Determination of Microbiological Quality of Consumed Fruit and Vegetable Salad (Kachumbari) around University of Kabianga, Kenya

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DETERMINATION OF MICROBIOLOGICAL QUALITY OF CONSUMED FRUIT AND VEGETABLE SALAD (*Kachumbari*) AROUND UNIVERSITY OF KABIANGA, KENYA

BY

OGOTI DUNCAN MOGIRE

MIC/0032/17

A Research Project Submitted To The Department Of Biological Sciences, School Of Science And Technology In Partial Fulfillment Of The Requirements For The Award Of A Degree Of Bachelor of Science In Microbiology From The University Of Kabianga

APRIL, 2020

DECLARATION

I Ogoti Duncan Mogire declare that this research project is my own original work and that has not been presented /submitted anywhere for examination in this or any other institution for the award of degree or diploma. Other authors work cited herein has been duly acknowledged in the text.

NAME: OGOTI DUNCAN MOGIRE

SIGN …… DATE ……

APPROVAL

This project is submitted with my Approval as Project Supervisor.

Name: …….. Signature..... Date…….....

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DEDICATION

I dedicate this research project to the Department of Biological Science, School of Science, University of Kabianga and the ministry of public health. I also dedicate it to Bosibori Mercy Obara who helped me in coming up with this broad idea. I also dedicate it to the vegetable and fruits vendors, who participated immensely in development of this research project.

ACKNOWLEDGEMENT

I express my gratitude to God for seeing me through my entire research project development. I also thank the institution of University of Kabianga especially the academic staff for the support they have given me to reach this point. My special thanks go to my supervisor, madam Zeddy Yegon whom despite of many duties agreed to guide me in developing the project. I express my deep thanks to my beloved family for supporting me financially. I also thank everybody who was constantly beside me and helped in research project development.

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ABSTRACT

With increased student population and health consciousness in and around University of Kabianga, Kenya, there has been increased consumption of fruit salad and vegetable salad (*Kachumbari*) and consequently an increase in fruits and vegetable vendors. However, there safety concerns due to an increase in reported cases of diarrhea and stomach related problems among the student population. The objective of this study will determine the microbiological quality of fruit salads and vegetable salads sold around University of Kabianga. Fifteen fruit salad samples and vegetable salad samples, five each from different sampling zones (University of Kabianga gate, Kabianga Market, and Chepnyogaa Market), will be collected randomly. Fruit salads and *Kachumbari* were randomly sampled in Kabianga market, Chepnyogaa market and at the university main gate, and then transported in clean polythene bags to the laboratory for analysis within two hours. The media was prepared as per manufacturer‘s instructions. Serial dilution was done and dilutions from10^{-2} to 10^{-4} were used. Representatives of unique bacteria colonies were sub-cultured in Nutrient agar to obtain pure isolates. Bacteria were characterized based on their cultural characteristics. Enumeration of bacteria colonies on Plate count agar was done using a colony counter machine. The isolated samples were Gram stained. Biochemical characterization was carried out and included: Catalase Test, coagulase test. The data was collected and analyzed using spreadsheet and presented in graphs and tables. The bacterial isolates were identified as; *Staphylococcus aureus, Salmonella spp., Escherichia coli*. The salad samples were found to be contaminated hence unsafe for consumption.

CHAPTER 1

1.0 Background Information

Around University of Kabianga, Kenya, with recent increases in student population, there has been a steady rise in the number of street food vendors selling to University students and staff and the local community. All around Kenya, consumption of street-vended food has been implicated as a vehicle for transmission of infectious microorganisms in food borne outbreaks, including areas around University of Kabianga.

Street-vended food including ready-to-eat food and beverages, which are prepared and sold outside established buildings or in makeshift structures by street vendors are gaining importance in Kenya due to their economic contribution in job creation and reducing food insecurity(*Gitahi et al, 2012*). In particular, salads, which can be defined as a food made primarily of a mixture of raw vegetables and/or fruits are gaining prominence due to their health and nutritional benefits. The fruits and vegetable salads have proved to be cheap around the area and many students have resorted to eat them and thus increased consumption since the fruits are made available also in favorable quantities. However, safety and quality are the two common concerns with regard to street-vended foods (*WHO, 2016; Muhonja, Kimathi, 2014*).

Poor hygiene and sanitation practices are one of the major bottlenecks in street food vending. These predispose consumers to food borne diseases, particularly where the products are consumed

without further processing, washing or peeling (*Rane, 2011*). The water used for washing and rinsing the fruits and vegetables is of questionable quality and could serve as a source of contamination and cases of fruits and vegetable contamination with microorganisms during production; harvesting, packing and distribution have been reported(*Andrews et al, 1979*).

Some of the fruits are sold after peeling and after peeling they always get exposed to air of which acts as a source of microorganisms and even the storage containers are not well sealed. The water that is used to wash the fruits is drawn from river Kabianga of which poses a health problem since even people bath there and thus introducing microorganisms into the water. The environment around the centers is not to standard and thus people throw wastes all over of which creates a biohazard to the products and the people around. For instance, *Salmonella* has been found in a wide range of "organically grown" products including beans, peas, sunflower seeds, and alfalfa. Moreover, microorganisms multiply faster on cut produce, owing to the greater availability of nutrients and water (*Montville, 2001*).

