kachumbari" had the highest coliform count (1.4×10^6 cfu/g).

This may have been due to the excessive post handling process and the use of raw vegetables that may not have been adequately washed. Comparable findings were observed in a study in Nigeria on microbial safety of ready to eat foods, where 'wall nut' (a type of street food) had the highest coliform count (7.1×10^9 cfu/g) which was thought to be as a result of the natural micro flora and poor handling (Oranusi & Braide, 2012). According to Wei *et al*. (2006), the presence of coliforms in street vended foods may be linked to contamination as a result of use of contaminated water during preparation and washing, incomplete heating or even secondary contamination through contact with contaminated materials such as chopping boards and knives.

E .coli contamination was observed in 25.2% of the food samples in this study. Comparable findings were observed by Haranisho *et al*. (2005) where 22.5% of the street foods were contaminated with *E .coli.* Comparably, another study in Sudan observed an occurrence of *E. coli* contamination in 23% of the vended foods (Mohammed, 2017). Other studies have however observed higher occurrences of *E. coli* contamination. In this study, almost all (5/8; 62.5%) samples of boiled eggs were contaminated with *E. coli.* Comparable observations were made in a study in Zimbabwe where all the egg roll samples (20/20; 100%) were contaminated with *E. coli*. The high occurrence of *E. coli* contamination in the boiled egg samples may have been as a result of the post handling process that requires the vendor to peel the egg, cut it into two and insert the "kachumbari". This may also indicates poor holding temperatures and further contamination from probably the surroundings and the vendors especially if they fail to wear protective clothing such as aprons and the head gears or handling money and food with an open palm. *E. coli* normally survives in the gastrointestinal tract of human and normally found in faces. Therefore, according to Yeboah *et al*. (2010) the presence of *E. coli* in food is an indication of fecal contamination probably at one stage of preparation or from the materials used.

*Klebsiella pneumonia*e was also detected in a sample (0.46%) of the boiled egg with "*kachumbari*". A higher occurrence (17%) was observed in a study in Ghana which may have been due to the fact that the assessment on bacteriological quality of street foods in that study involved raw vegetables (George *et al*., 2014). According to Feglo and Sakyik (2012), the detection of *Klebsiella* species can probably be as a result of ambient temperature for the bacteria in the environment and hence the bacteria can be transmitted from the soil, water and vegetables when consumed raw in salads. The "kachumbari" component may have therefore contributed to the *Klebsiella* contamination of the boiled egg sample in this study. All the other microorganisms of interest in this study, namely; *Salmonella*, *Staphylococcus aureus*, *Shigella* and *Clostridium perfringes* were not detected. These findings were consistent with findings of previous works. In a study in Ethiopia no *Salmonella* species was detected, and according to Getu *et al*. (2013), it is usually difficult to predict the association of *Salmonella* species with specific food products. In yet another study in Qatar, no *Salmonella* was detected in all the food samples that were analyzed (Tahra *et al*., 2014). A study in Zimbabwe also did not detect *Salmonella* species in all the food samples analyzed (Raphael *et al*., 2014). Research by Gilbert *et al*. (2000) also ascertains that no S*almonella* should be detected in ready to eat foods.

Contrary to findings in this study, *Staphylococcus aureus* was detected in 32.4% of the samples analyzed in a study in Brazil. The samples that tested positive for *S. aureus* were however not heat treated or were exposed to mild heat (Samara *et al*., 2014). The present study however mainly analyzed cooked foods that had undergone heat treatment. This may have been the reason why the findings differed with those observed in the Brazil study. A study carried out in Ghana detected presence of *Shigella sonnei* in a sample of "macaroni" which is a type of food that is served with tomato stew that is stirred into the "macaroni".

According to Mensah *et al*. (2002), serving was done using bare hands as this type of food is slippery making it difficult to use a spoon or a fork. The use of bare hands was identified as a risk factor that resulted in an increase in the level of food contamination while the use of a fork or spoon reduced the level of contamination. The contrary findings in this study may be attributed to the fact that no vendor used bare hands to serve food. *Clostridium species* was identified in a study in South Africa, however as opposed to the present study that mainly analyzed cooked food, the isolation and identification in South Africa was obtained from raw beef. *Clostridium perfringens* isolates were also detected in 1.4% of retail foods in America. The study purposely surveyed the foods that have most commonly been implicated as vehicles for *Clostridium perfringes*, namely; pork, beef, poultry, seafood and processed meat products (Wen Q & McClane, 2004) which was not the case in this study.

5.2 Food handling practices associated with food contamination

This study observed that access to fresh running water was negatively ($p<0.005$) associated with food contamination, whereby a decreased risk [(OR= 0.355; 95% CI= 0.177 – 0.713)] of having contaminated food was observed if one had access to fresh running water. A study in Malawi similarly observed that poor access to fresh running water can harbor fecal bacteria and serve as a source of bacterial contaminants in food (Steven *et al*., 2008).

Vendors who washed their hands before handling food items had a decreased risk [(OR= 0.018; 95% CI= 0.006 – 0.051)] of having contaminated food. This may imply that, observing personal hygiene can help in reduction of food contamination. The findings of this study are in agreement with a study in Ethiopia which observed that vendors with poor personal hygiene had a 4 fold risk of having contaminated food as compared to those who had good personal hygiene (Getu *et al*., 2013). Contrary to what is available in literature, food contamination was higher (40%) among vendors who

claimed to wash their hands after handling raw food items compared to those who did not (34.1%).

