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Bacteriological Contamination Of Street Foods Among Street Food Vendors In Githurai And Gikomba Markets- Nairobi County, Kenya

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Abstract: ***The street food trade is a growing sector in many developing countries today and Kenya is one of those countries. The increase in the street food trade especially in market places has been brought about by the larger number of people who are involved in different kinds of businesses who mainly depend on the street foods. One of the main health hazards associated with street foods is microbial and environmental contamination. Studies conducted in Africa have revealed that pathogenic organisms like Salmonella and Escherichia Coli are some of the bacteriological contaminants that pose a health hazard to consumers of street foods. The main objective of this study was to determine the bacteriological contamination of street vended foods by Escherichia .Coli, Salmonella, Shigella, Staphyllococcus Aureus and Closrtidium Perfringes in Githurai and Gikomba markets- Nairobi County. The target population was 149 street food vendors who were selling the street foods at the market places with reference to Githurai and Gikomba markets. This population was targeted because of the nature of businesses that are carried out within these markets mainly being the sale of cheap second hand clothes and other items that attract a large number of people. This study adopted an analytical research design whereby microbial analysis of food samples was carried out in the laboratory.***

Systematic random sampling was used to select the study participants from whom food samples were bought totaling to 218 food samples. The overall level of occurrence of food contamination was 34.9%. 25.2% of these food samples were fecally contaminated evidenced by testing positive for E. coli. Klebsiella pneumoniae was also detected in a sample of boiled egg with "kachumbari" though this microorganism was not among those to be tested in this study.

Keywords: Street food, Street food vendors, Bacteriological contamination

I. INTRODUCTION

Street-vended foods are defined as those foods prepared on the street and ready to eat, or prepared at home and consumed on the street without further preparation (Martins and Anelich, 2000).Food borne diseases are common in developing countries including Kenya because of the prevailing poor food handling and sanitation practices, inadequate food safety laws, weak regulatory systems, lack of financial resources to invest in safer equipment, and lack of education for food-handlers (WHO, 2004). The street food trade is a growing sector in many developing countries today and the expansion is linked with urbanization and the need of urban populations for both employment and food. The safety of street foods is a major consideration, which deserves and has received attention.

The main health hazard associated with street foods is microbial contamination (Abdussalam and Kaferstein, 1993

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and Arambulo *et al*., 1994). Factors implicated in causing microbial contamination include poor food preparation and handling practices, inadequate storage facilities, the personal hygiene of vendors, and a lack of adequate sanitation and refuse disposal facilities ([Abdussalam and Kaferstein, 1993). Unsafe sources, contaminated raw food items, improper food storage, poor personal hygiene during food preparation, inadequate cooling and reheating of food items and a prolonged time lapse between preparing and consuming food items were mentioned as contributing factors for outbreak of food borne diseases in Ethiopia (Linda and Irma, 2005). Studies conducted in different parts of Ethiopia also showed the poor sanitary conditions of catering establishments and presence of pathogenic organisms like campylobacter, *Salmonella, Staphylococcus aureus, Bacillus cereus and Escherichia coli,* (Knife and Abera, 2007, Abera *et al*., 2006, Bayleyegn *et al*., 2003, Tefera *et al*., 2009, and Mekonnen *et al*., 2011).

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 a survey of street food vendors in Lusaka and Harare (Graffham *et al*., 2002).In Kenya, it was observed that the preparation surfaces used by the vendors had remains of foods prepared earlier. More than one food types were prepared at the same surfaces which could promote cross contamination (Muinde and Kuria, 2005).