Therefore, continued surveillance of street-vended food is of importance to assure consumer safety, irrespective of the incorporation of handling methods intended to reduce food contamination. The cleanliness of the vendors is not proper, and their health status cannot be established hence they can potentially serve as sources of contamination. The handling of the *kachumbari* by most vendors is also not proper as it is neither covered nor refrigerated.

Therefore, dust particles can fall on the foods and serve as sources of contamination and the contaminants can grow amply at ambient temperatures. Due to this there have been a number of students who every semester have been diagnosed of diarrhea and stomach problems.

Therefore, intervention measurements and policies are needed to ensure that the problems are eliminated and thus the reason why need to do the study.The present study will be conducted to determine the microbiological quality of vegetable salads and consumed fruit salad sold near University of Kabianga, Kenya.

1.1 OBJECTIVES

1.1.1 General objectives

To determine the microbiological quality of vegetable and consumable fruit salads.

1.1.2 Specific objectives

I. To determine the microbial load on fruit and in vegetable salad [*Kachumbari*].

II. To screen for pathogenic microorganisms among the fruits and the vegetable salad.

1.1.3 Hypothesis

Fruits and vegetable salads do not contain pathogenic microorganisms.

1.2 STATEMENT OF PROBLEM

Kabianga is a region with a diverse kind of self-employed businessmen and women. The most interesting of all is the fruit vending and salad vending of which has provided enough cash to the owners. The challenge is the suspected health problems that these services will pose in the health of human beings.

Therefore, continued surveillance of street-vended food is of importance to assure consumer safety, irrespective of the incorporation of handling methods intended to reduce food contamination. The cleanliness of the vendors is not proper, and their health status cannot be established hence they can potentially serve as sources of contamination. The handling of the *kachumbari* by most vendors is also not proper as it is neither covered nor refrigerated. Therefore,

dust particles can fall on the foods and serve as sources of contamination and the contaminants can grow amply at ambient temperatures.

All these activities are harmful to human health. They introduce pollutants which have very detrimental effects on the health of the Consumers. Many introduce bacteria, viruses which are responsible for diseases such as cholera, dysentery and typhoid. Due to this there have been a number of students who every semester have been diagnosed of diarrhea and stomach problems. Therefore, intervention measurements and policies are needed to ensure that the problems are eliminated and thus the reason why need to do the study.

1.3 JUSTIFICATION OF THE STUDY

A large proportion of world population does not have access to safe vegetable and clean fruit salads and also the various vegetable salads provided for sale in the market.

Microbiological examination offers the most sensitive test for the detection of recent and potentially dangerous pollution on food materials such as fruit salad and vegetable salads, thereby providing a hygienic assessment of the quality of the various fruits and salads with high sensitivity and specificity.

Therefore this study is conducted to help in the formulation of policies in the health sector of the institution of which is to help many students and even the staff to get good fruit salads and salads to eat and much more to reduce suffering among many who face the consequences. Thus this improves the well being of the concerned and thus reduces the health budget of the university.

CHAPTER 2

2.0 LITERATURE REVIEW

2.1. Dietary value of fruits and vegetables

A healthy person requires various forms of nutrients in order to maintain the state of the body that is carbohydrates, proteins, vitamins, minerals, and even water. Fruits and vegetables are an extraordinary dietary source of nutrients, micronutrients, vitamins and fibre for humans and are thus vital for health and well being (*Amoah, 2014*). Well-balanced diets, rich in fruits and vegetables, are especially valuable for their ability to prevent vitamin C and A deficiencies and are also reported to reduce the risk of several diseases (*Daniele et al, 2013; Ramos et al 2013*). The United States Department of Agriculture recommends five to nine servings of fruits and vegetables daily(*WHO, 2015*). Bacteriologically safe fruits and vegetables are essential to maximize the health benefits promised by adequate consumption of these produce.

2.2. Vegetable and fruit salads and salad dressings

Salad refers to a food that is made of a mixture of raw vegetables and/or fruits (*Uzeh et al., 2009; Rajvanshi, 2010*). It is usually made up of fresh-cut or minimally processed vegetables or fruits with or without salad dressing. Across the globe, vegetables mostly used in salad preparation include cucumber, pepper, tomatoes, onions, carrots, spring onions and radishes. Some non vegetable ingredients that may also be used are olives, mushrooms, egg, green beans, cheese, herbs, nuts, poultry, meat and some sea foods.

Fresh salads are not part of the normal Ghanaian diets, but factors such as westernization of the Ghanaian culture have made it essential component of food served by fast food vendors, canteens and restaurants with about 200,000 consumers every day in Accra alone (*Amoah et al., 2007*). According to FEHD (2002), salad dressings provide characteristic flavours and also offer certain preservative effects.

2.2. Chain of distribution of the salads of fruits and vegetables

Where land is available, families grow fruits and vegetables for their own use. Otherwise, produce is purchased from local farmers and retail outlets for further preparation at home, or as a part of meals eaten in restaurants and other food-service facilities. These retail businesses out of the home have led to increased quantities of fruits and vegetables in many urban centers and higher institutions of learning. Advances in agronomic, processing, preservation, distribution, and marketing technologies have enabled the produce industry to supply nearly all types of high-quality fresh fruits and vegetables to those who desire and are willing to purchase them year around. However, some of these same technologies have also brought an increased risk of human illness associated with a wide range of pathogenic microorganisms (*Lund, Wamelen, 2012*).