This finding may have been as a result of use of recycled water for hand washing. The vendors cleaned the raw food items using water placed in bowls and then used the same water to clean the knives and also to wash their hands. This presented a potential risk of cross contamination as a result of using recycled water for hand washing. The method of hand washing was significantly($x^2_{3,\ 0.05}$= 60.657, $p<0.001$) associated with food contamination. Vendors who washed hands using soap and running water had no occurrence (0%) of food contamination. However, occurrence of food contamination was 17.2% among vendors who used plain water placed in a bowl and 16.7% among those who used soap and water placed in a bowl. Vendors who neither washed their hands before handling food items or after handling raw food items had the highest (85%) occurrence of food contamination. This may imply that proper hand washing skills reduces the potential for occurrence of food contamination.

These findings are consistent with findings of Todd *et al*. (2007) who reported that several food borne disease outbreaks were as a result of poor handling practices such as cross contamination between raw and cooked products and poor personal hygiene of food handlers such as failure to wash hands. There was a significant ($p<0.05$) negative association between use of an apron and food contamination. Vendors who wore an apron had a lower (19%) occurrence of food contamination compared to those who did not (55.4%). On the other hand, although use of a head cover was not significantly ($p>0.05$) associated with food contamination, there was a higher occurrence (40.2%) of food contamination among the vendors who did not use a head cover compared to 26.3% of those who did. Similarly, in a study in Togo, failure to wear aprons and caps was observed to be the likely causative factor for contamination of food samples (Adjrah *et al*., 2013). In this study, though storage of leftover food was not significantly ($p<0.05$) associated with food contamination. However, the study only explored the method of storage and not the duration of storage. This could be the reason why the

findings differed with those of a study in Ethiopia that observed that storage of left over foods for more than a day, was a risk factor for contamination of street vended foods ($p<0.05$) (Getu *et al*., 2013).

Findings of this study showed no significant ($x^2_{3,\ 0.05}= 0.755$ $p=0.860$) association between the way food was served and food contamination. However, a higher occurrence (42.9%) of food contamination was observed among vendors who used a plastic bag or plates and least (30.8%) among vendors who used labeled paper bags normally distributed by manufacturers. The labeled paper bags were mostly used for the sale of sausages or '*smokies*' which is a type of sausage. The plastic bags however, were poorly stored, as most vendors kept them in the open which posed a risk of contamination from the environment. Some vendors also blew air into the plastic bags before serving food, while others would cut the bags into small pieces so as to avoid 'misuse'. The small pieces of plastic bags would then be used to serve foods such as boiled eggs with some vendors charging a higher price, if a consumer needed to have the food completely wrapped. These kinds of practices may have contributed to the higher occurrence of food contamination among vendors who used plastic bags or plates to serve food, since the plates were on the other hand cleaned using recycled water. These findings were consistent with observations made in a study in Haiti where bags and plates were identified to be some of the possible sources of food contamination (Ruth, 2012). According to Barro *et al.* (2007), plastic bags are usually contaminated by the food handlers as pathogens may invade the interior surfaces of the bags during packaging due to poor handling practices of the vendors.

It was observed that vendors who sold both "take away" foods as well as allowed the consumers to feed on site mainly used water in a bowl and soap to clean the dishes. In most cases the water was cold and recycled. Similar practices were also observed in a study in Uganda (Charles *et al*., 2011). According to FAO (2005), use of the same water several times a day creates an environment for cross contamination from dirty rinse water to cooked food via the rinsed plate. Recontamination of ready to eat foods

results in most cases from the use of utensils that were not thoroughly cleaned (F AO/WHO, 2005). Though associations between various food handling practices and food contamination were done, comparisons were not done using similar foods since the food vendors handled different foods.

5.3 Sanitation practices associated with food contamination

According to Baluka *et al*. (2015), environmental hygiene is important for food safety and necessary to support safe food handling and hygiene by employees. In the light of this, the present study explored the relationship between various environmental factors with food contamination and a significant ($p<0.05$) association was observed in some of them. A significant association ($p<0.001$) was observed between use of a toilet facility and food contamination whereby, a decreased risk [(OR= 0.095; 95% CI= 0.03 – 0.227)] of occurrence of food contamination was observed if one used a toilet facility. Vendors who used a toilet facility had a lower (22.1%) occurrence of food contamination compared to those who did not (75%).

Similarly, Idowu and Rowland, (2006) reported that vending sites usually lack basic facilities such as toilets and hand washing facilities since nearness to customers is the primary target of street food vendors, and hence such conditions enhance the incidence of food borne illnesses and transmission of diseases. As observed in a study in Uganda where the toilet facilities were pay toilets and were mainly flush toilets (Charles *et al*., 2011). Similarly, the toilet facilities in the two study areas were mainly the modern (flush) toilets whereby the vendors paid Kshs.10 to use them. The greatest challenge that was observed with this type of toilet facility was the inadequate sewerage system.

In one of the study areas, waste water was flowing along the street which was as a result of a burst sewer (Appendix V). This phenomenon was observed along various streets within the markets even as vendors continued with the sale of food, oblivious of the hazard posed by the burst sewer.

This provided an environment which was favorable for flies and other types of vectors that could have served as vehicles of transmission of contaminants. Availability of running water either within or immediately outside the toilet facility for hand washing was negatively ($x^2_{2,\ 0.05}$= 36.046 p<0.001) associated with food contamination in this study.

