MICROBIAL QUALITY AND SAFETY OF COOKED FOOD SOLD IN SELECTED SCHOOL CANTEENS IN THE AKUAPEM NORTH MUNICIPALITY

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY, ENVIRONMENTAL SCIENCE

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DECLARATION

I, EMMANUEL OWUSU do hereby declare that except for the references cited, which have been duly acknowledged, this thesis titled “THE MICROBIOLOGICAL QUALITY AND SAFETY OF COOKED FOODS SOLD IN SELECTED SCHOOLS CANTEENS IN THE AKUAPEM NORTH MUNICIPALITY” is the product of my own research in the Institute of Environmental and Sanitation Studies, University of Ghana Legon, from August 2012 to June 2013. This thesis has not been published or submitted either in part or in whole anywhere for the award of a degree in any other University.

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DEDICATION

This work is dedicated first and foremost to the almighty God for his boundless mercies and protection throughout the hard moments encountered in the completion of this work. The work is also dedicated to all the saints in the Lord’s vineyard.
ACKNOWLEDGMENT

I am very grateful to my hardworking supervisors, Dr. R. Esena of School of Public Health and Dr. T. Y. Annang of the Institute of Environmental and Sanitation Studies for their guidance, useful suggestions and constructive criticisms that helped in no small measure in the completion of this research work. Your guidance, pieces of advice, encouragement and moral support throughout the study have been invaluable and memorable.

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ABSTRACT

Improving the microbial quality and safety of cooked food in the school canteen is an effective means of reducing the burden of diarrhoeal diseases among school children. Studies across Africa have highlighted that foods sold on streets pose a great health hazard and contribute significantly to morbidity and even mortality among children. The main objective of this study was to determine the microbiological quality and safety of cooked food sold in canteens in some selected schools to ascertain the safety of such foods. The study also aimed at assessing the level of knowledge of food vendors and students on foodborne diseases and food hygiene in the Akuapem North Municipality. The design of the research was cross-sectional descriptive study which involved field survey and laboratory analysis. Simple random and purposive sampling methods were used to select 300 students and 128 food vendors respectively from the 16 schools to answer the questionnaire. Structured questionnaire was used to collect data from 428 respondents (300 students and 128 food vendors) on their demographic characteristics, knowledge on food hygiene and foodborne diseases. The Codex Alimentarius Commission standard methods for analyzing food samples were used for testing and enumeration of microbes in 288 food samples. Data were analysed using the SPSS (version 16.0) and Microsoft Excel software. The chi squared test was used to determine the relationship between demographic characteristics of food vendors and their knowledge on certain aspects of foodborne diseases. Analysis of Variance (ANOVA) was used to test the relationships among food samples from four school circuits on their mean total microbial contamination. The laboratory analysis confirmed the presence of yeast and moulds, Staphylococcus aureus, Bacillus cereus, Escherichia coli and other coliform in most of the foods sampled. Salmonella spp. was only present in fufu, red pepper sauce and vegetable salad. Samples of fufu, vegetable salad macaroni and red pepper
recorded mean microbial contamination of 6.4 ± 0.40 log_{10} cfu/g, 6.5 ± 0.49 log_{10} cfu/g, 6.3±0.48 log_{10} cfu/g and 6.5; ± 0.53 log_{10} cfu/g respectively in the afternoon. Sausage and fried fish also had mean microbial load of 5.6 ± 0.77 log_{10} cfu/g and 5.5 ± 0.39 log_{10} cfu/g respectively. Waakye, iced kenkey, banku and kenkey however recorded relatively acceptable level of microbial presence both in the morning and afternoon in the study area. The results further showed that there were no significant differences (p>0.05) in the total microbial load in the foods sampled in the morning among the four circuits. There were however significant differences (p < 0.05) in the total microbial load in the foods sampled in the afternoon among the circuits. The microbial contaminations among most of the food samples were quite higher in comparison with the acceptable values of Ghana Standard Authority in the afternoon. The study further showed that almost all the food vendors were females with quite high illiteracy rate. Also, majority of the food vendors exhibited little knowledge on food hygiene and foodborne diseases. On the contrary, students exhibited good knowledge on foodborne diseases. It is concluded that food vendors lack adequate knowledge on food hygiene and foodborne disease and hence foods sold in the canteens are predisposed to microbial contamination. Also since students had adequate knowledge on foodborne diseases and food hygiene, they are bound to abstain from practices that could predispose them to foodborne diseases. In addition, the high microbial load found in most of the food implies that cooked food in the school canteens are of low microbial quality especially in the afternoons. It is recommended among others that regular quality checks are conducted by the regulatory authorities to ensure food safety in the school canteens and that School Health Education Programme (SHEP) coordinators be empowered through capacity building to monitor and supervise the activities of the food vendors.
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CHAPTER ONE

INTRODUCTION

1.0 Background to the study

Foodborne diseases have become a global public health concern in recent years. It has also become the most widespread health problem in the contemporary world and an important cause of reduced economic productivity (Adams and Moss, 1995). Food borne diseases are the major focus of public health policy worldwide to the extent that its prevention is a requirement for improving global living standards (Barrett et al., 1999). The most common food-related illnesses result from bacterial food infections and intoxications.

The increasing rate of urbanization in Ghana has caused most people including school children to depend on vended foods for their nutritional needs. Although foods in schools help to sustain the energy needed for academic work, many students are unaware of the imminent health implications in the consumption of contaminated vended foods and the role they themselves have to play in the prevention and control of foodborne illness. It is thus important that students are made aware of the inherent dangers in the consumption of vended foods in the school and measures that can be put in place to reduce to the barest minimum the incidence of food borne diseases in school canteens.

1.1 Statement of the problem

Food safety is a growing public health concern globally especially the foods served to students and pupils at schools by vendors. Children in the African region usually experience five episodes of diarrhea per year and it is estimated that about 800,000 children die each year from diarrhea
and dehydration (Mead et al., 1999). Saba and Gonzalez-Zorn (1999) identified that the microbiological food contamination in Ghana is alarming. In support of this notion, Mensah et al., (2002) indicated that there have been higher levels of contamination in vended food given to children than in food cooked at home in Ghana. The estimated number of foodborne diseases reported in Ghanaian hospitals is about 420,000 per year, with an annual death rate estimated at 65,000 and a total costs to the Ghanaian economy at US $ 69 million (WHO, 2006). These revelations call for concerted effort to ensure that the incidences of foodborne diseases are reduced to the barest minimum.

The burden of foodborne diseases due to unhygienic food preparation in Ghana is quite alarming. For instance, statistics from the Ministry of Health indicate that diarrhoea accounts for 84,000 deaths annually with 25 percent being children under five years (Ghana News Agency, 2003). Besides, Boadi and Kuitunen (2005) reported in a study in the Accra Metropolitan area that the burden of diarrhoea was found to be high among children who regularly eat street food but reduces with non-regular consumption of street food. Also Der et al. (2013) reported in a study in the Eastern Region that there is the proliferation of food joints with their attendant health problems in Ghana. Further, the burden of foodborne diseases due to unhygienic food preparation and handling in Ghana include the death of four persons in Sheho (Upper East Region of Ghana) after the consumption of contaminated meat (Ghana News Agency, 2013) and the death of nine people from cholera outbreak at Atebubu in Brong Ahafo Region (GhanaWeb, 2013). Besides another foodborne disease outbreak claimed one live and about 50 people hospitalized in Obuasi in the Ashanti Region. (Joy News, 2013)
The Akuapem North Municipal School Health Education Programme Coordinator (SHEP) revealed to the researcher in a personal communication that in some of the schools canteens in the municipality, there is no proper hand washing facilities. He intimated that hand washing by students and the washing of utensils are often done in a common bowl. The Municipal School Health Education Programme Coordinator further bemoaned that some school canteens are located close to dumping sites while some food vendors handled both money and food with their bare hands. It is therefore not surprising that several authors have identified inadequate personal hygiene among food handlers as one of the common practices that contribute to foodborne illness (Cogan et al., 2002). It is also on record that diarrhoea ranks third among the top ten admission cases in the hospitals in the Municipality (Akuapem North Municipal Assembly, Composite Budget, 2012). It is against this background that this research is conducted to investigate the sanitation issues and the microbial safety of vended foods in the canteens in the schools within the Municipal Assembly.

1.2 Justification of the study

Ready-to-eat foods (cooked foods) if not handled hygienically may pose a lot of health hazards. There is evidence that diarrhoea ranks fourth among the top ten out-patient cases in health facilities in the municipality (Akuapem North Municipal Assembly Composite Budget, 2012). Improving the microbiological quality and safety of cooked food in the school canteen is therefore one of the most effective means of reducing the burden of diarrhoeal diseases among school children.
This study ascertains the microbiological quality and safety of foods served in the school canteens so that the appropriate measures can be put in place where necessary. The findings from the study will create health awareness, especially on foodborne disease among the food vendors in particular and the community in general. The findings from the study will also educate students on some basic concepts on foodborne diseases and measures to avoid them. Furthermore, the recommendations will inform policy on the appropriate hygienic practices that could be adopted by food vendors in the preparation and handling of ready-to-eat foods.

1.3 General objectives

The general objective of this study is to determine the microbial quality of vended foods in school canteens in Akropong North Municipality

1.3.1 Specific objectives:

The specific objectives of the study are to:

1. determine the microbial levels of vended foods sold in schools in the Municipality,
2. assess the level of knowledge of food vendors on foodborne diseases
3. assess the knowledge of food vendors on hygienic practices of handling ready-to-eat foods and
4. assess the knowledge of students on foodborne diseases and food hygiene

1.4 Research questions

1. What is the microbial status of street vended foods sold to students in schools at Akuapem North Municipality?
2. What is the level of knowledge of food vendors on foodborne diseases?

3. What is the level of knowledge of food vendors on food safety and hygienic practices of handling food?

4. What is the level of knowledge of students on foodborne diseases and food hygiene?
CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The basic human requirement for the consumption of food places every human being at risk of contracting infection through foodborne pathogens. Ready-to-eat food refers to foods and beverages prepared and/or sold by vendors in streets and other public places for immediate consumption or consumption at a later time without further processing or preparation. The WHO (2006) identified that sale and consumption of ready-to-eat food are on the ascendancy within the West African Region and will continue to grow.

In recent times, due to the socio-economic changes emanating from massive urbanization, ready-to-eat foods is seen to have assumed a very important stage in the informal sector of most developing countries. WHO (2006) asserted that ready-to-eat food has numerous benefits. Notable amongst them include the fact that it serves as a source of inexpensive, convenient and often nutritious food for urban and rural poor. Further, ready-to-eat foods provide income for a vast number of persons, particularly women and offer a chance for self-employment and the opportunity to develop business skills with low capital investment. It is also common place knowledge in Ghana that ready-to-eat food provides fairly inexpensive priced snacks and meals for a wide variety of people.

In contrast to these benefits ready-to-eat foods provide, they are also potential sources, causes and carrier of diseases. The risk of vended food is dependent mainly on the type of food, the
method of preparation and the manner in which it is held before consumption. Among the frequent problems in the sale of vended foods is their actual and potential hazard caused by microbial contamination (Muñoz de Chávez et al., 2000). Some bacteria implicated in contamination of vended foods produce toxins called endotoxin while others produce exotoxins depending on the mode of production. The main pathogenic bacteria associated with foodborne diseases include Salmonella sp., Clostridium perfringens, Staphylococcus aureus, Listeria monocytogenes, Campylobacter jejuni, Clostridium botulinum, Bacillus cereus, and Escherichia coli (Okolie et al., 2012).

2.1 Food safety

Food safety has been defined as the conditions and measures that are necessary during the production, processing, storage, distribution and preparation of food to ensure that it is safe, sound, wholesome and fit for human consumption (WHO, 2006). Food safety is thus the condition which ensures that food will not cause harm to the consumer when prepared and/or eaten according to their intended use. In addition, food safety is a scientific discipline that describes handling, preparation and storage of food in ways that prevent foodborne diseases. Food safety, especially when relating to ready-to-eat foods is a critical issue because of the unhygienic conditions, under which some are prepared and sold (Rheinländer et al., 2008).