A. STATEMENT OF THE PROBLEM

There is inadequate data on how street foods contribute to a significant number of food poisonings (Lianghui *et al*., 1993). Studies done in Africa on street foods have revealed that their tremendous unlimited and unregulated growth has placed a severe strain on city resources, such as water, sewage systems and interference with the city plans through congestion and littering adversely affecting daily life. (Canet and N'diaye, 1996). According to Mwangi, (2002), there is a noticeable increase of food vendors in Kenya (Mwangi, 2002) and 40% of Nairobi residents consume street foods. Increase in food vending has been instigated by rapidly growing and changing food demands alongside the need to diversify and/or employ more income sources in the face of declining incomes (Mwangi, 2002).Street food vendors are often unlicensed, untrained in food hygiene and sanitation, and work under crude unsanitary conditions (FAO,2003). Globally, it has been reported that in 2005, 1.8 million people died from diarrheal diseases and a greater proportion of these cases was attributed to food contamination (WHO, 2011). Street food vendors are thought to be the source of food borne disease outbreaks due to inappropriate food handling practices (Jones *et al*., 2006). There is therefore a potential risk of food borne disease outbreaks to consumers. Street food vending 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 food contamination, majority of the inhabitants may be affected.

B. OBJECTIVE OF THE STUDY

The general objective of this study was to determine the bacteriological contamination of street vended foods by *Escherichia .coli, Salmonella, Shigella, Staphyllococcus aureus and Closrtidium perfringes* at consumption point in Githurai and Gikomba markets- Nairobi County.

II. FOOD POISONING DUE TO STREET FOODS

The epidemiological studies to suggest that street foods contribute to a significant number of food poisonings are inadequate; however, there have been several documented cases of food poisoning outbreaks due to street foods. Street foods were responsible for 691 food poisoning outbreaks and 49 deaths from 1983 to 1992 in Shangdong Province (China) (Lianghui *et al*., 1993). Food borne bacterial pathogens commonly detected in street vended foods are *Bacillus cereus*, *Clostridium perfringens*, *Staphylococcus aureus* and *Salmonella* spp (Muleta and Ashnafi, 2001). Food borne and waterborne diarrhoeal diseases are leading causes of illness and globally kill an estimated 2.1 million people annually, most of whom are children in developing countries (WHO, 2001).

III. RESEARCH DESIGN

A cross sectional analytical study design was used. The food samples were bought from the food vendors and analyzed in the laboratory for bacteriological contamination by *Escherichia .coli, Salmonella, Shigella, Staphyllococcus aureus and Closrtidium perfringes.*

A. RESEARCH SETTING

The study was conducted in Githurai and Gikomba markets within Nairobi County. Two study areas were involved so as to spread the sample to avoid vendors influencing each other in their responses since they are closely positioned in both of the two markets. Today there are more than 4000 traders in Gikomba. Gikomba is a market located about 800 metres from the 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 human carriers and hand carts who ferry goods across the market and the surrounding communities are mainly low income earners who largely depend on street vended foods due to the low cost incurred hence the necessity to carry out a study. 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 it for buying cheaply priced goods including street

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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 waiting that may affect a large population in Nairobi who may not only reside there but also those visiting the markets.

B. 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.

C. INCLUSION CRITERIA

Street food vendors aged 18 years and above and consent.

D. EXCLUSION CRITERIA

Street food vendors aged below 18 years
Street food vendors who did not consent.

E. 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 p value of 20% as used in a similar study in Ethiopia (Mekonnen *et al.*, 2011). The sample size was therefore calculated as follows:

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

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 since a preliminary survey done at the two areas revealed the population of interest was a total of 380 street food vendors:

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

F. 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 3 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.

G. DATA COLLECTION

An Informed consent form was first issued to the street food vendors for the purpose of obtaining consent after which a food samples were then bought and collected aseptically in sterile universal bottles, 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.

H. DATA MANAGEMENT AND ANALYSIS

Data from the study was first coded. Double entry was then done using Ms Access 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.

I. 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. The respondents were informed that the direct benefits of being involved in the study was that they would get feedback through community health workers on the contaminants detected in the food. This was to assist them in improving their hygienic practices in order to reduce the potential for future contamination.

Consent was also sought from the respondents through a consent form. 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.