A higher occurrence (30%) of food contamination was observed among vendors who had no access to running water compared to those who had access to running water (15.9%). This implies that water is an essential basic necessity that ensures better personal hygiene which in return serves to reduce the potential for food contamination. Other studies have observed that food that has been properly prepared can become contaminated when handled by unwashed hands and that poor access to hand washing water can be a risk factor for bacterial contaminants of food (Steven *et al*., 2008; Nkere *et al*., 2011).

Majority (62.4%) of the vendors in this study practiced open area dumping method to dispose waste. The open area dumping sites were however located at a distance away from most vending sites and hence the vendors stored the waste in plastic bags within the site then disposed it off later. Though the relationship between waste disposal and food contamination was however not statistically significant (P>0.05), vendors who used municipal containers had the highest (40.4%) occurrence of food contamination probably due to the fact these containers were filled beyond capacity hence attracting flies that could serve as vehicles of transmission of food contaminants. Similar findings were observed in a study in Uganda whereby, it was noted that the municipal council containers were not regularly emptied, therefore in most cases they were also over flowing. Such a practice was reported to create a dirty environment that compromised sanitation, hence becoming a habitat for rodents, breeding point for flies and promoted growth of microorganisms (Charles *et al*., 2011). This study observed that the relationship between presence of environmental contaminants and food contamination was not statistically significant (p>0.05).

Nonetheless, vendors reporting presence of such contaminants as flies, dust, insects, rodents, and sludge around the vending site, had a higher occurrence (37.1%) of food contamination compared to those who thought that the environment had no such contaminants (17.6%).

Consistently, according to Rane, (2011), most of the street vended foods are not protected against insects and dust, and this may harbor food borne pathogens. Presence of pests/rodents was significantly ($P<0.001$) associated with food contamination. Vendors reporting presence of pests/rodents had a 5.9-fold risk [(OR= 5.921; 95% CI= 2.831 – 12.383)] of having contaminated. 26.2% of the vendors reported presence of rats while 10.7% reported presence of both rats and moles. A significant ($P<0.001$) relationship was observed between the type of pests/rodent and food contamination.

Vendors who reported presence of both rats and moles had a higher (93.8%) occurrence of food contamination compared to vendors who reported presence of rats only (46.2%).The poor methods of waste disposal may have provided an environment conducive for breeding of pests/rodents, which may have served as agents of transmission of contaminants onto the prepared foods. Through observation, almost all the vendors in this present study handled money while serving food. Similar observations were made in a study in Ethiopia where 100% of the vendors handled money while serving food (Tesfaye *et al*., 2016). Consistently, Muinde and Kuria, (2005) observed that all the vendors in a study carried out in Kenya, handled money while serving food. In this study, it was also observed that vendors would use plastic bags, to prevent direct contact with the cooked foods while selling. Some environmental factors and food handling practices did not show any significant relationship with food contamination in this study. This may imply that there was no risk of food contamination, if direct contact was not made with food. Similar findings were observed in a study in Accra, whereby, environmental hygiene and the vendor's appearance did not show any significant relationship with the levels of contamination (Mensah *et al*., 2002).

Though associations between various sanitation practices and food contamination were done, comparisons were not done using similar foods since the food vendors handled different foods.

5.4 Conclusions

1. Bacteriological contamination level of street vended foods by *Escherichia .coli* was at 25.2%, however, all food samples tested negative for *Salmonella, Shigella, Staphyllococcus aureus and Closrtidium perfringes*

2. Food handling practices associated with food contamination were; access to fresh running water, hand washing before handling food items, the method of hand washing and use of protective clothing (apron).

3. Sanitation practices associated with food contamination were; use of a toilet facility, availability of running water around the toilet facility, presence of pests and rodents and the type of pests/rodents.

5.5 Recommendations

- There is need for the MOH to set effective food safety training requirements before issuing a license to any street food vendor as well as carry out regular inspections to ensure compliance. This may help to decrease the occurrence rate of microbial food contamination, as an occurrence of 34.9% is not negligible.

- The MOH through public health officers should facilitate provision of adequate fresh running water facilities and hand sanitizers for use in hand washing as well as encourage the use of protective clothing (aprons, caps and gloves) among the street food vendors.

- The MOH should also provide adequate sanitary facilities for use within the markets.

- The PHOs should offer free health education to the street food vendors, on the importance of maintaining environmental hygiene as this may help to reduce the risk of food contamination.

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APPENDICES

Appendix I: INFORMED CONSENT FORM

PART A

FOOD HANDLING PRACTICES AND ENVIRONMENTAL FACTORS ASSOCIATED WITH FOOD CONTAMINATION AMONG STREET FOOD VENDORS IN GITHURAI AND GIKOMBA MARKETS- NAIROBI COUNTY.

Introduction

I am carrying out a study among people who sell food on the streets in Githurai and Gikomba markets. I want to find out the safety of the street foods and the food handling practices as well as the environmental factors associated with food contamination in these two markets. Scientific evidence in other countries has shown that bacteria contamination is the main contributor of food poisoning outbreaks if not addressed early.

Purpose of the study

The main purpose of the study is: To establish the safety of street vended foods in terms of presence or absence of bacteria at consumption point among people who sell food on the streets in Githurai and Gikomba markets- Nairobi County, which will involve 149 respondents.