Food safety is an essential public health issue for all countries because contamination from microbiological and chemical sources in food is a major cause of illnesses. Foodborne diseases thus remain real and formidable problem in both developed and developing countries, causing great human suffering and significant economic losses.
The Ghanaian community has experienced an upsurge in the operation of fast foods joints with an estimated 60,000 food vendors in the capital, Accra alone (Ayeh-Kumi et al., 2009, Afele, 2006). It is imperative therefore to ensure food safety at all times in these ready-to-eat food establishments. In this regard, Abdussalam and Kaferstein (1993) supported the view that ready-to-eat foods can pose significant public health problems because most food handlers lack basic knowledge on safe food handling procedures. Abdussalam and Kaferstein further observed that controlling and supervision become difficult especially when large numbers of people are to be served with relatively inadequate resources.

It is essential that food handlers observe good personal hygiene since they can easily contaminate or transmit foodborne pathogens to consumers who patronize their food. In this regard, a study by Pether and Gilbert, (1971) confirmed that bacteria such as Salmonella typhi and Escherichia coli can survive for varying periods on the fingers and other parts of the body. The basic practice of hand-washing can therefore be very helpful in prevention of food-borne illnesses since the hand is a crucial vehicle for transferring micro-organisms from various sources; faeces, nose, skin and other parts of the body into food. Food handlers must therefore be screened by the appropriate regulatory bodies to ensure that they are always in good health before they sell to the public. In Ghana, one way to ensure food safety of ready-to-eat food is by screening (subjecting blood sample of vendors to laboratory analysis) before issuing health certificate periodically to food vendors. This is confirmed by a study by Musa and Akande (2002) which noted that in developing countries the common means of regulating vended food is through medical examination of food vendors.
According to Ackah et al. (2011), the public health requirements in Ghana enjoin food handlers to go through medical screening for infectious or contagious diseases such as typhoid fever, tuberculosis, cholera, dysentery and other communicable and air-borne diseases. They further intimated that Metropolitan, Municipal and District Environmental Health Officers should periodically conduct screening exercises during which the vendors are expected to go through complete physical and medical examination and obtain health certificates issued by the authorized health centers. This practice is consistent with what prevails in other developing countries. WHO (1980) also identified that in some developing countries, public health code expects food handlers to undergo some form of medical examination or screening before they can be employed in food establishments or as vendors.

The World Health Organization (WHO) and the Food and Agricultural Organization (FAO) however see these regulatory measures as ineffective since it is an expensive exercise for the impoverished food handlers and do not prevent infection after the examination (WHO, 2006). Notwithstanding the view of FAO and WHO, Onyemelukwe and Ibe (1993) asserted that many developing nations continue to place premium on food handlers undergoing medical examination since it ensures detection, treatment and subsequent reduction in transmission of foodborne pathogens.

The WHO enumerates five principles of food hygiene that can be implemented to ensure food safety. These include the prevention of contaminated food from spreading, separation of raw and cooked food to avoid cross-contamination, cooking food thoroughly at the right temperature, storage of food at the proper temperature and the usage of safe water and raw material for food
preparation (WHO, 2006). Failure to observe these principles in food preparation exposes consumers to pathogens and toxins that cause foodborne illnesses. One of the best ways to ensure that ready-to-eat food are devoid of pathogens and chemicals capable of causing foodborne diseases is the application of the principles in Hazard Analysis at Critical Control Points (HACCP). According to Bryan (1990), the HACCP system is a very essential approach to the prevention and controlling of foodborne illnesses that identifies the hazards associated with any stage of food production, processing, or preparation, assess the related risk and determine the operations where control procedures will be effective. Control procedures are thus targeted at specific operations that are crucial to guarantee food safety.

According to Bryan (1990), the steps involved in HACCP include identification of hazards and assessment of the severity of these hazards and their risks, determination of critical control points (CCPs) at which the identified hazards can be controlled and the specifications of criteria that indicate whether an operation is under control at a particular critical control point, establishment and implementation of procedures to monitor each critical control point to check that it is under control. Bryan (1990) further argued that in the food service operations the risks in food safety range from the food source, the methods used to freshen, preserve, process and prepare the foods; the duration and conditions of holding and display, and the interval between heating and consumption. The HACCP system among others offers a rational approach to the control of microbiological hazards in foods and avoids the many weaknesses inherent in the inspectional approach while circumventing the shortcomings of reliance on microbiological. In this connection, it could be safely concluded that the HACCP approach is useful in the identification
of hazards and evaluation of risks associated with the preparation and holding of foods sold to the public.

Bryan (1990) further indicated that four factors should be taken into account when conducting HACCP operation. These include the food property, food operation, volume of food prepared and susceptibility of consumer. The concept of food property relates to the epidemiological history of foods prepared and served in an establishment, and it takes into account the characteristics of the food such as pH, water activity, and determines its ability to support rapid growth of pathogenic and infectious microorganisms. The food operations factor determines the procedures that the foods usually undergo that expose them to contamination, that might fail to destroy contaminants, or during which the contamination increases. The volume of food prepared risk factor assesses the tendency of large volumes of the same food prepared for people in advance creates hazards when not stored in conditions that prevents bacteria growth. In that, the risks increase with the time of storage. The susceptibility of the consumer risk factor assesses those people more prone to disease than the general population such as the hospital patients, infants or the elderly Bryan (1990).

HACCP as a measure of ensuring food safety has many merits compared to the other traditional way of ensuring food safety. HACCP is a proactive approach that anticipates problems before they occur, provides control mechanisms, is rapid and easy to monitor and can be used to predict potential hazards. HACCP studies also identify critical food safety risk factors that can serve as basis for training and education of street food vendors as well as consumers. It places emphasis on monitoring of critical control points by persons directly involved in the food operation and
serve as inexpensive food safety assurance compared to chemical and microbiological methods of analysis.

2.2 Raw materials

To ensure food safety, raw materials should be bought from accredited and reliable sources and not from clandestine dealers (such as illegal slaughters). Raw materials are very relevant to the safety of street-vended food since they can be source of biological, chemical and physical hazards that may persist through preparation and processing of ready-to-eat foods. To ensure protection against food hazards, materials to be consumed in their raw state, should be transported and stored separately from other raw materials and non-food items. Also food materials should be transported in a manner that limit pathogen growth or toxin formation by effectively controlling time of transportation and the temperature and water activity of such raw materials (WHO, 2006). Raw foods such as raw meat and poultry are often contaminated at source with salmonellae, Campylobacter jejuni, Clostridium perfringens, Yesinia enterocolitica, Listeria monocytogenes and Staphylococcus aureus (Bryan, 1990).

Water is also a critical raw material in ready-to-eat food preparation processes. Contaminated water can transmit foodborne illnesses when used for washing of foods, incorporated in the food as an ingredient and used in the processing of food or used for washing equipment, utensils and hands. Angulo et al. (1997) intimated that water is a well known vehicle for enteropathogens such as E. coli, Salmonella sp. and Campylobacter sp. amongst others. In this connection, a study to determine the bacteriological quality of the water used by some food vendors in schools have revealed frequent contamination with total coliform and feacal coliform
(Chakravarty and Canet, 1996). Dawson and Canet (1991) observed that acute shortage of clean potable water compels many vendors to re-use the water, especially for cleaning utensils and used dishes.

It is important therefore that production and sales units secure their own supplies of potable water whether it is from a central system or an individual source such as a hand pump or a suitable source of safe water. They further advised that water meant for washing utensils; food and hands should be safe and should not be re-used. Running water, preferably hot water should be used for these purposes and where not available, a container can be used for washing, but it should be emptied and cleaned after each washing.

### 2.2.1 Preparing and processing of ready-to-eat food

Preparation and processing are very critical among the steps to which foods are subjected prior to their sale and consumption and are important in determining the safety of food. According to Bryan (1990), one cardinal principle in preparing and processing food is to avoid direct and indirect contact between raw and cooked or prepared foods which will be consumed without further heating. Foods to be eaten raw such as salads and peeled or cut fruit should be prepared with special attention to cleanliness. Grains such as rice, pulses, beans, vegetables and some fruits, especially if they are to be consumed raw, should be washed sufficiently with safe water in an effort to reduce contamination on their surfaces to an acceptable level (Bryan, 1990). The preparation of food long before its consumption, storage at ambient temperature, inadequate cooling and reheating, contaminated processed food, and undercooking are some of the key factors that contribute to food poisoning outbreaks.
2.2.2 Food storage

Proper handling, cooking, and storage practices in food service operations and in the home can prevent the majority of foodborne illnesses. Most foodborne diseases cases are caused by inappropriate handling in kitchens and restaurants of contaminated food including improper storage, undercooking, or cross contamination (Blaser, 2004). When the temperature of stored cooked food falls within the ambient temperature, a condition within which microorganisms thrive and multiply, there is bound to be high levels of microbial contamination in the food. Fewtrell et al. (2005) further concluded that diarrhoeal cases can be reduced by 39 % through improved household water treatment and safe storage. Similarly, Mitakakis et al. (2004) in a study identified food handling and storage practices in the home as major risk factors for gastroenteritis. Longer holding time of certain high risk foods create favourable conditions for the growth of foodborne pathogens that causes foodborne diseases. Foods vendors most often prepare ready-to-eat food in bulk, store them for several hours after cooking including overnight holding at ambient temperatures until sold. This practice can cause such foods to harbour high microbial populations (El-Sherbeeny et al., 1985; Bryan et al., 1992 and Lianghui et al., 1993). Bryan (1995) further observed that in such foods, the counts of pathogens including, Escherichia coli, Staphylococcus aureus, Bacillus cereus and Clostridium perfringens are bound to be unacceptably high.

2.2.3 Reheating

Reheating is a means of subjecting stored cooked food materials to temperatures high enough to destroy pathogenic microbes so as to make the food fit for consumption. During reheating the time-temperature exposure should be able to inactivate microorganisms and toxins of concern.
Omemu and Aderoju (2007) indicated in a study that some food vendors often partially or fully cook some products ahead of time, store them and then reheat them when requested by customers. If knowledge of food hygiene is low, the reasons for reheating food may simply be to make it warm and improve palatability, rather than to destroy pathogens. Bryan (1990) recommends that during reheating, the highest temperature attained at the geometric centre of foods or the time-temperature exposure of foods should be measured and recorded to determine whether pathogens could survive. Reheating should therefore be done thoroughly to ensure that stored cooked foods are microbiologically safe for consumption.

2.3 Public perception of foodborne diseases

The food choice of the average consumer is often influenced more by psychological interpretation of product properties rather than the physical properties of products themselves (Rozin et al., 1999) and food quality has been an important factor (Lewis, 1981). Consumers may use their senses in their descriptions of safe food, and feel that food that looks or smells bad should not be eaten. They cannot tell the risk of incurring a foodborne illness at the time of purchase or consumption of a food item, because the extent of microbial contamination or the level of chemical residues cannot be observed (Roberts et al., 2003). Fearing foodborne illness, some consumers may cut purchases of certain food items or avoid consuming them altogether (Roberts et al., 2003). Consumers need to make informed choices about their food and how it is handled and prepared. Tomlins et al. (2002) reported in a survey conducted in Accra Ghana that most consumers did not know association between poor hygiene and illness. This shows the rather low level of awareness among consumers on possible diseases that one could get when good hygienic practices are not observed in food handling.
Closely tied to the consumers’ perception of foodborne diseases is also their awareness of practices that predisposes them to foodborne illness. In Ghana, many measures have been put in place to instill in the citizenry the culture of hand washing with soap. For instance the National Community Water and Sanitation Programme among its mandate ensure that the public including school children are educated on the need to wash the hand with soap especially after using the toilet (GPPPHW Ghana, 2009). These measures being put in place are yielding positive dividends as Steiner-Asiedu et al. (2011) reported in a study that school children had very good knowledge on hand washing practices.

2.4 Knowledge of food handlers on food safety and personal hygiene

The term food handler applies to persons who prepare food and those who sell it, if they are different persons. Rheinländer et al. (2008) indicated that the safety of ready-to-eat foods is a major concern as these foods are generally prepared and sold under unhygienic conditions, with limited access to safe water, sanitary services, or garbage disposal facilities.