IV. RESULTS AND DISCUSSION

A. DEMOGRAPHIC CHARACTERISTICS

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 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%) were married, 39.6% single, 3.4% divorced/separated while 1.3% were widowed. In terms of their level of education, those who had acquired up to primary or secondary education were almost similar with 36.9% and 34.9% respectively. Only 4.7% had acquired university education while 23.5% of the respondents had no formal education.

B. THE AEROBIC PLATE COUNT

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. Food samples were grouped and in total there were 22 different types of food as shown below in table 1, after which the range and the mean bacteria count was calculated for the various types 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*'). All samples of the baked cake, cooked rice, cooked "*ugali*" and "*mukimo*" had the same bacteria count (Table 1). In terms of microbial quality, food samples were categorized into 3 depending on the number of colony forming units obtained after the APC and the levels. Based on these 3 categories and the results obtained in this study, all the samples of the baked cake (n=6) were satisfactory (APC= $< 10^4$), boiled beans had almost half (42.9%) of its proportion being unsatisfactory (APC= $> 10^5$). Majority (85.7%) of the boiled egg samples were satisfactory (APC = $< 10^6$) and this was the case for all the other types of food apart from "*ugali*" which had unsatisfactory results (APC = $>10^5$) and "*mutura*" which had a portion of 33.3% being marginal (APC=> 10^6).

On the other hand "*kachumbari*" and salads were not classified as they fall under level 3 whereby it would be expected that these foods would have an inherent high plate count because of the normal microbial flora present (Table 1).

Food type	Mean	Range
Boiled beans (n=7)	$4.13501\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $1.61\times10^6\ cfu/g$
Boiled eggs (n=28)	$7.15855\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $1.76\times10^7\ cfu/g$
Boiled egg & *kachumbari* (n=5)	$0.1968\ cfu/g\times10^{-5}$	$5.0\times10^3\ cfu/g$- $5.6\times10^4\ cfu/g$
Boiled maize (n=14)	$0.05822\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $2.6\times10^4\ cfu/g$
"*Chapati*" (n=17)	$0.16637\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $2.0\times10^5\ cfu/g$
"*Chips*" (n=13)	$0.16346\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $2.0\times10^5\ cfu/g$
Cooked cabbage (n=5)	$0.62364\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $2.6\times10^5\ cfu/g$
Fried fish (n=11)	$0.26133\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $2.0\times10^5\ cfu/g$
"*Githeri*" (n=15)	$0.25852\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $1.9\times10^5\ cfu/g$
"*Kachumbari*" (n=24)	$1.14892\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $1.5\times10^6\ cfu/g$
"*Kangumu*" (n=6)	$0.00048\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $1.3\times10^2\ cfu/g$
"*Mandazi*" (n=7)	$0.00391\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $2.4\times10^3\ cfu/g$
Salad (n=3)	$0.04803\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $9.6\times10^3\ cfu/g$
"*Samosa*" (n=17)	$0.00992\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $7.2\times10^3\ cfu/g$
Sausages (n=9)	$0.02117\ cfu/g\times10^{-5}$	$10\times10^0\ cfu/g$- $1.4\times10^4\ cfu/g$
"*Mutura*" (n=3)	$6.13333\ cfu/g\times10^{-5}$	$1.4\times10^5 cfu/g$-$1.5\times10^6 cfu/g$
Baked Cake (n=6)	$10\times10^0\ cfu/g$	0-0.00
"*Mukimo*" (n=2)	$10\times10^0\ cfu/g$	0-0.00
Cooked rice (n=1)	$10\times10^0\ cfu/g$	0-0.00
Cooked "*Ugali*" (n=1)	$1.4 cfu/g\times10^{-5}$	0-0.00
Sausage/Smokie With "*kachumbari*" (n=4)	$37.18425 cfu/g\times10^{-5}$	$1.7\times10^3 cfu/g$- $1.4\times10^7 cfu/g$
n= 218		