Study procedure

The study will involve responding to few questions that will take approximately 10minutes or less. A Food sample will then be bought from you for the purpose of determining the safety in terms of presence or absence of bacteria.

Nature of study

This study is voluntary. You are free to participate or not and may at any time during the study revoke your consent and withdraw from the study without any loss or penalty. Your refusal to participate in the study will involve no penalty or loss of benefits to which you are otherwise entitled.

Risks

There are no known harms associated with your participation in this research. However, you may or may not experience discomfort when responding to the questions. Therefore, although some of the questions may appear uncomfortable for you, it is necessary for you to answer them with honesty so that we may come up with accurate information that may warrant further investigations.

Benefits

There are no direct benefits to you for participating in this study. A probable benefit of participating in this study is that you will be a part of the people that will contribute important information on microbial safety of street foods and this may provide a basis for further investigations that may prevent a distressing outcome.

Study costs

There are no monetary benefits for your participation on this study as all the food samples will be bought from you and hence there will be no compensation needed.

Confidentiality

No reports will identify you individually in anyway. Study numbers rather than names will be used to label all study materials and interviews. A list linking your names and study numbers will be maintained by the research staff and stored in a locked place

where other people cannot access it. No information about you or provided by you during the research will be disclosed to others without your permission, except: if necessary to protect your rights or welfare, or if required by law. When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity and any stored data will be destroyed immediately after analysis.

Participation information

I am asking you to join this research study so that through your participation I am able to address the objectives. Upon enrolment into the study you will be asked questions regarding the food handling practices and environmental factors that may be associated with food contamination. I will also purchase a food sample from you for various tests to be done to determine the microbial safety of the food.

Contact and questions

If you have any questions about the research, please feel free to contact the principal investigator. If I have any further questions I may contact Miss Emmah Nyambura Kariuki; Mobile: 0724165189; Email: mmmtripple@gmail.com

For any information and questions pertaining to your rights as a participant in this research,

Please contact the following:
Kenya Medical Research Institute
Ethical Review Committee
P.O. Box 54840-00200,
Tel: 254-020-2722541/4, 072205901, 0733400003
Nairobi
Email; erc@kemri.org

PART B

Agreement

I have read the information sheet concerning this study and I understand what will be required of me if I take part in the study. Any questions concerning this study have been answered. I understand that at any time that I may wish to withdraw from this study I can do so without giving any reason.

I agree to take part in this study,

Signature……. Date……

Signature of witness**……**

Thumb print

SWAHILI TRANSLATION OF THE CONSENT FORM

KIAMBATISHO I: IDHINI YA KUHUSIKA KATIKA UTAFITI

SEHEMU YA KWANZA

SABABU ZINAZOHUSIANA NA KUCHAFUKA KWA CHAKULA KATI YA WACHUUZI WANAOUZA VYAKULA BARABARANI KATIKA SOKO YA GITHURAI NA GIKOMBA COUNTI YA NAIROBI.

Utangulizi

Ninafanya utafiti kuhusu kutambua utunzaji wa chakula mazoea na hatari za mazingira zinazohusiana na kuchafuka kwa chakula kati ya wachuuzi wanaouza vyakula barabarani katika soko ya Githurai na Gikomba, Counti ya Nairobi. Utafiti wa kisayansi katika nchi zingine waonyesha kuwa kuchafuka kwa chakula ndiko haswa kwasababisha madhara ya sumu tusipoweka mikakati mapema.

Sababu ya utafiti

Sababu ya kufanya utafiti huu ni kutambua utunzaji wa chakula mazoea na hatari zinazohusiana na kuchafuka kwa chakula kati ya wachuuzi wanauza vyakula barabarani katika soko ya Githurai na Gikomba Counti ya Nairobi.

Jinsi ya Kufanya utafiti

Utafiti utahusisha kujibu maswali machache yatakayochukua muda wa dakika kumi au chache. Kisha tutanunua chakula unachouza kutoka kwako kwa nia ya kufanya utafiti.

Hali ya utafiti

Utafiti huu sio wa huru. Uko huru kushiriki au kutoshiriki na pia unaweza kujiondoa wakati wowote bila kupigwa faini au kupoteza lolote. Kukataa kwako kushiriki hakutahusu kupigwa faini au kupoteza faida ambazo ungezipata.

Hatari

Hakuna hatari zijulikanazo zinazohusishwa na kuhusika kwako katika utafiti huu.Ingawa maswali mengine yanaweza kuonekana kukutia wasiwasi, ni muhimu uyajibu kwa uaminifu ili tuweze kukusanya taarifa sahihi inayoweza kutumika kufanya uchunguzi zaidi.

Faida

Hakuna faida ya moja kwa moja kwa ajili ya kushiriki katika utafiti huu. Faida inayowezekana ya kushiriki katika utafiti huu ni kuwa utakuwa sehemu ya watu watakaochangia taarifa muhimu kuhusu usafi wa chakula ambayo inaweza tumika kufanya utafiti zaidi unaoweza kuzuiamatokeo haya ya usumbufu.

Fedha za Utafiti

Hakuna faida zozote za kifedha utakazopatakwa kuhusika na utafiti huu kwa sababu vyakula vya utafiti vitanunuliwa kutoka kwako kwa hivyo hakuna fidia itakayo takikana.