2.3. Microbial contamination of fruit and vegetable salads

Changes in production and handling practices have created new challenges for national food borne disease surveillance programs. (*Hedberg et al, 2009*) discussed changing factors that contribute to the epidemiology of food borne disease. There are summertime increases in food borne illness which are not fully understood, although fresh fruits and vegetables very likely play a role, since they are consumed in higher quantities during the summer months (*Beuchat, 1996*).

In Kabianga fruits in form of salad and vegetables [*Kachumbari*] are commonly sold in public places such as the markets, road sides, streets and motor parks. In some cases, they are sold using mobile platforms like wheel barrows and trucks loaded with all kinds of fruits such as orange, banana, pawpaw, mango, pineapple, avocado pear, apple, garden egg and coconut. The fruits are sometimes loaded in trays and basin on vendors head. The choice of fruits and vegetables sold by a particular marketer is influenced by the level of profitability and availability of the fruits and vegetables as each fruit type is seasonal in nature. The vendors around the markets and their stalls hygienic conditions are not good and thus some have acted as reservoirs of the pathogenic microorganisms.

This has resulted to the spread of various food borne diseases and causing other health complications, for instance, twenty cases every semester which experiences stomachaches and diarrheal problems and thus the basis of this study.

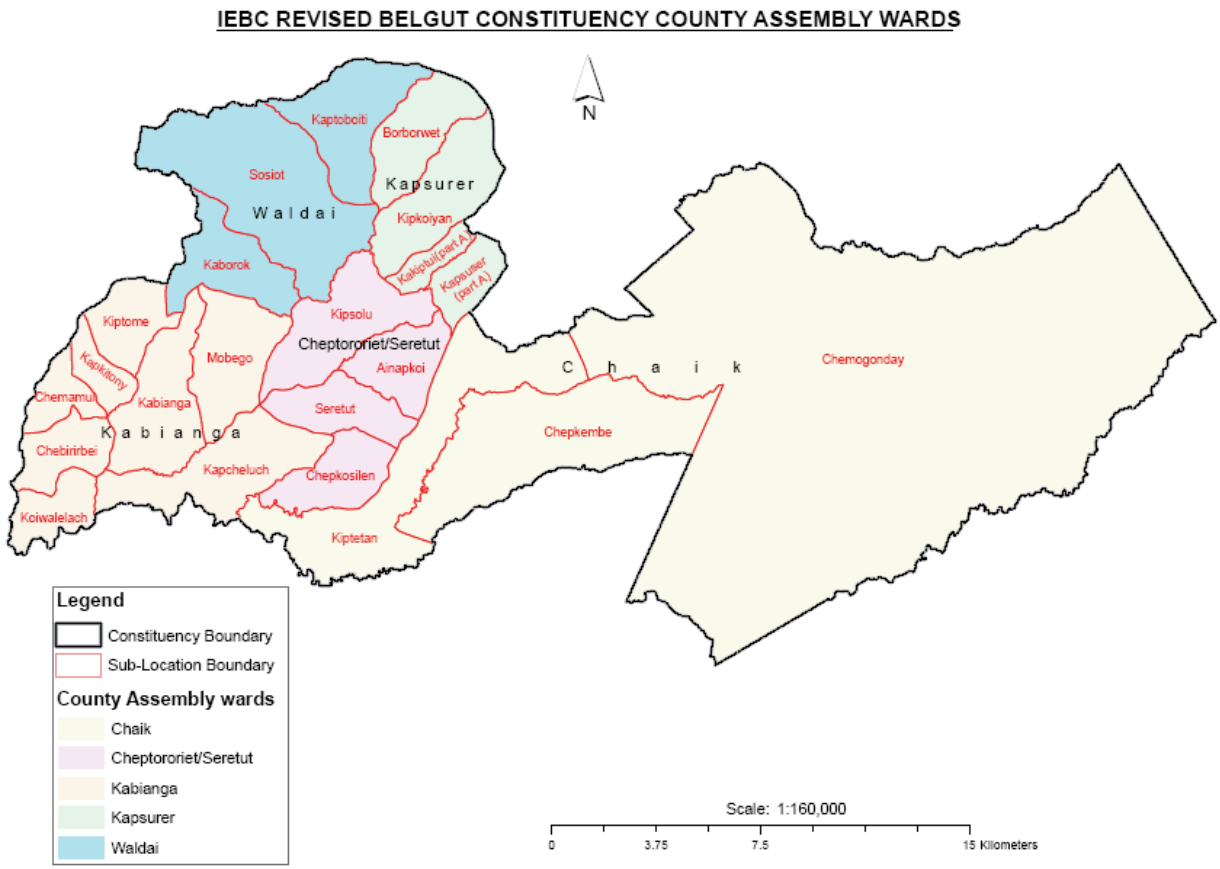
CHAPTER 3

3.0 Materials and methods

This chapter describes the study area and methods used to gather data in the following organization; - study area, sample collection, media preparation and sample preparation. It also includes sampling procedure, sample size, data collection techniques and lastly data analysis.