Table 1: The range and mean log_{10} bacteria count for the various food types

C. CLASSIFICATION OF THE VARIOUS FOOD SAMPLES AS PER THEIR AEROBIC PLATE COUNT

In terms of microbial quality, food samples were categorized into 3 depending on the number of colony forming units obtained after the APC and the levels. Based on these 3 categories and the results obtained in this study, all the samples of the baked cake (n=6) were satisfactory (APC= $< 10^4$), boiled beans had almost half (42.9%) of its proportion being unsatisfactory (APC= $> 10^5$). Majority (85.7%) of the boiled egg samples were satisfactory (APC = $< 10^6$) and this was the case for all the other types of food apart from "ugali" which had unsatisfactory results (APC = $>10^5$) and "mutura" which had a portion of 33.3% being marginal (APC=> 10^6).

On the other hand "kachumbari" and salads were not classified as they fall under level 3 whereby it would be expected that these foods would have an inherent high plate count because of the normal microbial flora present (Table 2).

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	1	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	-
Cooked rice(n=1)	1	0	0	-
Cooked 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%)

Table 2: Classification of the various food samples as per their Aerobic Plate Count

D. 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. After the incubation process, any tube showing gas production with fermentation during this test indicated the possible presence of coliform bacteria and was recorded as positive presumptive tube. All positive presumptive tubes

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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 are present than if only total coliform bacteria is detected.

According to the presumptive test results, there were four food types that had all the samples being 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%). Boiled beans had majority (85.7%) of its samples being coliform positive followed by fried fish (81.8%). On the other hand there were food types that had none of their samples being coliform positive namely; baked cake, "*mukimo*", and cooked rice. In general there were a 99 samples that were found to be coliform positive which represented nearly half (45.4%) of the food sampled (Table 3).

However, from those samples that were coliform positive (99), 60.6% (60/99) had unacceptable coliform count. The samples that had positive presumptive results were then subjected to further tests to detect the presence of fecal coliforms mainly *E. coli*. Boiled egg had the majority (62.5%) of its samples being positive for fecal coliforms, Boiled beans, sausage/*smokie* with "*kachumbari*" and "*samosa* had half (50%) of its samples being positive for fecal coliforms. Boiled egg with "*kachumbari*" had a proportion of 40% being fecally contaminated where as "*chapati*", Salad, sausage and "*mutura*" had the same proportion (33.3%) of its food being positive. In general, 25.2% of the food sampled in this study was fecally contaminated evidenced by testing positive for *E. coli* (Table 4).

Food type	**Range of MPN coliforms /g of food**	**Frequency (coliform+)**	**Percentage (coliform+)**	**Frequency (Unacceptable coliform count)**
Baked cake **(n=6)**	0	0	0	0
Boiled beans (n=7)	0- >2400	6	85.7	5
Boiled egg (n=28)	0- >2400	8	28.6	7
Boiled egg with *kachumbari*(n=5)	29- 240	5	100	3
Boiled maize (n=14)	0 - >2400	8	57.1	3
Chapati (n=17)	0 - >2400	9	52.9	5
Chips (n=13)	0 - >2400	4	30.8	3
Cooked cabbage (n=5)	0 - >2400	3	60	2
Fried fish (n=11)	0 - >2400	9	81.8	6
Githeri (n=15)	0 - >2400	8	53.3	5
Kachumbari (n=24)	0 - >2400	14	58.3	7
Kangumu (n=6)	9 and 40	2	33.3	0
Mandazi (n=7)	9 and 20	2	28.6	0
Mukimo (n=2)	0	0	0	0
Salad (n=3)	29 - >2400	3	100	1
Samosa (n=17)	0 - >2400	4	23.5	2
Sausage (n=9)	0 - >2400	3	33.3	2
Sausage/*smokie* with *kachumbari* (n=4)	20 - >2400	4	100	3
Smokie (n=20)	0 - >2400	3	15	2
Mutura (n=3)	>2400- >2400	3	100	3
Cooked *Ugali* (n=1)	120(no range)	1	100	1
Cooked rice (n=1)	0 (no range)	0	0	0
Total(n= 218)		99	45.4	60 (60.6%)