Kuweka siri

Hakuna taarifa zitakazokutambua wewe binafsi katika njia yeyote. Idadi za utafiti badala ya majina zitatumika kutambua vifaa vyote vya utafiti na mahojiano. Orodha ya kuunganisha majina yako na idadi za utafiti itahifadhiwa na wafanyakazi wa utafiti na kuhifadhiwa mahali ambapo pamefungwa ambapo watu wengine hawawezi kuipata.

Hakuna habari kukuhusu wewe au zitakazotolewa na wewe wakati wa utafiti zitakuwa wazi kwa watu wengine bila ruhusa yako, isipokuwa: kama muhimu kulinda haki yako au ustawi, au kama itatakikana na sheria. Wakati matokeo ya utafiti yatakapochapishwa au kujadiliwa katika mkutano, hakuna taarifa itakayowekwa ambayo itaonyesha utambulisho wako na taarifa yoyote itakayokuwa imehifadhiwa itaharibiwa mara moja baada ya uchambuzi.

Habari kuhusu utafiti

Ninakuomba uhusike katika huu utafiti ili kupitia kuhusika kwako niweze kutimiza nia za utafiti. Utakapohusika utaulizwa uyajibu maswali kuhusu utunzaji wa chakula mazoea na hatari zinazohusiana na kuchafuka kwa chakula. Nitanunua pia sehemu ya chakula kutoka kwako ambayo itatumika kufanya utafiti zaidi ili kubaini kama kiko sawa kwa matumizi.

Utambulisho wa wakaguzi na maswali

Kama una maswali kuhusu utafiti, tafadhali jisikie huru kuwasiliana na mchunguzi mkuu. Kama mimi nina maswali zaidi ninaweza kuwasiliana na Emmah Nyambura Kariuki, Simu: 0724165189,

Barua pepe: mmmtripple@gmail.com

Kwa habari yeyote au maswali kuhusu haki, zako kama mshiriki katika utafiti huu. Tafadhali wasiliana na wafuatao;

Karani,

Kenya Medical Research Institute

Ethical Review Committee

Sanduku la posta; 54840-00200,

Nambari ya Simu: 254-020-2722541/4, 072205901, 0733400003

Nairobi

Barua pepe; erc@kemri.org

SEHEMU YA PILI

Makubaliano

Nimesoma na kuelewe utafiti huu unahusu nini, na nimeelewa kushiriki kwangu katika utafiti huu kutahusu nini. Maswali yeyote kuhusu utafiti huu yamejibiwa. Ninaelewa kwamba ninaweza wakati wowote wakati wa utafiti rekebisha idhini yangu na kujiondoa kutoka kwa utafiti bila ya kupeana sababu yeyote.

Nimekubali kushiriki katika utafiti huu

Sahihi……
Tarehe……..

Sahihi ya anayesmamia**……..**

APPENDIX II: QUESTIONNAIRE

INTRODUCTION

How are you, my name is Emmah Mwangi from Jomo Kenyatta University of Agriculture and Technology; I am conducting a study on food handling practices and environmental factors associated with food contamination among street food vendors in Githurai and Gikomba markets-Nairobi county, Kenya and would appreciate your assistance and contribution for the success of the study by consenting to participate. There are no known harms associated with your participation in this research and there will be no monetary benefits or reward for your participation in this study except that you will be a part of the people that will contribute important information on street vended foods. No reports will identify you individually in anyway. Study numbers rather than names will be used to label all study materials and interviews. A list linking your names and study numbers will be maintained by the research staff and stored in a locked place where other people cannot access it.

1.SOCIO-DEMOGRAPHIC CHARACTERISTICS OF FOOD VENDORS

Name (optional) _____ Study number ☐

Gender

i) Female

ii)Male

1. When were you born? ——/——/——

2. What is your marital status?

(i) Married

(ii) Single

(iii) Divorced/separated

(iv) Widowed

3. What is your highest level of education?

(i) No formal training

(ii) Primary

(iii) Secondary

(iv) University/college

II. FOOD HANDLING PRACTICES AND HYGIENE OF FOOD VENDORS ON SITE

4. How did you acquire food preparation skills?

(i) Formal training

(ii) Parents

(iii) Observation

iv) Others, specify…….

5. How often do you go for medical checkups?

(i) Less than 3months

(ii) After every 3 months

(ii) After more than 3months

(iii) Never

6. Do you have a food handlers' medical certificate at the moment?

i) Yes

ii) No

Ask for evidence……..

7. Do you have access to fresh running water at this site?

(i) Yes

(ii) No

8. Do you always wash your hands before handling food items at this site?

(i) Yes

(ii) No

9. Do you always wash your hands after handling raw food items at this site?

(i) Yes

(ii) No

10. If yes (for Q8/9 or both), what do you use while washing your hands?

(i) Soap and running water

(ii) Running water only

(iii) Water in a container

(iv) Water in a container and soap

11. Do you always wear protective clothing (apron) while preparing or handling food items at this site?

(i) Yes

(ii) No

Observe for evidence……

12. Do you always cover your hair while handling food items at this site?

(i) Yes

(ii) No

13. While handling food items, do you as well handle money?

(i) Yes

(ii) No

14. How do you store leftover food items after selling?

(i) In a refrigerator

(ii) In a cupboard

(iii) Others, specify…….