The importance of the food handler in the vending of ready-to-eat foods cannot be overemphasized as they have a prime role to play in food businesses, and must guarantee that meals served to their customers are hygienic for consumption. Amponsah and Anamoaba (2010) asserted that the examination of knowledge on food handling and health problems of some food handlers proved that, they did not fully understand hazards, their risks and methods of managing such hazards in the preparation and handling of food. In Ghana the food vending business is dominated by women and hence the success or failure of food control programmes depends
heavily on them (Mensah et. al. 1999). Despite major role played by women in the food vending business in Ghana, Mensah et. al (2002) in a study in Accra indicated that there is high illiteracy rate among the women working as food vendors.

Food handlers have important roles to ensure food safety throughout the chain of food production, processing, storage and preparation. Any disregard for safety including mishandling of food and abuse of hygienic measures on the part of the food vendors may cause unpleasant consequences. In Ghana, the use of a polythene bag to package ready-to-eat food by food vendors is a common phenomenon. In the course of packaging the food, food handlers blow air into the polythene bags to open them and in the process a number of pathogens can be passed on to the consumer. Mensah et al. (2002) are of the view that many food handlers introduce biological and physical hazards through cross-contamination and mishandling of food. The use of the bare hands to serve food increases the level of contamination as entero-pathogens survive on the hands for three hours or longer.

Pathogens can be harboured and transmitted on to others by individuals who themselves are healthy. Such carriers may have recently suffered an attack of food poisoning and still be carriers of the organisms in their body. In some instances, carriers of food pathogens such as *Salmonella typhi* and *Bacillus cereus* act as host over a longer period of time as they acquire immunity to the organisms concerned. Such individuals might end up transmitting the organisms to other people through food without being aware of it. It is thus important that food handlers are educated on routes and means through which pathogens invade the food they prepare and sell to the public.
Addo et al. (2007) intimated that food vendors who sell ready-to-eat meals on the streets are important factors that contribute significantly to foodborne related diseases as they have very little or no educational background and hence have low understanding of food safety issues. Improper handling of cooked foods and sanitation practices may therefore lead to person-to-person, person-to-food and utensils-to-food cross-contamination resulting in outbreaks and infection from food borne pathogens. The transmission of enteric-related pathogenic microorganisms via the hands of food handlers thus continues to be a problem in the food industry (Barza, 2004). Hand-washing, a simple but very effective means to reduce cross-contamination is all too often forgotten by food handlers (Steiner-Asiedu, 2011).

2.5 Food Hygiene Awareness among food handlers

Food hygiene involves all conditions and measures necessary to ensure the safety and quality of food at all stages of the food chain. Walker et al. (2003) argued that food handlers usually cross-contaminate processed foodstuff and are likely to under-cook foods properly and improperly store food. Continuous training and education thus become very essential if food handlers are to handle food in a hygienic and safe manner with the best preventive measures being educating the food handler on good personal hygiene and food safety. Marth (1985) however observed that the food handlers are usually young, itinerant and inexperienced people who hardly stay on the job for a year and hence it becomes extremely difficult to find and educate them while actively working. In relation to this Walker et al. (2003) asserted that there is a high probability that the absence of continuous training and reinforcement is to be blamed for lack of food hygiene knowledge concerning a number of important aspects in safe food production. A lot of studies
have confirmed the rather low level of knowledge of food handlers on hygienic and microbial safety of ready-to-eat foods (Walker *et al.*, 2003; and Tebbutt, 1992).

Inadequate hygienic knowledge and lack of understanding of the basic principles of food hygiene coupled with no formal education (Addo *et al.*, 2007) is therefore a major bottleneck to the implementation of good hygienic practices in the handling of ready-to-eat foods in our schools and other public places. In this connection, Mensah *et al.*, (2002) reported in a study in Accra that food vendors were mainly women with quite high illiteracy rate. Ehiri and Morris, (1994) were of the view that there is the need to conscientiously prevail upon and motivate food handlers to put to practice their knowledge in food hygiene.

In contrast to the assertion made by Walker *et al.* (2003) it is a common place knowledge that ignorance coupled with reluctance by food handlers to apply the acquired knowledge also contributes in no small measure to food poisoning by food handlers (Bryan, 1990). Further, Angelillo *et al.* (2003) indicated in a study conducted in Italy that although food handlers had positive attitude towards food safety, it was not supporting their practices in food handling. There seem therefore to be no correlation between good knowledge in food handling and the actual practice in food processing among food handlers.

The hygienic aspects of food vending operations are also a major source of concern. For example, food stands (structures on which foods are displayed) are often crude structures, and running water may not be readily available in the canteen. Also toilets and washing facilities are rarely available. The washing of hands, utensils, and dishes is often done in buckets or bowls.
Disinfection is not usually carried out and insects and rodents may be attracted to sites where there is no organized sewage disposal (Mensah et al., 2002). Contrary to the observation made by Mensah et. al. (2002), Monney et. al. (2003) reported in a study at Konnongo (Ghana) that food vendors in educational institutions adhered to good hygienic practices so far as protection of cooked food from dust and flies, the use of apron, food serving and general food hygiene are concerned.

2.6 Microbial guidelines for ready-to-eat foods

Microbiological guidelines are criteria indicating the presence of microbes of the food concerned so as to reflect its safety and hygienic quality. The International Commission on Microbiological Specification for Food (ICMSF, 1996) guidelines on microbiological limit of pathogens in cooked foods is based on three components namely aerobic colony counts, indicator organism (only E. coli inclusive) and specific food poisoning pathogens. According to ICMSF (1996), the acceptable microbiological limit for ready-to-eat foods in colony forming unit per gram include; less than 10^2 cfu/g for E. coli, less than 10^3 cfu/g for coagulate positive S. aureus, Bacillus cereus, C. perfringens and enterobacteria. For Salmonellas sp. and C. jejuni, the ICMSF recommends zero cfu/g in a cooked food.

The International standards are not quite different from what pertains in Ghana. The Ghana Standard Authority (2003) specifies that the general microbiological limit for ready-to-eat foods should be less than 10^5 cfu/g. Others include less than 10^4 cfu/g for Aerobic Plate Count, less than 10^2 cfu/g for S. aureus, less than 3 cfu/g for faecal coliform and below 10 cfu for Yeast and Moulds. In meat sausages, staphylococci count is expected to be below 10^2 cfu/g. In soups and
gravy less than $10^4$ cfu/g is recommended for the food to be wholesome. Pre-cooked fish such as fried fish should have microbiological limit of 2 cfu/g for *S. aureus*, and zero cfu for *Salmonella sp*. In vegetable salad creams/mayonnaise, the Ghana Standard Authority recommends a microbiological limit of 10 cfu/g for *S. aureus* and zero cfu/g for *Salmonella sp*.

2.7 Foodborne diseases

A foodborne disease is referred to as any disease that results from the consumption of contaminated foods, pathogenic bacteria, viruses or parasites that contaminate food as well as chemical or natural toxins such as poisonous fungi. The victims of foodborne disease normally experience one or more symptoms such as nausea, vomiting, diarrhea, dehydration, abdominal pain, headache, and fever (FDA, 2012). Foodborne diseases are a serious health hazard and an important cause of morbidity and mortality in developing countries. It is an undisputable fact that most cases go unreported and scientific investigations are rarely conducted in most developing countries (Anuradha *et. al.*, 1999). The organisms causing foodborne diseases and poisoning are a result of unhygienic behaviour and inappropriate handling practices by humans. Foodborne illnesses are known to cost lives and money. Consequently, millions of people fall sick annually as thousands die after eating contaminated or mishandled foods.

2.8 Vulnerability to foodborne diseases

In developing countries, reduced immunity due to poor nutritional status render people particularly infants and children more susceptible to foodborne infections (WHO, 2002). Age is an important factor so far as vulnerability to foodborne diseases are concerned because those at the extremes of age have either not developed or have partially lost protection from immunity
(WHO, 2006). People with a weakened immune system also become infected with foodborne pathogens at lower doses which may not produce an adverse reaction in healthier persons. Seriously ill persons suffering for example, from cancer or AIDS, are more susceptible to infections with *Salmonella*, *Campylobacter*, *Listeria*, *Toxoplasma*, *Cryptosporidium* and other foodborne pathogens. Children, the elderly and people with weakened immune systems are therefore quite vulnerable to foodborne diseases. Host risk factors thus include age, immune status, underlying debilitating disease or stress factors, and the physiological state of the stomach and upper small intestine at the time of exposure to the agent. For these reasons a minimum infectious dose cannot be defined, although the risk of disease at low exposure for some agents is small (Health Protection Agency, 2009).

2.9 Epidemiology and transmission of foodborne diseases

Foodborne diseases can be transmitted through numerous means. As noted by Scott and Bloomfield (1990) gram-negative bacteria can survive on hands, dishes, washing-up sponges, and kitchen surfaces and be transmitted in sufficient numbers to foods. Some of general pathways of food contamination include unwashed dirty hands, contaminated water, food handlers, ingredients, during packaging and water. Cross-contamination may be caused by poor hygienic practices, contact with surfaces, soil and air, insufficient cooking and storage at ambient temperature. According to Hassan *et al.* (2004) and Andrade *et al.* (1998), foodborne pathogens can attach themselves to equipment surfaces used in the food preparation, form biofilms that could contaminate food and subsequently result in food spoilage and transmission of foodborne diseases. In this connection, Barza (2004) intimated that transmission of enteric-related
Pathogenic microorganisms through the hands of food handlers has been a major source of concern in the ready-to-eat food preparation.

Another mode of transmission of foodborne diseases usually implicated in the major outbreak of foodborne diseases is the faecal-oral route. Kung'u et al. (2002) are of the view that the etiological factors associated with diarrhoea in children include microbial agents which are usually transmitted through food and water contaminated with human faeces. According to Lucas and Gilles (2003), faecal-oral transmission occurs mostly through faecal contamination of food, water and the hands. In the pathway of faecal-oral transmission, food occupies a central and important position and can be contaminated directly by faeces, indirectly through dirty hands, polluted water, flies and contaminated soil Lucas and Gilles, (2003) further observed that a supposedly clean hands and food devoid of any odour or bad taste but contaminated may still carry and transmit diseases.

2.9.1 Causes of foodborne diseases and causal organisms

Dangerous microorganisms are widely found in soil, water, animal and people. According to Lucas and Gilles (2003) the main agents of foodborne and diarrhoeal diseases are enteroviruses, (e.g. rotavirus, Enterotoxigenic E. coli, Enteroinvasive E. coli, C. jejuni, Shigella, Vibrio cholera, Salmonella species, Entamoeba histolytica, Giardia lambia and Cryptosporidium parvum. These microorganisms may be carried on hands, wiping cloths, cooking ingredients, utensils and cutting boards. Cartwright (2003) identified that there is a wide spectrum of food and waterborne infections such as cholera, campylobacteriosis, cryptosporidiosis, E. coli
infections, salmonellosis, Shigellosis, enteric fevers, brucellosis, hepatitis, amoebiasis and trematode infections.

Most foodborne diseases are caused by microbial pathogens such as viruses, bacteria and parasites. Few of them might however be caused by physical and chemical contamination. The physical and chemical contaminants include human hair, soil particles, pesticide residue and contaminated food additive (Arambulo et. al., 1994). Most foodborne pathogens or chemicals enter the body through the stomach and intestines hence nausea, vomiting, diarrhoea and abdominal discomfort remains the commonest symptoms of foodborne illnesses. Pathogenic microorganisms contaminate food via food prepared by an infected person, the air particles and the activities of insects, pests, rodent and pets. However cross-contamination by a healthy infected person (carrier) remains one of the cardinal factors in the transmission of foodborne diseases. One of the historic incidence of transmission of foodborne pathogens occurred in the twentieth century when Mary Mallon (Typhoid Mary) infected about 51 people with Salmonella typhi. Mary Mallon who was later identified as an asymptomatic carrier of typhoid bacteria transmitted typhoid fever to people through poor personal unhygienic and insanitary habits (Lee and Hoffman, 2000). It is important therefore that good personal hygiene is maintained by all workers engaged in the preparation of ready-to-eat foods.