Table 3: Presumptive test results for fecal coliforms using the MPN technique

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)	0 -154	3	50
Boiled egg (n=8)	0 -154	5	62.5
Boiled egg with *kachumbari*(n=5)	44 -70	2	40
Boiled maize (n=8)	3 -20	2	25
Chapati (n=9)	3 -153	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)	0 -240	1	12.8
Kachumbari (n=14)	0 -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)	0 -7	1	33.3
Samosa (n=4)	0 -4	2	50
Sausage (n=3)	0 -19	1	33.3
Sausage/*smokie* with *kachumbari* (n=4)	0 -210	2	50
Smokie (n=3)	0	0	0
Mutura (n=3)	0 -150	1	33.3
Cooked *Ugali* (n=1)	0	0	0
Cooked 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*			

Table 4: Confirmatory test results for fecal coliform bacteria

E. 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 1) after which sub culturing was done on Triple Sugar Iron (TSI) and Sulfide Indole Motility (SIM) and the reactions observed (Fig 2). *Klebsiella pneumoniae* was also detected in a sample of boiled egg with "*kachumbari*" though this microorganism was not among those to be tested in this study. This was detected through the use of the Vitek machine.

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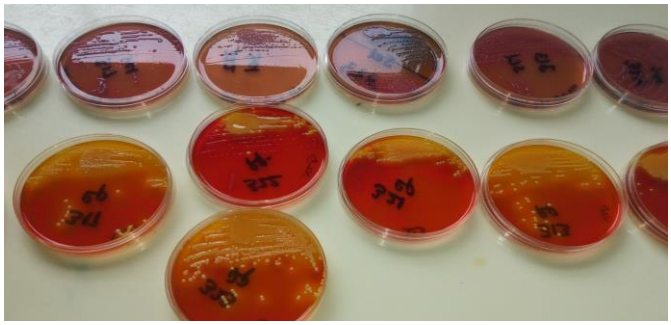


Figure 1: Growth on MacConkey agar and Xylose Lysine Deoxycholate

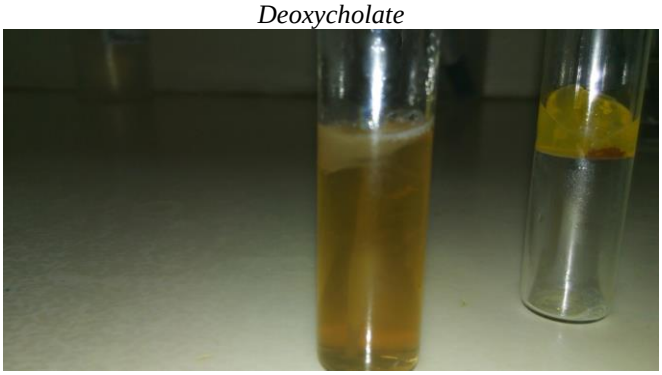


Figure 2: Reaction on SIM and TSI confirming an E. coli positive food sample

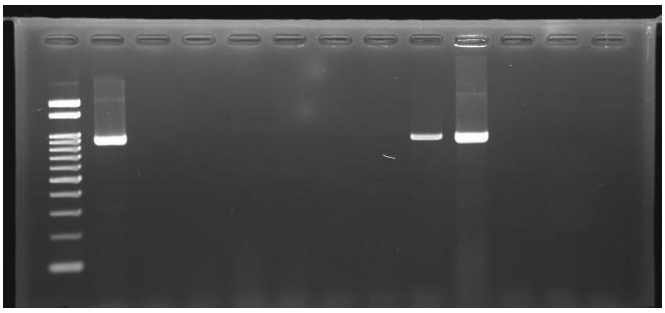
F. RESULTS FOR *E.COLI* PATHOTYPING

Multiplex-PCR was carried out by the method described by Toma. 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, 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	Ratchtrachen chai *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