15. What do you use for cleaning up the utensils after the customers use them at this site?

(i) Running water and soap

(ii) Running water only

(iii) Water in a container and soap

iv) Water in a container only

v) Not applicable since my food items are take away

16. What do you use to pack the food items while selling?

i) A plastic bag

ii) A paper bag

iii) A newspaper

iii) Others, specify……

17. Where do you get the supplies of your food items from? .....

III. SANITATION PRACTICES/ ENVIRONMENTAL HYGIENE AROUND THE FOOD VENDORS

18. Do you have access to a toilet facility at this site?

(i) Yes

(ii) No

19. If yes, what type of toilet facility do you have?

(i) Latrine

(ii) Modern toilet

20. If the answer to question 17 is yes, does the toilet facility have availability of running water?

(i) Yes

(ii) No

21. How do you dispose any waste that maybe generated from your work at this site?

(i) Open area dumping

(ii) Waste bin

(iii) Others, specify…….

22. Do you encounter pests and rodents on site?

i) Yes

ii) No

If any, which pests are frequently encountered? ……

23. How are these pests controlled? ……

24. Is the surrounding environment free of potential contaminants?

i) Yes

ii) No

If no, list them……..

We have come to the end of the interview and we thank you very much for your time and cooperation.

KIAMBATISHO II: MASWALI UTANGULIZI

Habari yako, jina langu ni Emmah Nyambura Kariuki kutoka chuo kikuu cha Jomo Kenyatta cha kilimo na teknologia; ninafanya utafiti kutambua utunzaji wa chakula mazoea na hatari zinazohusiana na kuchafuka kwa chakula kati ya wachuuzi wanauza vyakula barabarani katika soko ya Githurai na Gikomba Counti ya Nairobi na nitashukuru msaada wako na mchango kwa ajili ya mafanikio ya utafiti kwa kukubali kushiriki. Hakuna hatari zijulikanazo zinazohusishwa na kuhusika kwako katika utafiti huu. Hakuna taarifa zitakutambua wewe binafsi katika njia yeyote. Idadi za utafiti badala ya majina zitatumika kutambua vifaa vyote vya utafiti na mahojiano. Orodha ya kuunganisha majina yako na idadi za utafiti zitahifadhiwa na wafanyakazi wa utafiti na kuhifadhiwa mahali ambapo watu wengine hawawezi kuipata.

I. Sifa za kijamii na demographia za wachuuzi wa chakula

Jina (kwa hiari yako) _____ Idadi ya utafiti

1. Hali ya maumbile ya kijinsia

i) Mke

ii) Mwanaume

2. Ulizaliwa lini? ___ /_____/ _____

2. Hali yako ya ndoa

i) Umeolewa

ii) Hujaolewa

iii) Umetalakiwa/mmetengana

iv) Mjane

3. Kiwango chako cha juu cha elimu ni kipi?

i) Hujapata elimu ya kisasa

ii) Msingi

iii) Sekondari

iv) chuo kikuu

II UTUNZAJI WA CHAKULA MAZOEA NA USAFI WA WACHUUZI WA CHAKULA MAHALI PA KUUZIA

4. Ulijifunza vipi jinsi ya kutayarisha chakula?

i) Katika shule ya utaalamu

ii) Wazazi

iii)Kwa kutazama

iv) Mengine…..taja……

5. Wewe huenda mara ngapi kutazamwa na daktari?

i) Baada ya Miezi mitatu

ii) Baada ya zaidi ya miezi mitatu

iii) Hujawai enda

6. Wewe una cheti cha daktari cha kukubalishwa kuuza vyakula hivi sasa?

i) Ndio

ii) La

Uliza kuonyeshwa cheti hicho…….

7. Je, una uwezo wa kupata maji masafi yanayotiririka kutoka kwa mfereji mahali hapa?

i) Ndio

ii) La

8. Je, wewe hunawa mikono kila wakati kabla ya kushika vyakula mahali hapa?

i) Ndio

ii) La

9. Je, wewe hunawa mikono kila wakati baada ya kushika vyakula mbichi hapa?

i) Ndio

ii) La

10. Kama ni ndio (Swali nane/tisa/au yote mawili),wewe hutumia nini ukinawa mikono mahali hapa?

i) Sabuni na maji yanayotiririka kutoka kwa mfereji

ii) Maji yanayotiririka kutoka kwa mfereji pekee

iii) Maji ya karai

11. Je, unavaa mavazi ya kujikinga uchafu kila wakati unapokuwa ukitayarisha na kushika yakula mahali hapa?

i) Ndio

ii) La

tazama kudhibitisha……

12. Je, wewe hufunika nywele kila wakati unapokuwa ukishika vyakula mahali hapa?

i) Ndio

ii) La

13. Unapokuwa ukishika vyakula hapa, je, wewe hushika pesa pia?

i) Ndio

ii) La

14. Unahifadhi vyakula vinavyobaki baada ya kuuza vipi?

i) Katika jokofu

ii) Katika kabati

iii) Mengine…..taja……..

15. Unatumia nini kusafisha vyombo baada ya kutumika mahali hapa?

i) Maji yanayotiririka kutoka kwa mfereji pamoja na sabuni

ii) Maji yanayotiririka kutoka kwa mfereji pekee

iii) Maji ya karai na sabuni

iv) Maji ya karai pekee

v) Haihusiki

16. Unatumia nini kufunga vyakula unapokuwa ukiuza?

i) Karatasi ya plastiki

ii) Gazeti

iv) Mfuko wa karatasi

v) Mengine,thibitisha……..