3.1 Study Area

The study will be conducted at University of Kabianga, Kericho County in Kenya. Kabianga area is found in Belgut constituency, Kericho west in Kericho County which covers an area of 337.4 $km^{2.}$



3.2 Sample Collection

The salad samples at the selected sites, that is, University gate, Chepnyogaa market, and Kabianga market, were collected. The salads collected were of equal pack of twenty shillings and five samples were collected from each site. A total of 15 samples were collected for the vegetable salad and 15 samples for the fruit salads. The samples of the vegetable salad and the fruit salad were examined in the science laboratory, Department of biological sciences, University of Kabianga

3.2.1. Media Preparation

Nutrient agar, Plate count agar, Staph 110 agar, McConkey agar, *Salmonella- Shigella* agar media were prepared according to the manufacturer's instructions. Nutrient agar medium was used in

isolation of bacteria. Plate count agar was used in viable cell count. Staph 110, MacConkey and *Salmonella-Shigella* agar were used in identification of bacteria.

3.2.2. Sample preparation

During sample preparation, 10g of each vegetable and fruit salad was weighed and crushed separately using sterile mortar and pestle. After crushing, the paste was transferred to separate conical flask containing 90ml normal saline that is to say for fruit salad and for vegetable salad. The mixture was shaken thoroughly to obtain a homogenous mixture, serial dilution was done and dilutions from 10^{-2} to 10^{-4} were used.

3.2.3. Enumeration of bacteria

A 1ml sample of the diluents was pour plated on Plate count agar and incubated at 37°C for 24hours. Plates containing 30-300 colonies were selected and counted using a colony Counter machine. They were then expressed as number of viable bacterial cells per gram of original fruit salad and vegetable salad sample (done separately). The average counts obtained from the selected dilution was multiplied with the dilution factor to obtain the number of colony forming units per gram of fruit (CFU per gram).

3.3. Isolation and characterization

3.3.1. Isolation of bacteria

A 1ml sample was streaked spread plated on Nutrient agar incubated at 37°C for 24 hours. A representative of unique bacterial colonies was sub-cultured on Nutrient agar plates to obtain pure isolates.

3.3.2 Morphological characterization of bacteria

Bacteria were first characterized based on cultural characteristics. From each plate, colony shape, size, colour, topography and margin were observed and recorded.

3.3.3. Gram staining

The isolated sample was Gram stained as per Gram (1984). Morphological characteristics such as color and shape were observed and recorded.

3.3.4. Biochemical characterization

3.3.4.1. Catalase Test

In each clean test tube, 2ml of H_2O_2 was poured. Using a sterile wire loop, colonies were picked and immersed in test tubes containing H_2O_2.The production of bubbles was observed and recorded.

3.3.4.2. Coagulase test

On a slide containing the emulsifier was added 2 colonies indicating the presence of *S. aureus*. There was observed clumping.

3.4 DATA COLLECTION AND ANALYSIS

Data was collected using various features and tests, that is colony counts for microbial loads of which is colony forming units, colony morphologies which includes; shape, size, color, elevation, texture, the number of isolates positive for all tests and biochemical characterization of the bacterial isolates majorly catalase test, coagulase test, TSI and Gram staining to distinguish gram positive from gram negative bacteria.

Data was analyzed using mean, and standard deviation for the colony forming units and the number of isolates and also for the comparison of the data collected from the different centers. The data was then presented using tables, bar graphs and pie-charts for the comparison of the three sites of study.

CHAPTER 4: RESULTS

4.0. Determination of the various isolates

4.0.1 Detection of E. coli

The MPN (most probable number) technique on pour plates, described by Camacho *et al*. (2009), was used; this method relies on the ability of some coliform bacteria to ferment lactose when incubated at 44 °C for 24 h. To determine the presence of *Escherichia coli*, positive confirmatory tests were used; to isolate and confirm the strain, Eosin Methylene Blue Agar was used, incubating samples for 24 h at 35 °C ± 2 °C, and subsequent biochemical tests. A more sure growth of *E. coli* was seen on the growth on the MacConkey Agar.

4.0.2 Determination of Staphylococcus aureus

A total count of *S. aureus* was conducted by direct plating on Staph 110 agar, with an incubation time of 48 h at 35 °C ± 2 °C. The presence of typical colonies was confirmed using coagulase test, as established by KEBS standards.

4.0.3 Detection of Salmonella spp.

Following the NOM-114-SSA1-1994 standard, a pre-enrichment culture with a lactose broth was used, followed by an enrichment culture with tetrathionate broth, subsequent seeding on selective media, *Salmonella Shigella* Agar and biochemical tests, H_2S production; all cultures were incubated for 24 h at 35 °C ± 2 °C.

4.0.4 Determination of Shigella spp.

An enrichment culture with nutrient broth was used, samples were then replated on selective media that is Salmonella -Shigella Agar, and further biochemical tests were conducted. All cultures were incubated for 24 h at 35 °C ± 2 °C.