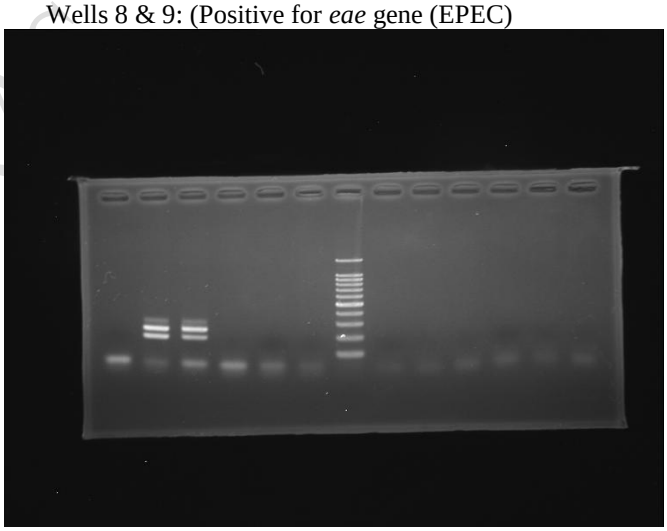
Table 5: Primers used in multiplex PCR for detection of diarrheagenic E. coli. EPEC, enteropathogenic E. coli. ETEC, enterotoxigenic E. coli. EAEC, enteroaggregative E. coli. EIEC, enteroinvasive E. coli.

RESULTS FOR E.COLI PATHOTYPING



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

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



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/cvd432* genes (EAEC)

Wells 16-18 (Negative Controls)

As shown in the above illustrations in well 8 and 9, two samples tested positive for *Enteropathogenic E. Coli (EPEC)* and one sample as illustrated on well 15 tested positive for *Enteroaggregative E. Coli.* All the other pathogenic *E. Coli* (ETEC, enterotoxigenic *E. coli*, EIEC, enteroinvasive *E. coli*) were not detected as shown in the illustration below;

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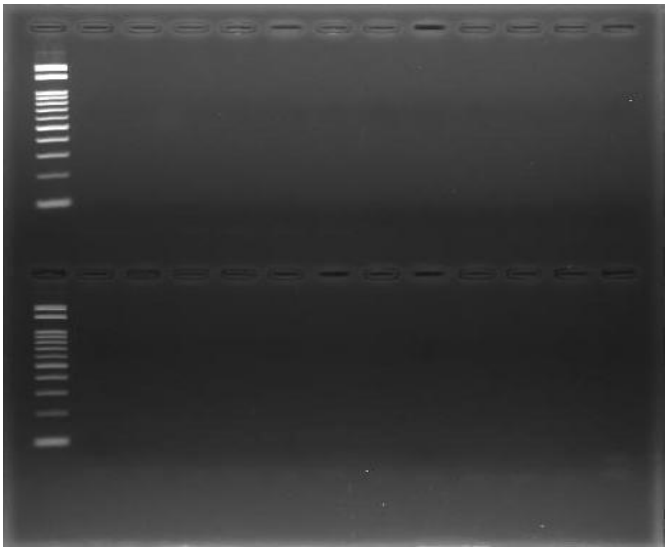

G. DISCUSSION

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 and *Escherichia coli*, and presence of *Klebsiella Pneumoniae.* These findings differed from findings of a study carried out in Ethiopia where a higher occurrence (64.3%) of food contamination was observed (Getu *et al*., 2013). The findings of this study may have differed due to the fact that in the Ethiopia study, they were able to isolate two different bacteria species namely; *E. coli and Staph aureus* as opposed to *E. coli* alone. On the other hand, comparable findings have been 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).

A low occurrence (3%) of food contamination was observed in a study carried out in Doha, Qatar, Elobeid *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). Total viable count in all samples varied between 10.0 - 1.4× 10^6 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 - 25.81x10^5 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 – 3.61×10^5 cfu/g (Getu *et al*., 2013).