17. Wewe hupata bidhaa zako kutoka wapi? .....

III. USAFI WA MAZINGIRA YA WACHUUZI WA CHAKULA MAHALI PA KUUZIA

18. Je, kuna chumba cha kujisaidia unachoweza kukitumia mahali hapa?

i) Ndio

ii) La

19. Kama ni ndio, chumba hicho ni cha aina gani?

i) Choo cha kuchimbwa

ii) Choo cha kisasa

20. Kama jibu la swali 17ni ndio, chumba hicho cha kujisaidia kina maji yakutiririka kutoka kwa mfereji?

i) Ndio

ii) La

21. Unatupa wapi takataka ambazo zaweza patikana kutokana na kazi yako?

i) Mahali wazi

ii) Katika pipa

iii) Mengine…..taja……..

22. Wewe hupatana na wadudu?

i) Ndio

ii) La

kama kunao, ni wadudu wa aina gani ambao unakumbana nao mara mingi?.....

23. Wewe hukumbana na wadudu kivipi? ……

24. Je, mazingira yako huru kutokana na uchafu unaoweza kuwa na madhara?

i) Ndio

ii) La

kama ni la, taja…….

Tumefika mwisho wa mahojiano yetu na tunakushukuru sana kwa mda na ushirikiano wako.

APPENDIX III: OBSERVATION CHECK LIST

Observe for the following and indicate appropriately;

How food is being served (blowing of air into the plastic bag, storage of plastic bag, use of newspapers,)… …….

How waste is being disposed……

Availability of basic sanitary facilities (running water, toilets, etc) …….

Use of protective clothing (apron, head cover)…….

Handling of food (handling of money while selling food, hand washing)
……..……...

Cleaning of dishes……..

General appearance of the surrounding environment……..

General hygiene of the vendor and the environment……..

APPENDIX IV: The Vitek Machine used for specific identification of microorganisms with varied characteristic colonies.

APPENDIX V: IMAGES OF THE VENDING SITES

Image showing sludge formed by wastewater from near a food vendor

Image showing one of the methods used for waste disposal

Image of a vendor positioned next to a bus stop

Image of a vendor selling food items adjacent to another trader selling clothing items

Image of a vendor selling food items by the roadside

Image showing the poor sanitary conditions under which some of the vendors operated

APPENDIX VI: ILLUSTRATIONS OF THE RESEARCHER WORKING IN THE LAB

Image showing the researcher carrying out the procedure for Aerobic Count of Viable microorganisms and enumeration of Coliform bacteria

Image showing the researcher culturing the food homogenate onto the Rappaport and Selenite cystine broth for examination for Salmonella/Shigella

Image of the researcher carrying out the Salmonella/Shigella test using Rappaport and Selenite cystine broth

Image showing the researcher sub culturing onto Xylose Lysine Deoxycholate agar

Image of the researcher sub culturing from Selenite cystine onto MacConkey agar

APPENDIX VII: IMAGES OF SOME OF THE LABORATORY PROCESSESS EMPLOYED FOR GROWTH AND IDENTIFICATION OF MICOORGANISMS

Incubation process at 30 degrees celcius for growth of microorganisms on plate count agar

The plate count machine for aerobic count of microorganisms

Incubation process at 44 degrees in a water bath for enumeration of coliforms

Incubation Process at 43 degrees for growth of Salmonella/Shigella on Rappaport and Selenite cystine media

APPENDIX VIII: APPROVAL LETTER FROM SCIENTIFIC STEERING COMMITTEE

KENYA MEDICAL RESEARCH INSTITUTE

P.O. Box 54840-00200, NAIROBI, Kenya
Tel (254) (020) 2722541, 2713349, 0722-205901, 0733-400003; Fax: (254) (020) 2720030
E-mail: director@kemri.org info@kemri.org Website:www.kemri.org

KEMRI/SSC/103570 13th April, 2015

Emmah Kariuki

Thro'
Director, CPHR
NAIROBI

REF: SSC No. 2927(Revised) – Bacteriological Safety of Street Foods and Factors Associated with Food Contamination among Street Food Vendors in Githurai and Gikomba Markets, Nairobi County

I am pleased to inform you that the above mentioned proposal, in which you are the PI, was discussed by the KEMRI Scientific Steering Committee (SSC), during its 224th meeting held on 4th February, 2015 and has since been approved for implementation by the SSC.