2.9.2 Bacterial foodborne diseases

Bacterial foodborne diseases occur when bacteria contaminated food is eaten and the bacteria continues to grow in the intestines, setting up an infection which causes illness. Salmonella, Campylobacter, haemorrhagic E. coli and Listeria and others cause infections of bacteria origin.
2.9.3 Salmonella species

*Salmonella* species are Gram-negative, flagellated facultative anaerobic bacteria. Most of them are motile with flagella. They ferment glucose and produce acid and gas (H$_2$S) or acid only. The genus *Salmonella* is divided into two species that can cause illness in humans. These are *S. enterica* and *S. bongori*. Further, *Salmonella enterica*, which is of the greatest public health concern, comprise of six subspecies: *S. enterica* (I), *S. enterica salamae* (II), *S. enterica arizonae* (IIIa), *S. enterica diarizonae* (IIIb), *S. enterica houtenae* (IV) and *S. enterica indica* (VI) (Food and Drug Administration, 2012). Adams and Moss (1995) observed that in comparison with the rest of the gram-negative rods, *Salmonella* is resistant to various environmental factors, thrive at temperatures ranging from 8 °C and 45 °C and in a pH range of 4 to 8. Infection results from the ingestion of food or water containing sufficient number of these bacteria that eventually invade the small intestine (Adams and Moss, 1995).

*Salmonella* species is usually harmful to humans and animals. *Salmonella* induces three main types of illnesses in humans including enteric fever (typhoid fever), bacteremia and enterocolitis. The presence of *Salmonella* species in ready-to-eat foods may be a result of undercooking, poor food handling practices and cross contamination. Human beings constitute the largest sources of food contamination and the major route of infection is contaminated food and water (Marriot, 1985). According to WHO (2004) typhoid fever is still common in the developing world where it affects about 12.5 million persons each year.

There are three main ways *Salmonella* species can enter the food supply chain to cause illness. Animals harbour *Salmonella*, making meats, poultry, eggs, and milk often implicated vehicles. *Salmonella*, which are introduced into the environment, possibly through manure and litter, may
persist and contaminate fruits and vegetables on the farm. Cross-contamination in the food
service environment or the home often between raw poultry and ready-to-eat products, such as
raw vegetables, causes salmonellosis. Man induces salmonellosis through unhygienic food
handling practices and perpetuates salmonellosis through recontamination of animal by-products,
which are incorporated into livestock feeds.

Foods linked to *Salmonella* illness include meats, poultry, eggs, milk and dairy products, fish,
shrimp, spices, yeast, coconut, sauces, freshly prepared salad dressings made with unpasteurized
eggs, cake mixes, cream-filled desserts and toppings that contain raw egg, dried gelatin, peanut
butter, cocoa, produce (fruits and vegetables, such as tomatoes, peppers, and cantaloupes), and
chocolate (FDA, 2012)

Generally, the source of contamination of *Salmonella* infection can be traced to a carrier whose
personal hygiene is poor. *Salmonella* can frequently be isolated from raw foods of animal origin.
Environmental contamination can also result in *Salmonella* being present in a wide variety of
foods, although generally at lower numbers. Their presence in ready-to-eat foods may be a result
of undercooking, poor handling practices and cross contamination. *Salmonella* can occasionally
be isolated from fresh fruit and vegetables, and these may be a source of contamination when
included in ready-to-eat food.
2.9.4 *E. coli*

There are six recognized pathogenic groups among which four are known to be transmitted through contaminated food and water. The four are enterotoxigenic *E. coli* (ETEC), enteropathogenic *E. coli* (EPEC), enterohemorrhagic *E. coli* (EHEC) and enteroinvasive *E. coli* (EIEC). In general *E. coli* is a Gram-negative rod-shaped bacterium. They are characterized by the production of Shiga toxins, enterotoxins and other disease causing substances. *E. coli* can be differentiated from other coliform by its ability to ferment lactose at 44°C. They cause diseases ranging from traveler’s illness, infantile diarrhoea to bacillary dysentery. They have fatality rate ranging from 3 % to 50 % and an infective dose range as low as 10 cells to as high as 10 billion cells. The incubation period of the disease ranges from about 4 hours to nine days. Among the four pathogenic group, the common symptoms include bloodless diarrhoea to entirely bloody diarrhoea, fever, vomiting, abdominal pains, malaise and dysentery. The route of entry ranges from purely oral (e.g., ingestion of contaminated food, water, or faecal particles) to person-to-person. *E. coli* can survive for varying periods on the fingers and other parts of the body (Pether & Gilbert, 1971).

*E. coli* is part of the normal microflora of the intestinal tract of humans and warm-blooded animals (NSW/FA, 2009). Their presence in ready-to-eat foods (fully cooked or those containing raw fruits or vegetables) is therefore an indication of poor hygiene and sanitation or inadequate heat treatment of food.

The foods associated with the four groups of foodborne *E. coli* infection are similar with some little difference. For instance Food and Drug Administration (FDA) (2012) noted that infected
humans are the only known reservoirs of EIEC and for that matter any food contaminated with human faeces from an ill individual, either directly or via contaminated water can be infectious. On the other hand raw or undercooked ground beef and beef products are the vehicles most often implicated in O157:H7 outbreaks (FDA, 2012). Foods implicated in past EPEC outbreaks include raw beef and chicken, but any food exposed to fecal contamination is strongly suspected. Further, most ETEC outbreaks are linked to consumption of contaminated food or water. ETEC is often found in faeces of asymptomatic carriers, and humans appear to be the most likely source of ETEC (FDA, 2012).

2.9.5 Coliform

Coliform are gram-negative, rod-shaped facultative anaerobic bacteria that fermented lactose to produce acid and gas on incubation at 35-37°C (FDA, 2012). Coliform originate mainly from the intestinal tract of warm-blooded animals including man and are indicator organisms of faecal contamination of food and water. They are indicator organisms whose presence in cooked foods indicates health hazards. High levels of coliform in cooked foods may therefore be attributed to mishandling, poor processing and possible transmission of enteric pathogens such as Salmonella, Shigella and E. coli (Wood et. al., 1983). Although faecal coliform is an indicator in cooked foods, their presence in fruits and vegetables may sometimes not portends feacal contamination since there are other genera of the bacteria in the environment with non-faecal origin.

Coliform are usually associated with vegetables, fruits, water and any other food depending upon the hygienic status of the food handler and the environment in which the food was prepared.
Therefore any food visibly exposed to faecal contamination should be a strong suspect of coliform colonization.

**2.9.6 B. cereus**

It is a Gram-positive, facultative anaerobic, endospore-forming rod. *B. cereus* occurs widely in the environment and usually isolated from soil and vegetation. It has an optimal growth temperature of 28°C to 35°C, with a minimum growth temperature of 4°C and a maximum of 48°C. Growth occurs in pH ranges from 4.9 to 9.3, and the organism tolerates 7.5% salt concentration. Mead *et al.* (1999) observed that an estimated 27,000 cases of foodborne illness due to *B. cereus* occur annually in the United States.

Two types of illness are caused by two distinct metabolites (toxins):

- The diarrheal type of illness is caused by a large-molecular-weight protein. Onset of this type is 6 to 15 hours after consumption of contaminated food.

- The vomiting (emetic) type of illness is associated with cereulide, an ionophoric low-molecular-weight dodecadepsipeptide that is pH-stable and heat- and protease-resistant. The onset of emetic type is 0.5 to 6 hours after consumption of contaminated foods.

The FDA (2012) observed that the symptoms of the diarrheal syndrome include diarrhea, abdominal cramps, and tenesmus, whereas nausea and vomiting are the principal symptoms of the emetic syndrome. The number of organisms that often causes human illness is $10^6$ to $10^8$. Notable among the complications likely to occur in severe cases include severe systemic and pyogenic infections, gangrene, septic meningitis, cellulitis, panophthalmitis, lung abscesses, infant death, and endocarditis (FDA, 2012).
The varieties of foods, associated with both the diarrheal-type food poisoning and the vomiting-type include meats, milk, vegetables, fish, starchy foods, (macaroni, potato, pasta, rice products, dishes that contain corn and corn starch), cheese products and food mixtures (sauces, puddings, soups, casseroles, pastries, and salads) (FDA, 2012).

2.9.7 S. aureus

*S. aureus* is Gram-positive, non-motile, catalase-positive, small, spherical bacteria (cocci), which, on microscopic examination, appear in pairs, short chains, or bunched in grape-like clusters. Staphylococci are ubiquitous and impossible to eradicate from the environment. Many of the 32 species and subspecies in the genus *Staphylococcus* are potentially found in foods due to environmental, human, and animal contamination (FDA, 2012).

The FDA (2012) further observes that *S. aureus* is found in foods and can make toxins (enterotoxins) that might not be destroyed by cooking, although the bacterium itself can be destroyed by heat. Several different protein enterotoxins exist some of which include Staphylococcal enterotoxins A, B, C1, C2, C3, D, E, G, H, I (Balaban and Rasooly, 2000). In this connection, Mead *et. al.*, (1999) indicated that staphylococcal food intoxication is estimated to cause 185,000 cases of foodborne illness annually. *S. aureus* is mesophilic and grow in temperature ranges of 7°C to 47.8°C, with 35°C being the optimum temperature for growth. The growth pH range is between 4.5 and 9.3, with an optimum between 7.0 and 7.5.

The staphylococcal enterotoxins have an infective dose of less than 1.0 microgram representing about 100,000 organisms /g in food. Bergdoll (1979) identified that the onset of staphylococcal foodborne illness may occur between 30 min and 8 hours following consumption of the toxin-
contaminated food. The route of entry is consumption of food contaminated with enterotoxigenic S. aureus or ingestion of the enterotoxins. Common symptoms of staphylococcal intoxication include nausea, vomiting, retching, abdominal cramping, sweating, chills, prostration, weak pulse, shock, shallow respiration, and subnormal body temperature.

Bergdoll (1979) intimated that S. aureus mostly inhabit the nose and throat (on the hands and fingertips) and on the hair and skin of healthy individuals. Any food which requires handling in preparation may therefore easily become contaminated. S. aureus are thus expected to exist in all foods of animal origin and handled directly by humans. (FDA, 2012) noted that the major foods usually implicated in staphylococcal food poisoning include meat and meat products; poultry and egg products; salads, egg, tuna, chicken, potato, and macaroni; bakery products, such as cream-filled pastries, cream pies sandwich fillings; and milk and dairy products.

2.9.8 Yeast and moulds

They are present in soil, in the air, on the skin and in the intestines and they are found almost everywhere due to the extremely small size of their spores. They are transferred from place to place by people, equipment, or food and air currents. Moulds can grow in a wide range of foods. Unlike bacteria, moulds can grow in foods that are highly acidic and have low moisture. Freezing does not destroy moulds and yeast. One mould species may produce many different mycotoxins, and the same mycotoxins may be produced by several species (Robbins et al., 2000). The presence of moulds in a cooked food may indicate the growth of other equally harmful fungi species including Aspergillus flavus and Aspergillus niger. These species of fungi have been implicated for the production of aflatoxins (a type of mycotoxins) in foods. Yin et al.,
(2008) observed that Aflatoxins B$_1$ the most toxic among the mycotoxins (B$_1$, B$_2$, G$_1$, and G$_2$) is highly carcinogenic and may cause several adverse conditions including cancer of the liver. Children exposed to aflatoxins might experience stunted growth or be chronically underweight and thus become susceptible to infectious diseases in childhood and in later life (Center for Science in the Public Interest 2005). Mycotoxins produced by moulds are thus a dangerous toxin whose presence in cooked food poses health hazard. Harmful mycotoxins are normally associated with foods of maize origin, peanuts and spices (Yin et al., 2008)
CHAPTER THREE
MATERIALS AND METHODS

3.0 The Study Area

Akuapem North Municipal Assembly is situated at the southern end of the Eastern Region and is about 58 km from the nation’s capital city, Accra. It has an estimated population of about 136,483 with a growth rate of 1.8% (National Population and Housing Census, 2010). It covers about 450 sq km of the total land of the region. The Akuapem north municipality has about 230 settlements with Akropong as its capital town. Geographically, the municipality is situated between latitudes 5°80’000” and 6°10’000” and longitudes 0° 20’000” and 0° 00’000”. The municipality is mountainous, with hills ranging between 381m and 500m in height above sea level.