In terms of the coliform count, 60.6% of the food samples had unacceptable coliform count. These findings differed from those of a study carried out in Bangok that observed 41.3% of the food samples collected as having unacceptable coliform count (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 since it involves cutting of the sausage/*smokie* and inserting the '*kachumbari*' which mainly includes raw vegetables that require adequate washing with clean water. 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 of the food since it has a shell that is removed with the teeth (Oranusi *et al*., 2012).

The natural environment habours coliforms and in this study, vendors reported presence of various environmental contaminants such as sewage. According to Wei Q *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. The results were in agreement with the findings of 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 food (Elwathig, 2011).Other studies have however observed higher occurrences of *E. coli* contamination. A study in Ethiopia detected *E .coli* in 44.6% of the food samples (Getu et al., 2013) while another study in Zimbabwe reported *E .coli* in 53% of food samples. This high occurrence in the Zimbabwe study may have been due to the fact that all the samples of three out of the five food types in the study, namely; egg rolls, chicken stew and doughnuts were all contaminated with *E. coli* (Raphael *et al*., 2014). In this study, boiled eggs had the highest (5/8; 62.5%) occurrence of *E. coli.* which is in agreement to observations made in the Zimbabwe study where all the egg roll samples (20/20; 100%) were contaminated with *E. coli*. Boiled eggs preparation involves breaking the shell manually hence excessive handling which might later contaminate the product. This 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 (Raphael *et al*., 2014).

E. coli normally survives in the gastrointestinal tract of human and normally found in faces, therefore according to Yeboah- Manu *et al*., 2010, the presence of *E. coli* in food types is an indication of faecal contamination probably at one stage of preparation or from the materials used. *Klebsiella pneumonia*e was also detected in one sample (0.46%) of the boiled egg with "*kachumbari*" though this microorganism was not among the pathogens that were to be tested in this study. A higher occurrence of 17% was observed 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 (Feglo *et al*., 2012), the detection of *Klebsiella* sp 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 which mainly includes raw tomatoes and onions 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 (Getu *et al*., 2013). 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 did not detect *Salmonella spp* in all the food samples analyzed [Raphael *et al*., 2014). Research by Gilbert *et al*., (2000) also ascertains that no salmonella should be detected in ready to eat foods (Gilbert *et al*., 2000). Absence of *Salmonella spp* in this study may indicate appropriate food preparation even though the hygiene and the sanitation standards may not have been adequate based on the actual environment. According to Barro *et al*., (2007), microbiological safety of street foods requires sequential and logical step by step analysis towards reducing the risks of food borne illness by monitoring food preparation steps up to consumption. This is because, most food preparation steps including their environment and handling personnel significantly contribute to the contamination, growth and survival of the microbes responsible for food borne illness (Barro *et al*., 2007). 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 dealt with cooked foods that had undergone heat treatment.

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 the researcher, serving was then done using bare hands as this type of food is slippery making it difficult to use a spoon or a fork. Mensah *et al*., (2002) went further to identify the use of bare hands 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 (Mensah *et al*., 2002). In this study, serving was mainly done by use of a nylon paper that was wrapped around the hand prior to touching any food or a spoon and hence no vendor used bare hands. This may have been the aspect that led to the contrary findings. *Clostridium species* was identified in a study in South Africa, however as opposed to the present study that mainly examined cooked food, the isolation and identification in South Africa was obtained from raw beef. *Clostridium perfringes* 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 *et al*., 2004) which was not the case in this study.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Microbial food contamination is a public health problem in Githurai and Gikomba markets as an occurrence rate of 34.9% is high compared to findings of a study in Qatar that observed an occurrence rate of 3% of street food contamination (Tahra *et al*., 2014).

B. RECOMMENDATIONS

Based on the findings of this study the following recommendation can be made;

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. This may help to decrease the occurrence rate of microbial food contamination especially by pathogens that are transferred to food by the street food vendors.

DEFINITION OF TERMS AS USED IN THIS STUDY

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.

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