4.1. Descriptive data of the microorganisms isolated

Table 1
Colony Morphology on the Different Media

Microorganism	Shape	Color	Elevation	Texture	Gram stain	Coagulase test	Catalase test	Hydrogen sulphide production
*E. coli[*MacConkey]	Rod	Dark pink	flat	Opaque	negative	---	positive	----
*S. aureus[*Staph 110]	Circular	Yellow	convex	Opaque	positive	positive	positive	---
*Salmonella[*SS Agar]	Round	Colorless with black spots at the centre	---	Opaque at the centre	---	---	---	Positive

Table 2 [For *Kachumbari*]

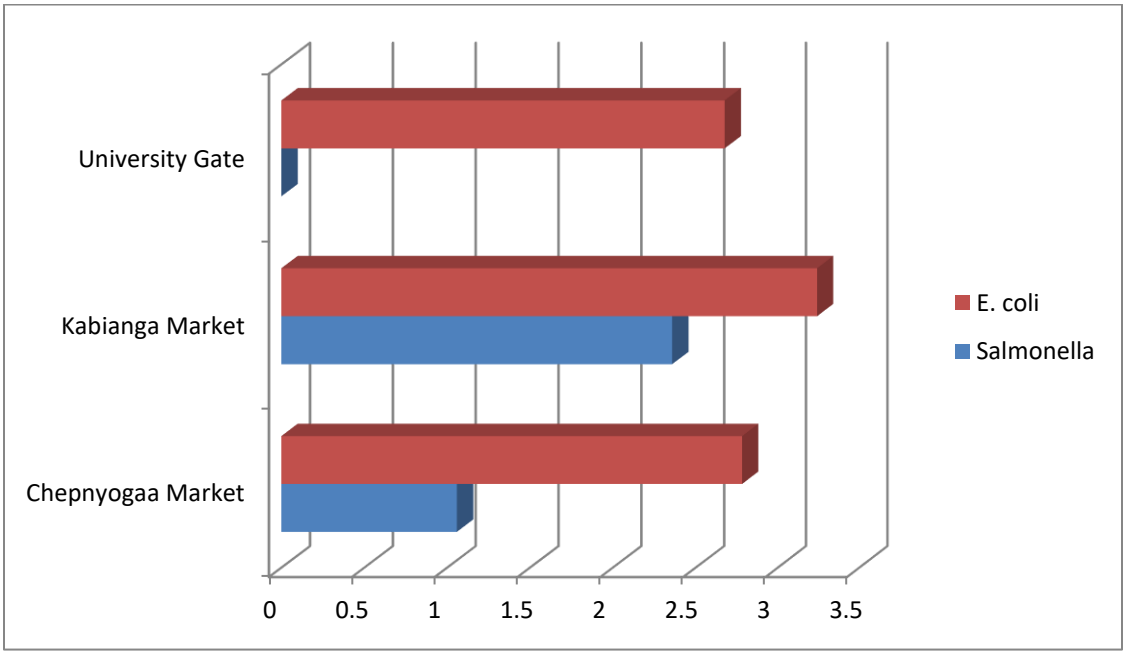
Mean concentration ranges of *E. coli* spp. and *Salmonella* spp. in *kachumbari* samples around University of Kabianga, Kenya

Sampling zone/microbial count	*Salmonella* spp. counts Log10 CFU/g	*E. coli* spp. counts Log10 CFU/g
Chepnyogaa Market	1.016 ± 0.486	2.782 ± 0.240
Kabianga Market	2.359 ± 0.321	3.242 ± 0.238
University Gate	0	2.676 ± 0.173

N/B: - Results are means ± standard deviations of triplicate samples. CFU: Colony forming units, *E. coli: Escherichia coli*

Figure 1

A bar graph representing the data to log to base 10 of Salmonella and E. coli present in the Kachumbari



4.2. Raw dhania, onions, tomatoes

The microbiological analysis of the salad samples indicated that *kachumbari* was contaminated with pathogens. The *E. coli* was present in 80% of the samples analyzed and in all the sampling zones while *Salmonella* tested positive in 70% of the samples and was prevalent in two of the three sampling zones (Table 1). The *E. coli* concentrations in the samples ranged between log10 of 2.676 CFU/g in food kiosks and log10 of 3.242 CFU/g in samples that were collected from University gate vendors (Table 1). The mean average for *E. coli* was log10 of 3.047 CFU/g, which were several orders high compared to the Kenya Bureau Standards recommended value of < 10 CFU/g. The concentrations of *Salmonella* ranged between log10 1.016 CFU/g and log10 2.359 CFU/g with an average of log10 2.067 CFU/g. *Salmonella* should be negative in food samples, and for the concentrations detected in this study, it is an indication of a health hazard that needs to be addressed. Whereas *E. coli* was detected in all the sampling zones, *Salmonella* was not detected in

the food kiosks (Table 1). The food kiosks also had lower levels of *Salmonella*, indicating that coupled with hygiene, food safety can be maintained if food could be sold in kiosks compared to open places.

4.3. Fruit Salads

As for fruit salads, 5 samples of fruits such as pineapple, mango, watermelon, orange, apple, and banana were collected from the specific sites.

4.3.1. Escherichia coli

Table 3
Results for *E. coli* in fruit salads.