The vegetation of the municipality is forest with shrub and semi-forest. It has also got deep valleys which makes farming activities very difficult. Land degradation is a major threat in the study area because of inefficient agricultural management practices. There are two raining seasons with the major rainfall occurring between May and August and the minor rainfall in October. Average annual rainfall is about 1,270 mm. Mean temperatures range between 24°C and 30°C and night temperature between 13°C and 24°C. There is generally poor sanitation in the Municipality with majority of the people using public open dump, a condition that can cause outbreak of diseases in the area. The urban towns in the municipality include Adukrom, Akropong, Mamfe, Mampong, Okorase and Larteh.
The Educational directorate in the municipality has nine circuits (a number of schools located in the same area) headed by a circuit supervisor who report to the municipal director of education. The municipality has both rural and urban circuits. Each of the urban circuits has at least one Senior High School. On the average every school has a canteen that ranges from an open space under a tree, sheds to wooden structures where food vendors display their foods on a table or stand. Most of the school canteens in the municipality have no stand pipes attached to the canteens. Students who cannot afford the luxury of sachet water therefore drink from water in a common bowl or bucket usually provided by the vendors.

Figure 1: Map of the study area. (Source: Center for remote sensing and geographical information system, Ghana)
3.1 Reconnaissance survey

Reconnaissance visits were made to the various school canteens within the study area to find out the environmental and sanitation conditions prevailing there. The school canteens were inspected to identify the potential sources of cross-contamination of ready-to-eat foods.

Several visits were made to the schools under study to discuss and collect information from the School Health Programme (SHEP) coordinators and the headmasters on the sanitation and health issues in the schools. Further, visits were also made to the offices of the Municipal Education Service, the Municipal Environmental Health and Sanitation and the Municipal health management team to discuss and collect information on the prevalence of foodborne illnesses in the municipality.

3.1.0 Study design

The research was cross-sectional descriptive study using both qualitative and quantitative method for data collection. It was in two main parts; field survey and laboratory analysis. Data obtained from the field survey and laboratory analysis were used to determine the potential hazards associated with the ready-to-eat food (cooked foods) consumed by students in the school canteens.

3.1.1 Limitations of the study

Many challenges were encountered in the course of the study. The relative short period at the disposal of the Researcher coupled with resource constraint made it impossible for large sample size in terms of food samples and respondents to be used for the study. Also disappointment
from sponsors unduly delayed the completion of this study. Because most of the food vendors were illiterates, an additional time had to be spent in interpreting the questionnaire items to them in their mother tongues and in the process adversely affected the early completion of the study.

Furthermore, most of the food vendors were not willing to participate in the study although total confidentiality of their responses was assured. The Researcher was therefore left with the alternative of using the non-probability sampling method (purposive sampling) to pick only 128 food vendors for the study.
3.2.0 GENERAL PROCEDURE

3.2.1 Preparation of Plate Count Agar (PCA)

Approximately 23.5g of the solid agar was dissolved in 1 litre sterile distilled water (APHA, CM0463), the pH adjusted to 7.0 ± 0.2 and the solution boiled to dissolve completely at 100 °C. The agar was dispensed into flasks and autoclaved at 121 °C for 15 minutes. The agar was then left to cool and settle at 50°C.

3.2.2 Preparation of Salt Peptone Solution

Approximately 8.5g of sodium chloride and 1g of bacteriological peptone were weighed into 1 litre sterilized distilled water and the pH adjusted to 7.2 ± 0.2 and sterilized at 121 °C for 15 minutes.

3.2.3 Preparation of Buffered Peptone Water Broth (BPW)

The buffered Peptone water broth (BPW) was prepared by weighing 20g of the solute into 1 L sterilized deionized water and brought to a pH of 7.2 ± 0.2. The broth was then sterilized by autoclaving at 121°C for 15 minutes.

3.2.4 Preparation of Dichloran Roce Bengal Chloranphenicol (DRBC medium)

Approximately 15.7g of the solute was weighed into 500mls of sterilized distilled water and the pH adjusted to 5.7 ± 0.2 °C. Approximately 1 vial of Chloranphenicol was added to suppress growth of bacteria and sterilized at 121°C for 15 min.
3.2.5 Preparation of Tryptone Soya Agar (TSA)
This was prepared by dissolving 38g of the solute in 1litre sterilized distilled water with pH adjusted to $7.2 \pm 0.2$ and sterilized at 121°C for 15 min.

3.2.6 Preparation of Violet Red Bile Agar (VRBA)
Approximately 38g of the powder was dissolved in 1L and brought to boil at 100°C for 15 minutes to completely dissolve. The pH was adjusted to 7.4± 0.2

3.2.7 Preparation of Bacillus cereus Agar Base
This was prepared by dissolving 20.5g of the solute in 475mls of sterilized distilled water and pH adjusted to 7.2 ± 0.2. This was supplemented with 25ml egg yolk emulsion and 1 vial of poplymycin B. The agar was sterilized at 121°C for 15 minutes.

3.2.8 Preparation of Baird Parker Agar base
Approximately 31.5g of the powder was dissolved in 500mls of distilled water and the pH adjusted to 6.8 ± 0.2. The agar was then autoclaved at 121°C for 15 minutes. Twenty five grams of egg yolk tellurite dissolved in 500ml was then added as a supplement.

3.2.9 Preparation of Rappaport Vasiliadis (RVS) broth
About 13.38g of the media was dissolved in 500ml, pH adjusted to 5.2 ± 0.2 and the medium autoclaved at 115°C for 15 minutes.
3.3.0 Preparation of Brilliant Green Agar (BGA)

The Brilliant Green Agar (BGA) was prepared by dissolving 26g of solute in 500ml of distilled water, pH adjusted to 6.9 ± 0.2 and sterilized by autoclaving at 121 °C for 15 minutes.

3.3.1 Preparation of Xylose Lysine Deoxycholate (XLD) Agar

About 26.5g solute was dissolved in 500ml and mixed thoroughly with pH adjusted to 7.4 ± 0.2. The agar was heated with frequent agitation and boiled for 1 minute to completely dissolve the powder. It was then autoclaved at 118 °C for 10 minutes, cooled to 55-60°C and poured into Petri dishes for it to solidify.

3.3.2 Preparation of Oxytetracycline-Glucose Yeast Extract Agar (OGYEA)

About 17.5 g of the solute was dissolved in 500mL of distilled water and pH adjusted to 7.0 it was then sterilized at 115°C for 10 minutes. After sterilization, 1 vial of tetracycline supplement was added to it.

3.3.3 Preparation of Triple Sugar Iron (TSI)

The Triple Sugar Iron (TSI) medium was prepared by dissolving 19.5g of solute in 300ml distilled water. It was then autoclaved at 151°C for 15 minutes and later brought to cool at 50 °C.

3.3.4 Preparation of Urea Agar Base (UAB)

About 24g solute (granulated agar) was dissolved in 950 ml distilled water. The solution was then heated to boiling to dissolve the medium completely with pH adjusted to 6.8 ± 0.2. It was then sterilized by autoclaving at 115 °C for 20 minutes, cooled to 50°C and 50 ml of sterile 40% Urea
Solution (FD048) aseptically added and mixed. The agar base was then dispensed into sterile tubes and allowed to set in the slanting position.

**3.3.5 Preparation of Lysine Decarboxylase Broth (LDB)**

The Lysine Decarboxylase Broth (LDB) was prepared by dissolving 1 tablet in 10ml of sterile water and pH adjusted to 6.1 ± 0.2. It was then autoclaved at 121°C for 15 minutes.

**3.3.6 Food sampling method**

Three schools were selected randomly from four urban educational circuits in the municipality (Adukrom, Akropong, Larteh and Mampong) and food samples collected from each school in the morning and afternoon. The food samples collected for the study included ‘waakye’, ‘shito’, red pepper sauce, macaroni, fried fish, vegetable salad, sausage, groundnut soup, ‘banku’, iced ‘kenkey’, ‘kenkey’ and ‘fufu’. The food samples are described in appendix F. In all 288 food samples were analysed in the laboratories of Food Research Institute Ghana, for microbial contamination.

All samples were taken during the first and last breaks when the students usually take their breakfast and lunch respectively. Samples were then collected in a sterile plastic container and chilled with iced blocks in cooler box container. They were then coded with appropriate letters and numbers and sent to the laboratory within two and half hours for analysis.
3.3.7 Microbiological analyses

3.3.8 Sample preparation (homogenization and serial dilutions)

For each food sample 10g was aseptically weighed into 90 mls of sterile salt peptone solution ((XPS) containing 0.1 % peptone and 0.8 % sodium chloride with pH adjusted to 7.2 and homogenized in the Stomacher (model 4001, Seward Medical) for 30 seconds at normal speed. This provided $10^{-1}$ dilution. This was vortex for about 2 min to ensure uniform mixing. Using a sterile pipette, 1 ml of the $10^{-1}$ dilution was pipette into 9mls of sterile salt peptone water to obtain $10^{-2}$ dilution. This procedure was repeated for $10^{-3}$, $10^{-4}$, $10^{-5}$ and $10^{-6}$ dilutions. Further, from appropriate tenfold serial dilution, 1 ml aliquot of each dilution ($10^{-1}$, $10^{-2}$, $10^{-3}$, $10^{-4}$, $10^{-5}$ and $10^{-6}$) was inoculated into sterile Petri dish plates and the appropriate media added for enumeration and isolation.

After appropriate incubation, dilutions with 30–300 colonies were selected and counted. The number of colony-forming units per gram (cfu/g) of food was calculated by multiplying the number of bacteria by the dilution. All analysis was done in duplicate for reliability of results.

3.3.9 Enumeration of Aerobic Mesophiles (viable plate count)

Aerobic mesophiles were cultured by the pour plate method using plate count agar medium (OXOID CM 325). The plates were incubated at 30 °C for 72 hours (NMKL no. 86, 2006).

3.4.0 Enumeration and Isolation of total coliform

Coliform bacteria were cultured by the pour plate method using Tryptone Soya Agar medium (OXOID CM131) and adjusted to pH 7.3 and overlaid with Violet Red Bile agar (OXOID CM
107) with pH adjusted to 7.4 and incubated at 37 °C for 24 hours. Colonies were confirmed using Brilliant Green Bile broth (OXOID CM 31) at pH of 7.4 and incubated at 37 °C for 24 hours (NMKL no.44, 2004)

### 3.4.1 Enumeration of *E. coli*

_E. coli_ bacteria were cultured by the pour plate method using Trypsin Soya agar medium (OXOID CM131) adjusted to the pH 7.3 and overlaid with Violet Red Bile agar (OXOID CM 107) with pH adjusted to 7.4 and incubated at 44 °C for 24 hours. Colonies were confirmed using E.C. broth (OXOID CM 853) with pH adjusted to 6.9. Colonies that produced gas were confirmed for Indole production. This was done by sub-culturing into Tryptone water and incubated at 44 °C for 24 hours. Indole test was done by putting a drop of Convac reagent into the culture. Red ring colouration at the surface of Tryptone indicated Indole positive (NMLK no.125, 2005).

### 3.4.2 Enumeration of *S. aureus*

Enumeration of _S. aureus_ was done by the spread method using Baird-Parker agar (OXOID CM 275). Approximately 0.1 ml of the aliquot was inoculated onto the surface of Baird- Parker agar. A sterile glass rod was used to spread the medium onto the surface of the Baird Parker medium. The plates were incubated at 37°C for 48 hours. Colonies were confirmed for coagulase positive using Rabbit Plasma Serum. Coagulation of the serum indicated coagulate positive (confirmation test for _S. aureus_).
3.4.3 Enumeration of *B. cereus*

The enumeration of *B. cereus* was done by the spread plate method using *B. cereus* selective agar (OXOID CM 617 and SR99). Approximately 0.1ml of aliquot was inoculated onto surface of the *B. cereus* agar medium. Sterile rod was used to spread the inoculum on the surface of the agar medium and incubated at 30°C for 24 hours. Suspected colonies were confirmed on Blood Agar dish (OXOID CM 617). Haemolysis on Blood Agar indicates positive *B. cereus* bacteria.