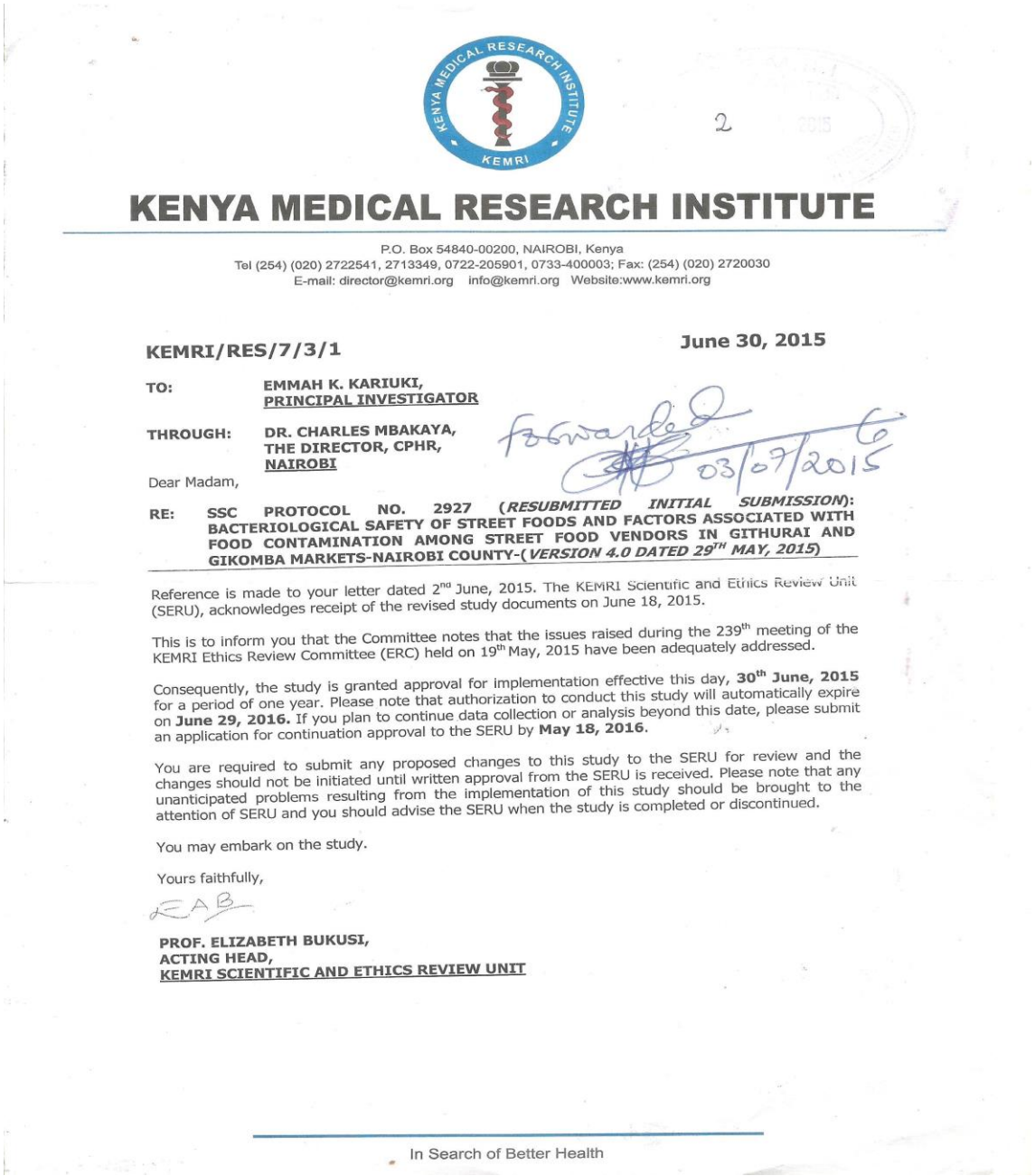
Kindly submit 4 copies of the revised protocol to SSC within 2 weeks from the date of this letter, i.e, 27th April, 2015 for onward transmission to the ERC.

We advise that work on this project can only start when ERC approval is received.

Prof. Sammy Njenga
SECRETARY, SSC

In Search of Better Health

APPENDIX IX: APPROVAL LETTER FROM SCIENTIFIC AND ETHICS REVIEW UNIT



KENYA MEDICAL RESEARCH INSTITUTE

P.O. Box 54840-00200, NAIROBI, Kenya
Tel (254) (020) 2722541, 2713349, 0722-205901, 0733-400003; Fax: (254) (020) 2720030
E-mail: director@kemri.org info@kemri.org Website:www.kemri.org

KEMRI/RES/7/3/1 **June 30, 2015**

TO: **EMMAH K. KARIUKI,**
PRINCIPAL INVESTIGATOR

THROUGH: **DR. CHARLES MBAKAYA,**
THE DIRECTOR, CPHR,
NAIROBI

forwarded 03/07/2015

Dear Madam,

RE: SSC PROTOCOL NO. 2927 (*RESUBMITTED INITIAL SUBMISSION*): BACTERIOLOGICAL SAFETY OF STREET FOODS AND FACTORS ASSOCIATED WITH FOOD CONTAMINATION AMONG STREET FOOD VENDORS IN GITHURAI AND GIKOMBA MARKETS-NAIROBI COUNTY-(*VERSION 4.0 DATED 29TH MAY, 2015*)

Reference is made to your letter dated 2nd June, 2015. The KEMRI Scientific and Ethics Review Unit (SERU), acknowledges receipt of the revised study documents on June 18, 2015.

This is to inform you that the Committee notes that the issues raised during the 239th meeting of the KEMRI Ethics Review Committee (ERC) held on 19th May, 2015 have been adequately addressed.

Consequently, the study is granted approval for implementation effective this day, **30th June, 2015** for a period of one year. Please note that authorization to conduct this study will automatically expire on **June 29, 2016.** If you plan to continue data collection or analysis beyond this date, please submit an application for continuation approval to the SERU by **May 18, 2016.**

You are required to submit any proposed changes to this study to the SERU for review and the changes should not be initiated until written approval from the SERU is received. Please note that any unanticipated problems resulting from the implementation of this study should be brought to the attention of SERU and you should advise the SERU when the study is completed or discontinued.

You may embark on the study.

Yours faithfully,

EAB

PROF. ELIZABETH BUKUSI,
ACTING HEAD,
KEMRI SCIENTIFIC AND ETHICS REVIEW UNIT

In Search of Better Health