	Positive samples	Samples outside the Norm	Average CFU/g or ml	Range
Chepnyogaa Market	4(20%)	4 (100%)	3.5	< 3 – 23
Kabianga Market	2(28.5%)	2 (100%)	2.5	< 3 - 24
University Gate	2(15.3%)	2 (100%)	4.6	< 3 - 25

Chart 2

A pie- chart representing the data in percentages of the positive samples per sampling zone and the total negative samples

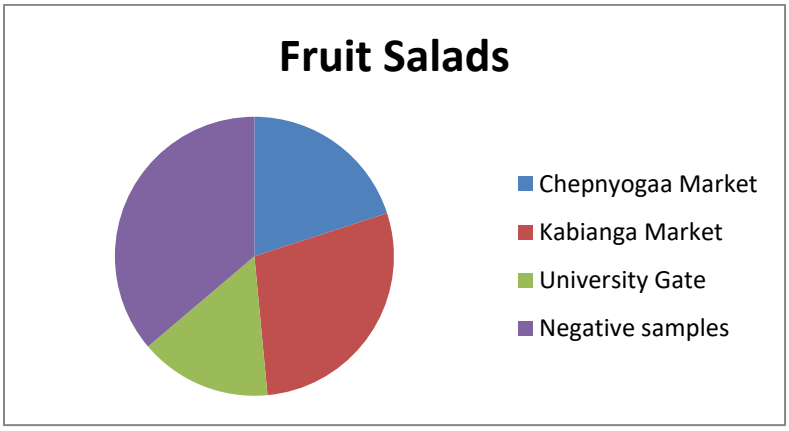
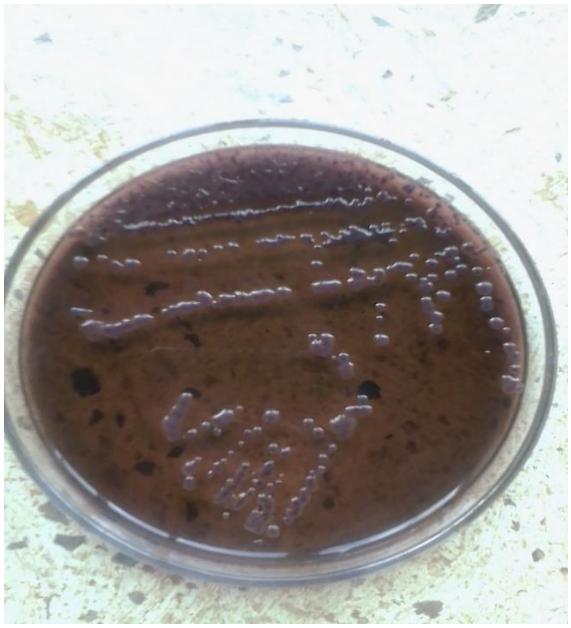


Diagram 1



(a) *E. coli* on Nutrient agar

(b) *E. coli* on MacConkey agar

Table 3 shows the general data about *Escherichia coli* isolation. Among the total samples, 35.2% were found positive for bacterial contamination. All positive samples were out of the official KEBS regulations, which states that there must be no fecal contamination in these foods. Fruit

salad from Chepnyogaa market had the largest number of contaminated samples, with an 87.5% (*n* = 4/5) and a contamination average of 640 MPN/ml; however, Salad from university gate showed the highest average of *E. coli* contamination with 654 MPN/ml, while Kabianga market showed the lowest average with 5 MPN/ml. Fruit salads showed less contamination, with only 20% (*n* = 1/5) of the samples showing *E. coli* contamination; again, any positive sample was considered as out of standard. The counts of these organisms were of 9 MPN/g – 23 MPN/g.

4.3.2. Detection of Staphylococcus aureus

Table 4
Results for *Staphylococcus aureus* of fruit salads

	Positive samples	Average CFU/g or ml	Range
Chepnyogaa Market	4 (30%)	560	100 - 10 000
Kabianga Market	3 (42.8%)	69.2	100 - 400
University Gate	3 (23%)	1471	100 - 10 000

Chart 3

A pie- chart representing the data in percentages of the positive samples per sampling zone and the total negative samples

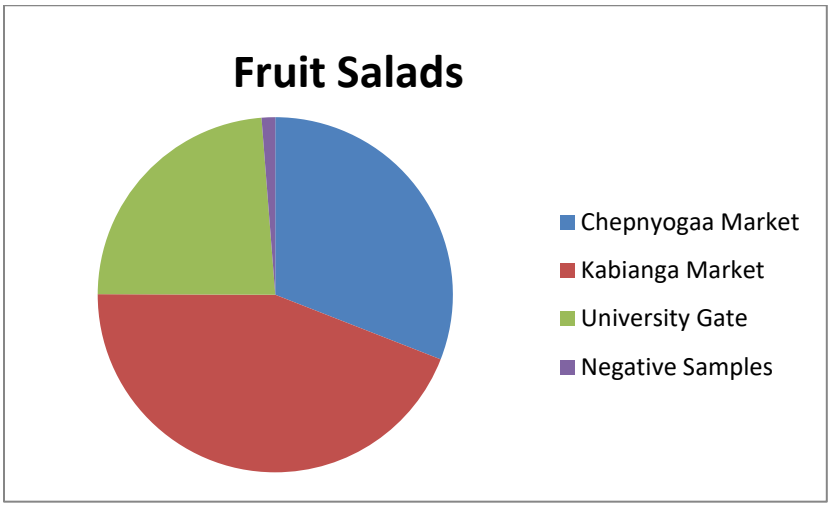


Diagram 2. *S. aureus* on Staph 110 agar

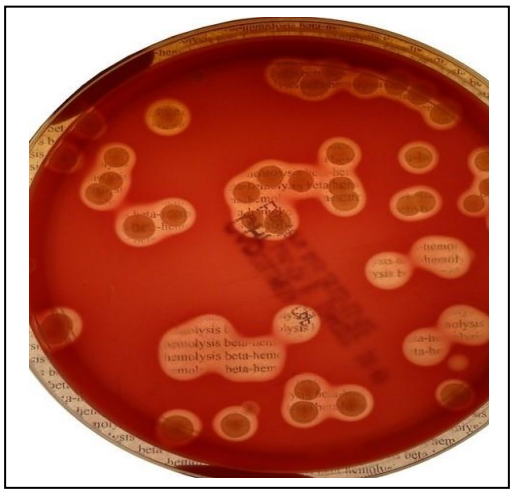


Table 4 shows the overall results for *S. aureus*; 35.2% of the samples showed contamination by this microorganism. 37.5% of the Chepnyogaa market samples showed contamination, with counts of 100 CFU/ml – 200 000 CFU/ml. University gate showed higher contamination than the rest of the samples, with 62.5%. Kabianga Market showed the lowest contamination level, with