3.4.4 Enumeration of Yeast

About 10g of the food samples were transferred into empty 9cm Petri dishes. Two dishes were use for each of the dilutions. About 15ml of the OGYEA medium was added to the food samples and mixed gently. The plates were turned three times clockwise and three times counter-clockwise in accordance with ISO 7954 (1987). The Petri dishes were turned upside down and incubated at a temperature of 25 ± 2°C and pH of 7.0 for 3 to 5 days. The number of colonies in plates containing 50 to 500 colonies were counted and recorded.

3.4.5 Detection of *Salmonella* species

Approximately 25g of the food sample were weighed aseptically into sterile Stomacher bag and 225ml buffered peptone water added to it. This was homogenized thoroughly and incubated at 37°C for 16 to 21 hours. Following incubation, 0.1ml of broth (buffered peptone water) was transferred into 10ml of Rappaport-Vasiliadis (RVS) broth and incubated in a water bath at 42°C ± 0.5°C for 24 ± 3 h. Following enrichment, a loopful of the Rappaport-Vasiliadis (RVS) broth culture was streaked onto XLD Agar plates, and the plates were incubated at 37°C ± 0.5°C
for 24h ± 3 h. Presumptive colonies (lightly transparent zone of reddish colour and black center) were maintained on non-selective TSA agar slants for further biochemical tests.

### 3.4.6 Biochemical confirmation

Suspected colonies were confirmed on Triple Sugar Iron medium, Urea Agar Base (UAB) medium and Lysine Decarboxylase Broth medium and incubated at 37 °C for 24 hours.

#### 3. 4.7 Triple Sugar Iron confirmatory (TSI) test

Using aseptic techniques, a colony of the test organism was picked with a sterile inoculating loop, and the slant of the media streaked. Using a sterile inoculating needle, the butt of the media was then stabbed. Tubes were then inoculated at 37°C for 24 hours after which they were observed. A yellow butt and a red slant indicated fermentation of lactose or sucrose. Blackening of agar indicated the production of H₂S gas. A red butt on a slant indicated that none of the sugars were fermented and neither gas nor H₂S were produced. Blackening and gas formation in TSI tube indicates presence of *Salmonella*.

#### 3.4.8 Urea Agar Base confirmation

Urea agar was stabbed by sterile loop and was incubated for 24 h at 37 °C. The colour change from yellow to pink indicates absence of *Salmonella*. 
3.4.9 Lysine Decarboxylase agar confirmation

Lysine iron agar (LIA) surface was streaked and the butt was stabbed and was incubated for 24 h at 37 °C. In the Lysine Decarboxylase agar confirmation, colour change from purple butt to yellow butt indicates the absence of *Salmonella*.

3.5.0 Social survey

3.5.1 Sampling technique

A minimum student sample size of 384 was obtained using the Fischer’s formula for population above ten thousand (Araoye, 2003).

\[
\begin{align*}
n & = \frac{Z^2 \cdot P \cdot (1-P)}{d^2} \\
Z & = 1.96 \text{ (corresponds to 95% confidence level)} \\
P & = 50\% \text{ (proportion with good knowledge on foodborne diseases)} \\
(1-P) & = q = 50\% \text{ (proportion with poor knowledge on foodborne diseases)} \\
d & = \text{level of precision} = 0.05
\end{align*}
\]

\[
n = \frac{(1.96)^2 \cdot (0.50) \cdot (0.50)}{(0.05)^2} = 384
\]

Although the computed minimum sample size was 384, a multi-stage sampling technique was however used to obtain a sample size of 300 students. This adjustment in sample size was done in order to enable the Researcher work with a manageable sample and finish the study on time. The simple random sampling was use to select the actual 300 students from the 16 schools who participated in the study (appendix Z). This was done by writing yes or no on sheets of papers,
folding them and asking students to pick one paper each from the box. Those who picked yes were supplied with the questionnaire and those who picked no were rejected. In the case of the food vendors, 128 people were purposively selected (hand-picked) to answer the questionnaire. The food vendors were purposively sampled because most of them were unwilling to participate in the study. The Researcher was therefore compelled to select only the 128 vendors who were willing to respond to the questionnaire. In all, 428 respondents were chosen to answer the questionnaire. The reasons for selecting 428 respondents were due to financial constraint and limited time at the disposal of the Researcher.

### 3.5.2 Structured questionnaire

The questionnaire items were structured according to the objectives of the study and given code numbers. Letters of introduction were given to the heads of the various schools to formally seek permission to administer the questionnaire. Questionnaire was then given to the students to be returned the following day to a designated teacher in the school. The questionnaire were subsequently retrieved from the designated teachers three days after and sorted for further analysis. The questionnaire items were interpreted to the illiterate food vendors in their own dialect (mostly Akan) by some selected teachers who further guided them to answer the questionnaire within two days. On the third day, questionnaires were collected and coded for further analysis.

### 3.5.3 Data analysis

The values obtained from microbiological analyses were computed using the Microsoft Excel to determine their means and standard deviations. These were graphically presented using
exploratory graphs to highlight possible trends. The social survey data was collected using both opened ended and closed ended questionnaire. Statistical Package for Social Sciences (SPSS) version 16.0 was used to compute for frequencies and percentages which were then used to draw graphs, tables and pie charts for the analysis of the study. Also the SPSS was used to determine the significant p values in the total microbial load among the circuits.

3.3.4 Ethical consideration
The questionnaire of the study was submitted to the Ethical Committee of the University of Ghana, Legon for their approval before they were deployed. Food vendors and students were recruited into the study after they had given their approval. Also, the purpose of the study was explained to the food vendors and their consent sought before the food sample was taken and the research instruments administered.

3.5.5 Quality assurance and data processing
To enhance quality, questionnaires were pilot tested and the necessary corrections made. Food analysis was also duplicated to ensure that the results obtained are valid and reliable. All computation on the SPSS software was also doubly checked.
CHAPTER FOUR

RESULTS

4.0 Demographic characteristics of food vendors

A total of 128 food vendors were sampled from 16 different schools in the Akuapem North Municipality. The demographic characteristics of the respondents are shown in Figure 2. Food vendors within the 30 to 39 age range were the majority representing 67% of the total respondents. The age ranges 40 to 49 and below 30 years age groups recorded 16% and 13% respectively. Fifty years and above age groups (representing 6% of the total respondents) was the lowest age group. Also, the result from Figure 3 shows that about 99% of the respondents were females.

Further, the results from Figure 3 show that about 48% of respondents had no formal education. About 21% and 19% of the respondents had attained primary and middle school education respectively. About 4% of the respondents indicated that they had had JHS education while about 2% had completed Islamic (Arabic) education. Concerning the experience of respondents in food vending, about 48% said they had 7 to 10 years experience of selling food in the school canteen while 31% had 3 to 6 years of experience in the food vending business. The results also showed that 12% of the respondents have less than three years experience whereas only 9% of the respondents have more than 10 years of experience in the food vending business.
4.1 Status of food vendors in the training of food handling

Figure 3 presents responses on whether food vendors had ever received training in food handling. From the results, as many as about 75 % of the respondents indicated that they had been trained in food handling while only 25 % of the respondents indicated that they have never received training in food handling.
4.2 Sources of education on food handling

Figure 4 summarizes the source of education on food handling by food vendors. As many as 90% of the respondents indicated that they received their training from the home while 9% indicated they received their training from school. Only 1% of the respondents indicated they received their training from health professionals.
4.3 Screening and possession of certificate/license of fitness

The results shown by figure 5 showed that about 82% of the respondents had been screened and given certificate to sell whereas about 18% of the respondents indicated they have never been screened before.
4.4 General knowledge of food vendors on foodborne disease and food hygiene

In Figure 6 respondents answers as to whether they have ever heard about foodborne diseases or not is shown. About 93% of the respondents indicated that they had heard of the concept while only 7% indicated they had never heard of foodborne diseases before.
Figure 6: A bar chart showing respondents’ knowledge on foodborne diseases (FBD)

Figure 7 presents knowledge of respondents on the symptoms of foodborne diseases. About 52 % of the respondents chose convulsion as a symptom of foodborne disease while 27 % chose diarrhoea and vomiting. About 17 % and 4 % of the respondents chose rashes and constipation respectively as common symptoms of foodborne diseases.

A chi square result between the educational level of food vendors and their knowledge on symptoms of foodborne diseases showed a significance value of p < 0.05 (Appendix P). This implies that educational level of the food vendors had a significant influence on their knowledge on symptoms associated with foodborne diseases.
The respondents’ knowledge of the common symptoms of diarrhoea as evidenced by Figure 8 shows that about 32% of the respondent indicated passage of more than three liquid stools in a day as a common symptom of diarrhea. About 28% and 32% of the respondents indicated passage of a bloody stool and passage of mucoid stool in a day respectively as symptoms of diarrhoea. Also, about 6% of the respondents indicated that the passage of one liquid stool in a day as common symptom of diarrhoea while about 2% indicated abdominal pains and others as a common symptom of diarrhoea.
Figure 8: A bar chart showing respondents’ knowledge on common symptoms of diarrhoea

Figure 9 presents ailments which might prevent food vendors from selling in the school canteen. About 59% of the respondents indicated that only malaria might prevent them from selling food in the canteens while about 19% indicated that they would not sell food in the school canteen when they have typhoid fever. Only 18% and 4% of the respondents respectively indicated that Cholera and other diseases (headache, stomach pains and diarrhoea) would prevent them from selling in the school canteen.

A chi square test was done to test the relationship between educational level of food vendors and their knowledge on the diseases that will prevent them from selling in the school canteen. The
results revealed significant at value p < 0.05 (Appendix Q). This shows that food vendors’ level of education determines to a large extent whether they will sell in the schools’ canteen or not when they suffer from diseases that are contagious or not.

Figure 9: A bar chart showing disease that prevents food vendors from selling in the canteen

Figure 10 summarizes results on sources of contamination of ready-to-eat foods in the school canteen. About 11% of the respondents indicated food ingredients are possible sources of food
contamination while as many as 89% of the respondents indicated food cannot be contaminated through ingredients.

Also about 76% of the respondents indicated that drinking water can be a possible source of food contamination whereas about 24% of the respondents refuted the assertion. In addition whereas about 19% of the respondent saw cooking utensils as possible source of contamination, 81% of the respondent indicated that food contamination cannot occur through cooking utensil. Moreover, as to whether human hands can serve as a source of contamination, about 74% of the respondents answered in the affirmative while about 26% of the respondents refuted the assertion. Further, about 83% of the respondents indicated that garbage or refuse close to the canteens can be a source of food contamination while about 17% of the respondents refuted the assertion.

A chi square result between experience in food vending and knowledge on cooking utensil and garbage closeness to the canteen as possible sources of cross-contamination revealed a significant at value p > 0.05 (appendix R). This shows that there is no significant relationship between experience of food vendors and their knowledge on cooking utensils and garbage as a source of cross-contamination.
Figure 10: A bar chart showing sources of contamination of ready-to-eat foods

Figure 11 presents the results on how respondents clean their used serving plates and spoons. The results showed that majority (78%) of the respondents’ cleaned dirty plates and spoons in a common bowl with soap and water while 16% of the respondents indicated that they clean dirty serving plates and spoons by wiping with napkin. Only 6% of the respondents indicated that they wash dirty plates and spoons with soap under running water in the canteen.
In addition, a chi square test results between training of food vendors in food handling and their knowledge on the hygienic means of washing dirty plates and spoons revealed significant p value > 0.05 (appendix U). This implies that there was no significant relationship between training in food handling and knowledge on hygienic practices so far as food handling in the canteen is concerned.

Figure 11: A bar chart showing how food vendors clean dirty serving plates and spoons in the school canteen
Plate 1: The common bowl from which all dirty plates and spoons are washed in a school canteen in Akropong circuit

As shown by Figure 12, when respondents were asked how they treat their vegetables meant for salad, 60% said that they washed them with water while about 28% said they use vinegar to wash them. Again 9% and 3% of the respondents indicated they treat such vegetables by using salt solution and wipe them respectively.
As shown by figure 13, about 72% of the respondent said they store their leftover food in a refrigerator. However, about 16% of the respondents said they heat leftover and store in the cupboard while 12% of the respondents indicated that they leave the leftover food in the kitchen and heat it the following morning. When asked how they store cooked leftover foods and raw foods, about 95% of the respondents said that cooked leftover foods and raw food materials are stored separately while only 5% of the respondents indicated that they store both cooked and
raw foods together. Further, about 74% of the respondents indicated that they store leftover food separately from raw foods so as to maintain the flavour of the cooked food while about 29% indicated that they do that so as to prevent the transfer of pathogens from the raw foodstuffs to the cooked foods.

Furthermore, a chi square test results between training on food handling and why, how and where respondents store their leftover cooked foods produced a significant value at p > 0.05 (appendix V). This was indicative of the fact that there was no significant relationship between the training received by food vendors and their knowledge on hygienic practices on handling cooked foods. There was however a significant relationship between educational level of food vendors and their knowledge on storage of leftover foods separately as the chi test results conducted produced a significant p value < 0.05 (Appendix V).
Figure 13: A bar chart showing where, how and why respondents store leftover food

How often respondents torch or serve food with bare hands in the canteen is shown by Figure 14. Out of 128 respondents, about 93% indicated that they sometimes touch ready-to-eat foods with their bare hands while about 6% of the respondents said that they sometimes touch cooked foods with their bare hands when serving food in the canteen. Only 1% of the respondents said that they do not touch cooked foods with their bare hands when serving food in the canteen.
Figure 14: Pie chart showing how often respondents touch or serve food with bare hands in the canteen

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>1%</td>
</tr>
<tr>
<td>Sometimes</td>
<td>6%</td>
</tr>
<tr>
<td>Not at all</td>
<td>93%</td>
</tr>
</tbody>
</table>
Plate 2: A food vendor fetching meat to students in a school canteen with the same bare hand used in handling money
Figure 15 shows responses food vendors gave on whether they washed their hands after blowing the nose or visiting the toilet in the course of selling. About 63% of the respondents indicated that it is not important to wash the hand after blowing the nose while 37% of the respondents indicated that it is very necessary to wash the hand after that. Also, whereas about 99% of the respondents indicated that they wash their hands after visiting the toilet, 1% of the respondent indicated that it is not necessary to wash your hand after visiting the toilet.

Figure 15: A bar chart showing the importance food vendors attach to hand washing after blowing the nose and visiting the toilet.
Figure 16 shows the responses food vendors gave on the right way of washing the hands after blowing the nose or visiting the toilet while serving food. About 53% and 19% of the respondents indicated that they wash their hands with only water and with only warm water respectively. As low as 10% of the respondents indicated that they wash their hands with warm water and soap as 18% indicated that they do so with ordinary water and soap.

The chi square test between training in food handling and food vendors’ knowledge on hand washing showed no significant value at p > 0.05 (Appendix W). This is an indication that there is no significant relationship between training in food handling and food vendors’ knowledge on the hygienic way of washing the hands whenever they visit the toilet or blow their nose.
Figure 16: A bar chart showing how food vendors wash their hands after visiting the toilet or blowing the nose in the course of serving food.

4.5 General knowledge of students on foodborne diseases

Table 1 shows the results on whether respondents had ever heard of food-borne disease or not. About 96% of the respondents from SHS indicated that they have heard of the concept while only 4% said they have not heard of the concept before. Again, 94% of the respondent from JHS indicated that they had heard of the concept of food-borne disease before while only 6% indicated they had never come across the concept.
Table 1: Knowledge of students on foodborne disease (FBD)

<table>
<thead>
<tr>
<th>Knowledge on FBD</th>
<th>SHS</th>
<th></th>
<th>JHS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>heard of foodborne disease</td>
<td>143</td>
<td>96.0</td>
<td>138</td>
<td>93.9</td>
</tr>
<tr>
<td>Not heard of foodborne disease</td>
<td>6</td>
<td>4.0</td>
<td>9</td>
<td>6.1</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>100.0</td>
<td>147</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2 shows the respondents view on the causes of foodborne diseases. Majority of the respondents from SHS (75 %) indicated foodborne diseases are caused by germs /pathogens while only about 6 % indicated foodborne diseases are caused by lack of exercise. Also, about 19 % of the respondents indicated foodborne diseases are caused by witchcraft. Further, about 73 % respondents from JHS said foodborne diseases are caused by germs, 21 % said it is by witchcraft and about 6 % indicated it is caused by lack of exercise.

In addition a chi square test was performed to test the relationship between the form or level (JHS 1 to SHS 3) of the students in schools and their knowledge on the causes of foodborne diseases. The results (Appendix S) showed that there was a significant value at p < 0.05 indicating a significant association between the level of the students in the school and their knowledge on causes of foodborne diseases.
Table 2: Student knowledge on the causes of foodborne diseases

<table>
<thead>
<tr>
<th>Cause</th>
<th>SHS Frequency</th>
<th>SHS Percent</th>
<th>JHS Frequency</th>
<th>JHS Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>germs/pathogens</td>
<td>110</td>
<td>74.8</td>
<td>101</td>
<td>73.2</td>
</tr>
<tr>
<td>witchcraft/wizard/witches</td>
<td>28</td>
<td>19.1</td>
<td>29</td>
<td>21.0</td>
</tr>
<tr>
<td>lack of exercise</td>
<td>9</td>
<td>6.1</td>
<td>8</td>
<td>5.8</td>
</tr>
<tr>
<td>Total</td>
<td>147</td>
<td>100.0</td>
<td>138</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 3 presents results on how foodborne pathogens are transmitted. Approximately 77% of the respondents from SHS indicated it is transmitted through contaminated foods, palms and water while about 18% said that it is transmitted through air particles. Also, about 3% of the respondents said it is transmitted through sex as 1% of the respondents indicated it is transmitted through other means like dust and soil. Regarding the JHS students, about 50% of the respondents said that it is transmitted through contaminated food, water and hands while about 36% indicated it is transmitted through air particles. Again, whereas about 12% of the JHS respondents said foodborne diseases are transmitted through sex, only 2% of the respondents indicated it occurs through other means.
Table 3: Student knowledge on the transmission of foodborne disease

<table>
<thead>
<tr>
<th>Transmission of FBD</th>
<th>SHS</th>
<th>JHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through contaminated foods, palms and water</td>
<td>115</td>
<td>72</td>
</tr>
<tr>
<td>Frequency</td>
<td>77.2</td>
<td>49.7</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trough air particles</td>
<td>27</td>
<td>52</td>
</tr>
<tr>
<td>Frequency</td>
<td>18.1</td>
<td>35.9</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Through sex</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Frequency</td>
<td>3.4</td>
<td>12.4</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Frequency</td>
<td>1.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>145</td>
</tr>
<tr>
<td>Frequency</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4 presents results on whether hand washing with soap can prevent the spread of foodborne pathogens. In the SHS category, about 99% of the respondents answered in the affirmative while about 1% of the respondents said no. Also about 96% of the JHS respondents said that the spread of foodborne pathogens can be prevented through hand washing with soap while about 4% of the respondents refuted the assertion.
Table 4: Students knowledge on the effect of hand washing in preventing the transmission of foodborne diseases

<table>
<thead>
<tr>
<th></th>
<th>SHS</th>
<th>JHS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>Hand washing with soap can prevent transmission</td>
<td>144</td>
<td>98.</td>
</tr>
<tr>
<td>Hand washing cannot prevent transmission</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>100.0</td>
</tr>
</tbody>
</table>

As shown by Table 5, about 96 % of SHS respondents indicated that eating with well washed spoons can prevent the spread of food-borne pathogen while about 4 % respondents said otherwise. In the case of the JHS respondents about 92 % indicated that well washed spoons can prevent transmission of foodborne diseases as against 8 % of the respondents responding in the negative.

Table 5: Preventing transmission of foodborne pathogens (FBP) through washed spoons

<table>
<thead>
<tr>
<th></th>
<th>SHS</th>
<th>JHS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>Percent</td>
</tr>
<tr>
<td>Preventing transmission of FBP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Well washed spoon can prevent transmission of foodborne disease</td>
<td>138</td>
<td>96.5</td>
</tr>
<tr>
<td>Well washed spoon cannot prevent transmission of foodborne disease</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>Total</td>
<td>143</td>
<td>100.0</td>
</tr>
</tbody>
</table>
As presented in Table 6, about 75% of the SHS respondents said diarrhoea or vomiting is a common symptom of foodborne disease while about 12% of the respondents chose constipation as common symptom of foodborne diseases. Also, about 5% and 8% of the respondents said the common symptoms of foodborne disease were headache and skin rashes respectively. Among the JHS respondents, about 69% of the respondents indicated diarrhoea/vomiting as the common symptom of foodborne disease whereas about 13% chose constipation as a common symptom of food-borne diseases. Again, whereas 11% of the respondents said headache constitutes a common symptom of foodborne diseases, 5% of the respondents indicated that rashes are the common symptom of foodborne diseases.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>SHS Percent</th>
<th>JHS Frequency</th>
<th>JHS Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>8</td>
<td>5.4</td>
<td>16</td>
<td>10.9</td>
</tr>
<tr>
<td>Diarrhoea/vomiting</td>
<td>111</td>
<td>74.5</td>
<td>102</td>
<td>69.3</td>
</tr>
<tr>
<td>Skin rashes</td>
<td>12</td>
<td>8.1</td>
<td>8</td>
<td>5.4</td>
</tr>
<tr>
<td>Constipation</td>
<td>18</td>
<td>12.1</td>
<td>21</td>
<td>13.6</td>
</tr>
<tr>
<td>Total</td>
<td>149</td>
<td>100.0</td>
<td>147</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Plate 3: Student washing hands without soap in a common bowl before eating in one of the school canteens

Plate 4: School children eating in an open shed (school canteen) closer to a dumping site
Plate 5: Food vendors displaying cooked foods in a school canteen (open space under a tree near a gutter)
Plate 6: Typical school canteens in Adukrom circuit sited closer to toilet and urinal.
Plate 7: A school canteen in Akropong circuit with weedy premises and all sorts of waste littered around.

4.6 Microbiological analysis

In all, 288 samples were analysed from 16 schools in four different circuits. Bacterial growth was observed in almost all the food analysed. Samples were taken in the morning and afternoons from the 16 schools selected. The means of the results from the food sample analysis were converted to $\log_{10}$ cfu/g.

Mean PCA counts in food sample in Akropong circuit

The mean PCA count in the food items expressed as $\log_{10}$ cfu/g or cfu/ml is shown by Figure 17. The mean PCA counts in the circuit ranged from $1.1 \pm 1.01$ $\log_{10}$ cfu/g to $5.4 \pm 1.21$ and $2.7 \pm 0.45$ to $7.0 \pm 0.84$ $\log_{10}$ cfu/g in the morning and afternoon respectively. Macaroni and red
pepper recorded the highest microbial load with PCA count of $7.0 \pm 0.76$ and $7.0 \pm 0.77$ log$_{10}$ cfu/g respectively in the afternoon. Fufu, vegetable salad and sausage also recorded quiet a significant microbial load in the afternoon. The rest of the samples had levels of contamination lower than the recommended load by Ghana Standard Authority which prescribes values of $<5.0$ log$_{10}$cfu/g. All samples showed a significant growth rate from the morning to the afternoon. However, sausage had the highest growth rate of $3.2 \pm 0.41$ to $6.7 \pm 0.94$ log$_{10}$cfu/g (Figure 21). Among the same food samples, microbial contamination were higher in the afternoon than in the morning with fufu showing the highest difference in microbial growth ($4.1 \ 0 \pm .77$ to $6.9 \pm 0.03$ log$_{10}$ cfu/g).