1375 CFU/ml. Fruit salads showed less contamination by this microorganism, with 30% (n = 6/20) of positive samples and a contamination range of 100 CFU/g to 10 000 CFU/g.

4.3.3. Detection of Salmonella spp.

Table 5
Results for *Salmonella* spp. and *Shigella* spp. of fruit salad

	Salmonella spp. Positive samples	*Shigella spp.* Positive samples
Chepnyogaa Market	3 (15%)	0
Kabianga Market	2 (28.6%)	0
University Gate	1 (7.7%)	0

Chart 4

A pie- chart representing the data in percentages of the positive samples per sampling zone and the total negative samples

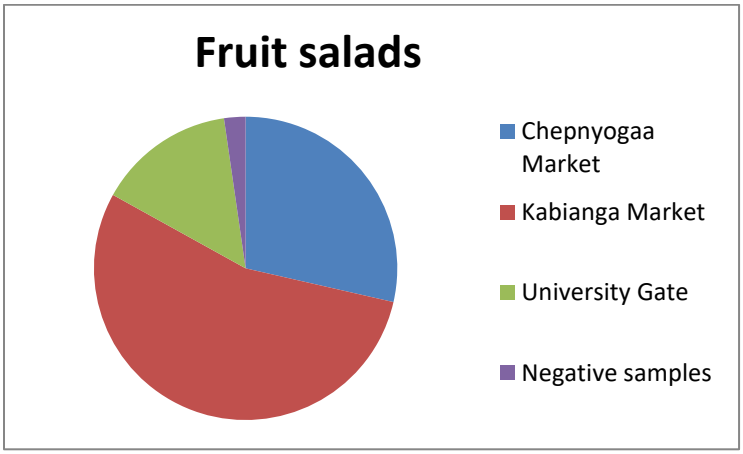


Diagram 3. *Salmonella* spp on *Salmonella- Shigella* agar

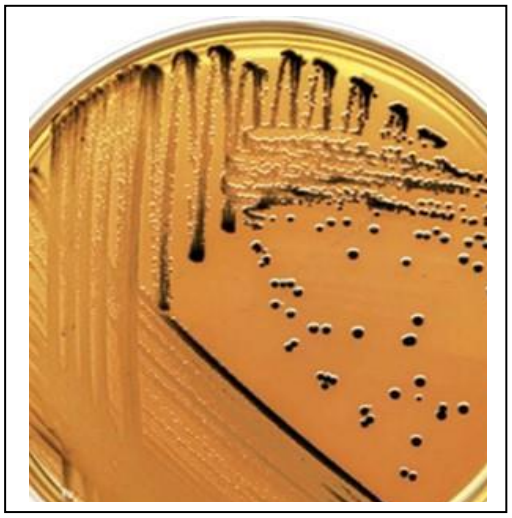


Table 5 shows the overall results. The presence of *Salmonella* spp. was detected in 16.2% of all samples analyzed of the University Gate. Among Chepnyogaa market samples, 16.6% were positive for contamination with this microorganism. In the case of Kabianga Market, this microorganism was present in 15% of all samples; the group of fruit salads with orange juice was the most contaminated with 28.6% of them infected. In the case of *Shigella* spp., there was no positive sample for *Shigella spp.*

CHAPTER 5: DISCUSSION

5.1 *Kachumbari* [vegetable salad]

The present study aimed at assessing the prevalence of *Salmonella* spp., *E. coli, Shigella* and *S. aureus* in the most consumed salad (*kachumbari*) around University of Kabianga, Kenya. The result showed that in the 30 samples examined; *Salmonella* spp. was present in 15 samples while *E. coli* was present in 25 samples. This result showed that *E. coli* was more predominant than *Salmonella* spp. The presence of these pathogens in the salads could be a direct reflection of sanitary quality of the cultivation water, harvesting, transportation, storage, and processing of the salad (*Beuchat1996*). *Salmonella* spp. and *Shigella* spp. are non-lactose fermenters usually associated with water contamination. Contamination with these organisms could arise from washing vegetables with contaminated water or handling of the vegetables by infected workers (*Rane, 2011*). According to a studies done by *Amponsah- Doku et al, 2017*, on the bacterial contamination of dhania (ingredient in the salad) and at production sites, markets and street food restaurants in the city of Kumasi, and Ghana in general, the levels of thermotolerant coliforms on dhania was increased by 18.0%, while *Enterococci* numbers reduced by 64.0% from the farms to the street foods. This indicates that contamination of *kachumbari* could have occurred during transporting, washing, and processing of the vegetables before consumption.

Vegetables are commonly associated with food poisoning, and they harbor disease-causing organisms. Processing of raw vegetables into salads for sale creates conducive environments and opportunities for the multiplication of pathogenic microorganisms on the salads (*Ameko et al,*

2012). This is because the salads still retain enough moisture to promote microbial growth, and also the natural protective covering on the leaves against the entry of microorganisms may have been lost during harvesting, storage, transport, and processing .The *kachumbari* may also have undergone some fermentation during sale and the increased acidity could promote the growth of certain microbes such as *Salmonella* spp. which grow well in optimal pH of 4.2-8.2 (*Ameko et al, 2012*)

Vegetables can be contaminated with pathogens from animal and human reservoirs and the environment as a result of production practices. A major source of contamination is organic fertilizer (e.g. manure and municipal sludge) and fecal contaminated water (*Montville, 2001*). The need for microbial assessment of these vegetables for production of food salads and for other use cannot be over emphasized to reduce possible contamination (*Nma, Oruese, 2013*). *Kachumbari* handled in buildings (kiosks) where they are not exposed to sunlight, and dust particles had less contamination, indicating the need to handle food in kiosks or in buildings.

5.2. Fruit salads

Food security has been defined as the ability of a society to address the food needs of its people (Barcelo, 1989).However; this definition should not be limited only to the field of food availability, because even if it is enough food available, the biological utility of food can be affected if its safety is not taken into account (*Daley et al, 1982*).

Today, it is well known that food-handling personnel play an important role in ensuring food safety, since mismanagement and the breach of hygiene regulations by those engaged in the selling of food can help pathogens get into contact with it, survive in it and multiply to a scale at which they are able to cause diseases in consumers. Thus, the results of this study reflect improper

practices of food preparation and the lack of knowledge among employees of food selling establishments about proper food handling, processing and hygiene, which causes food to suffer contamination by the microorganisms mentioned above.

This study showed that fruit salads are more contaminated, which is attributable to the fact that most of the fruit salad samples were collected in open-air exposed establishments; in addition, the preparation of fruit salad requires a lot of handling.There is a remarkable difference between these results and those reported by Félix, Campas & Meza (2005), who evaluated the presence of *E. coli, S. aureus* and *Salmonella* spp. They found a range of 200 – 450 000 E. *coli* in salads .On the other hand; *Salmonella* was present in only 3% of salads. This can be explained because in their study the fruit salads were collected from street establishments; consequently, fruit salads showed higher contamination by *E. coli, S. aureus* and *Salmonella* spp., the opposite of what was found hereby.

In the present research work, *S. aureus* was isolated in 37.5% of Fruit salad samples, largely above the percentage reported by Tambekar, Jaiswal, Dhanorkar, Gulhane & Dudhane (2009), who isolated this microorganism in only 6% of the fruit juice samples. In this study, the presence of these bacteria was much higher in fruit salad samples, yet the amount of enterotoxigenic *S. aureus* was not enough to be toxic. The reason for the low counts of *S. aureus* is that this microorganism is not competitive, and in most cases, it was isolated together with other bacteria. The presence of these bacteria is attributable to the fact that it is part of the normal flora of the human body, where it is found in the nasopharyngeal tract and on the skin. When collecting the samples, it was observed that, during the preparation of fruit salads, the vendors tend to use their bare hands when picking the peeled fruits, and they also speak during the preparation; it was also realized that, when serving salads, it makes contact with their skin, and droplets of it fall into the main container of fruit salad.

E. coli was isolated in this study, being considered the most important fecal microorganism.

Salmonella spp. was isolated in 16.6% of the total samples, a very similar result to that reported by Tambekar *et al.* (2009) and Ukwo, Ndaeyo & Udoh (2011), both of whom reported the presence of this microorganism in 17% of the juice samples analyzed. However, only 15% of fruit salad samples showed contamination by this microorganism, a low percentage compared with those reported by Bayona (2009), who presented that 25% of the fruit samples were contaminated by this organism.

In this study, no *Shigella* spp. was isolated from the fruit salad samples, unlike the study by Lewis, Thompson, Rao, Kalavati & Rajanna (2006), which reported contamination by these bacteria in 16.6% of his fruit salad samples. Regarding the absence of this microorganism in fruit salads, this coincides with the studies made by Utzinger, Arias, Monge & Antillón (1992).

5.3 CONCLUSION AND RECOMMEMDATION

5.3.1. Conclusion

In conclusion, street-vended foods have clearly a higher degree of contamination than those sold in closed establishments. *E. coli* were detected in 82.3% of all samples, while contamination by *Staphylococcus aureus* was detected in 35.2% of them, *Salmonella* spp. was present in 16.1% of them, *and no Shigella* spp. Was present in any of them.

In addition to the excessive handling and the lack of water for washing, the environmental pollution also contributes to contaminate vegetable and fruit salads. For all these reasons, it is necessary to establish preventive measures, such as the training of the sales personnel, focusing on hygiene practices in handling and processing of these fast selling ready to eat foods. These could prevent

many food borne diseases, since access to good quality food is a basic requirement for the preservation of human health.

5.3.2. Recommendations

The ministry of public health or relevant government bodies should educate *kachumbari* and fruit salad vendors about quality and hygienic vending of fruits**.**

In-person contact of the salads during preparation and storage should be avoided as this creates ports of entry for the pathogens**.**

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APPENDICES