Analysis of variance (appendix X) conducted revealed that there was no significant difference in PCA count in food samples collected from schools in Akropong circuit from that of the other circuits in the morning ($p > 0.05$). However, there were a significant difference in the level of (PCA) count in food samples in the afternoon between schools from Akropong and schools from the other circuits as the analysis of variance results indicated that $p<0.05$ (Appendix Y).
Plate 8: Colonies of microbes growing on a Plate Count Agar (PCA) medium x 1/3
Mean distribution of types of microbe in food samples in schools at Akropong circuit

Figure 18 presents a graph of the mean distribution of microorganisms in the food samples analysed. Yeast and molds were isolated in all the food samples in significant quantities except in groundnut soup, kenkey and banku. The highest yeast and mould counts in the samples expressed as $\log_{10} \text{cfu/g}$ were as follows: vegetable salad; $2.2 \pm 1.18$, fufu; $2.0 \pm 0.03$ and macaroni; $2.0 \pm 0.76 \log_{10} \text{cfu/g}$. 
The *B. cereus* counts in the food samples were also quite significant except in groundnut soup, kenkey and ‘banku’ which had no counts. The highest mean *B. cereus* counts expressed in log\textsubscript{10} cfu/g included 3.2 ± 0.012 for macaroni, 3.1 ± 0.05 for fufu 3.0 ± 0.65 log\textsubscript{10} cfu/g for vegetable salad (Figure 22). Kenkey and banku had no *E. coli* counts. All other food samples had significant microbial counts with vegetable salad recording the highest counts of 2.6 ± 1.63 log\textsubscript{10} cfu/g. In addition, apart from kenkey and banku, all other foods had different ranges of *S. aureus* contamination. As shown by figure 22, red pepper had high *S. aureus* contamination of 3.4 ± 0.41 log\textsubscript{10} cfu/g followed by fufu with 3.1 ± 0.18 log\textsubscript{10} cfu/g. Vegetable salad, fried, fish and sausage also had quite an appreciable count of 3.1 ± 0.37, 2.9 ± 0.27 log\textsubscript{10} cfu/g and 2.8 ± 0.53 log\textsubscript{10} cfu/g respectively.

Further, as indicated in Figure 22, coliform counts were also quite appreciable. Vegetable salad, macaroni and sausage had relatively high coliform loads of 4.2 ± 1.13, 3.7 ± 0.80 log\textsubscript{10} cfu/g and 3.6 ± 1.09 log\textsubscript{10} cfu/g respectively. Banku, kenkey and fufu had no counts for coliform. All other food sample recorded relatively lower but microbiologically significant counts of coliform contamination.
Mean PCA counts in food samples tested in schools in Mampong circuit

The results of PCA counts of the food samples from the schools in Mampong circuits are presented in Figure 19. Although all the food samples had an appreciable rate of growth of aerobic mesophiles from the morning to afternoon, that of fufu was quiet high. The mean microbial growth in the fufu ranged from $4.7 \pm 1.58 \log_{10} \text{cfu/g}$ in the morning to $6.4 \pm 0.75 \log_{10} \text{cfu/g}$ in the afternoon. It is also clear from Figure 23 that vegetable salad had the highest mean PCA counts ($6.7 \pm 0.17 \log_{10} \text{cfu/g}$), followed by red pepper ($6.6 \pm 0.79 \log_{10} \text{cfu/g}$) and fufu recording $6.4 \pm 0.75 \log_{10} \text{cfu/g}$. Besides, sausage also had relatively microbiologically
significant aerobic mesophilic count of $5.4 \pm 1.36 \log_{10} \text{cfu/g}$ in the afternoon. All other food samples had mean contamination levels below the acceptable bacterial count in these foods of $<5.0 \log_{10} \text{cfu/g}$, in Ghana. Generally the microbial contaminations were higher for all food samples in the afternoon than in the morning.

There was no significant difference in the total mean microbial contamination in the foods sampled at Mampong circuit and other circuits as the analysis of variance showed significance value at $p>0.05$ (Appendix U). However, in the afternoon, there was a significant difference in total mean microbial load in foods sampled between Mampong circuit and other circuits at significance of $p<0.05$ (Appendix Y).

![Figure 19: A bar chart showing the mean PCA counts of samples from schools in Mampong circuit](image-url)

Figure 19: A bar chart showing the mean PCA counts of samples from schools in Mampong circuit
Mean distribution of microbes in food samples analysed in schools at Mampong circuit

The mean microbial distribution in food samples of schools in Mampong circuit is presented in figure 20a and 20b. Kenkey, banku and groundnut soup recorded no yeast and mould counts in the morning. In the afternoon however, groundnut soup recorded yeast and mould count of $0.4 \pm 0.7 \log_{10} \text{cfu/g}$ but kenkey and banku still showed no growth. All other food samples recorded yeast and mold counts in the morning with red pepper and fufu recording the highest count of $1.8 \pm 0.63$ and $1.9 \pm 0.69 \log_{10} \text{cfu/g}$ respectively. In the afternoon, although all food samples apart from kenkey and banku recorded an appreciable growth in yeast and moulds vegetable salad recorded the highest counts of $2.0 \pm 0.51$ (Figure 20 a).

Also, there were no \textit{B. cereus} counts in groundnut soup, iced kenkey, banku and kenkey in the morning. All other food samples had different ranges of \textit{B. cereus} contamination in the morning as fufu, vegetable salad, macaroni, red pepper and fried fish had very significant counts. From Figure 20b banku, kenkey, iced kenkey and groundnut soup still had no \textit{B. cereus} count in the afternoon. It shows from Figure 20b that whereas all food samples had significant growth of \textit{B. cereus} with vegetable salad leading, only fufu experienced no growth in the afternoon. Similarly kenkey, banku, iced kenkey and groundnut soup had no \textit{E. coli count} in the morning and afternoon as Shito and wakye recorded the least counts. However, the rest of the food samples had quiet significant counts with red pepper sauce recording the highest count of $3.0 \pm 0.41 \log_{10} \text{cfu/g}$ in the morning. The afternoon saw an appreciable growth of \textit{B. cereus} in Shito ($1.5 \pm 1.32$), macaroni ($2.7 \pm 1.61$), fufu ($1.7 \pm 0.07 \log_{10} \text{cfu/g}$) and vegetable ($3.4 \pm 1.41 \log_{10} \text{cfu/g}$ ) with red pepper maintaining the lead of $4.0 \pm 1.52 \log_{10} \text{cfu/g}$ (Figure 224 b).
Figure 20a: A graph showing the mean distribution of microbes in food samples from schools in Mampong circuit in the morning.
Figure 20b: A graph showing the mean distribution of microbes in food samples from schools in Mampong circuit in the afternoon

**Mean PCA count of food samples tested in schools at Adukrom circuits**

The mean PCA count for food samples in the Adukrom circuit is presented by Figure 21. Shito had the highest count of \(4.2 \pm 0.88 \log_{10} \text{cfu/g}\), followed by fufu \(3.8 \pm 0.23 \log_{10} \text{cfu/g}\) while wakye had the least count of \(1.0 \pm 0.70 \log_{10} \text{cfu/g}\) in the morning. All other food samples recorded a mean mesophilic aerobic counts ranging from \(1.4 \pm 0.6\) to \(3.6 \pm 0.49 \log_{10} \text{cfu/g}\) in the morning. In the afternoon, fufu, macaroni, red pepper, fried fish; vegetable salad sausage and shito had a mean PCA count ranging from \(3.9 \pm 0.37\) to \(5.2 \pm 0.53. \log_{10} \text{cfu/g}\). Meanwhile, the
acceptable bacterial count of Ghana Standard Authority in these foods is $<5.0 \log_{10} \text{cfu/g}$. Thus the mean PCA counts were relatively higher than the acceptable levels. All other food samples however had a tolerable mean PCA count range of $2.2 \pm 0.24$ to $3.8 \pm 1.62 \log_{10} \text{cfu/g}$ (Figure 21).

In addition, the analysis of variance (Appendix U) indicated that there was no significant difference between the foods sampled at Adukrom circuit and the other three circuits in the morning ($p>0.05$). On the contrary, the analysis of variance (V) indicated a significant difference between the food sampled in Adukrom circuit and other circuits in the afternoon ($p<0.05$).

![Graph showing mean PCA counts for food samples in Adukrom circuit](http://ugspace.ug.edu.gh)

**Figure 21:** A graph showing mean PCA counts for food samples in Adukrom circuit
Mean distribution of microbes in food samples tested in schools at Adukrom circuit

Figure 22a and 22b presents the results of the mean microbial load in schools at Adukrom circuit. Almost all food samples had various degrees of Yeast and molds contamination (not exceeding $1.8 \log_{10} \text{cfu/g}$) in the morning except kenkey and groundnut soup which had no counts (figure 22 a). The trend remained the same in the case of groundnut soup and kenkey in the afternoon. However, there was an appreciable growth of yeast and molds in all food samples with fufu recording the highest count of $2.2 \pm 0.01 \log_{10} \text{cfu/g}$ in the afternoon. Also, there were no $B. \text{cereus}$ count in, groundnut soup, kenkey and banku in the morning and afternoon. Shito had no count of $B. \text{cereus}$ in the morning but showed a slight growth in the afternoon ($0.3 \pm 0.53 \log_{10} \text{cfu/g}$). The rest of the food samples had various levels of $B. \text{cereus}$ counts in the morning and showed slight growth in the afternoon. Fufu, however, had a very significant leap in microbial growth from $2.2 \pm 0.23 \log_{10} \text{cfu/g}$ in the morning to $3.2 \pm 0.01 \log_{10} \text{cfu/g}$ in the afternoon.

Additionally, as shown by Figure 22 (a) and (b), $E. \text{coli}$ were present in all the food samples except in Shito, sausage, fried fish, groundnut soup, iced kenkey, wakye, kenkey and banku in the morning. There were however relatively higher counts in red pepper and vegetable salad with a microbial load of $3.3 \pm 0.55 \log_{10} \text{cfu/g}$ and $2.8 \pm 0.56 \log_{10} \text{cfu/g}$ respectively in the morning. In the afternoon all food samples that had no growth remained the same except wakye which had a count of $0.5 \pm 0.01 \log_{10} \text{cfu/g}$. The rest of the food samples had an appreciable growth in $E. \text{coli}$ load with fufu leading in microbial growth from $1.6$ to $2.5 \log_{10} \text{cfu/g}$ (Figure 22a and 22b). Similarly, there were no $S. \text{aureus}$ count in groundnut soup, iced kenkey, kenkey and banku in both the morning and afternoon samples. In spite of the absence of $S. \text{aureus}$ load in wakye in the
morning, it recorded quiet significant counts in the afternoon ($1.4 \pm 0.85 \log_{10} \text{cfu/g}$). All other food samples had quite significant counts in the morning and continued to show an appreciable growth in the afternoon. Further, coliform had the highest count among all the microorganisms in the food samples. As shown by Figure 22a, there was no coliform count in Shito, groundnut soup, iced kenkey, kenkey and banku in the morning. This trend continued in the afternoon except in banku which showed a slight growth (Figure 22b). Sausage had the highest coliform count ($3.5 \pm 0.11$) while the rest of the food samples recorded varying degrees of contamination in the morning. All food samples that had coliform count in the morning recorded quite a significant change in microbial load in the afternoon with vegetable salad recording the highest count of $3.9 \pm 0.96 \log_{10} \text{cfu/g}$ (Figure 22b).

![Figure 22a: A bar chart showing the mean distribution of microbes in food samples from schools in Adukrom circuit in the morning](http://ugspace.ug.edu.gh)
Mean PCA count of food samples tested in schools at Larteh circuit

Figure 23 presents the mean PCA (total microbial) counts in the various food samples in the morning and afternoon analyzed in schools at the Larteh circuit. It is clear from Figure 23 that kenkey and banku had no PCA count in the morning. All other foods had varying levels of counts in the morning with wakye recording the least count (1.7 ± 1.56 log\textsubscript{10} cfu/g) while vegetable salad had the highest counts (5.8 ± 1.55 log\textsubscript{10} cfu/g). In the afternoon, all the food samples recorded PCA counts below reference standard of Ghana (less than 5.0 log\textsubscript{10} cfu/g)
except red pepper, vegetable salad, macaroni, fufu, fried fish and sausage recording 6.7 ± 0.39, 6.7 ± 0.26 6.4 ±1.03  6.3 ± 0.77, 5.6 ± 0.58 and 5.1 ± 0.81 respectively log$_{10}$ cfu/g.

The analysis of variance (Appendix U) revealed that there was no significant difference in the total microbial load between foods sampled in Larteh circuit and the rest of the circuits in the morning (p>0.05). However, there was a significant difference (p>0.05) between foods sampled at Larteh and the three circuits.

![Figure 23: A bar chart showing mean PCA counts for food samples in schools from Larteh circuit](image)
Mean distribution of microbes in food samples tested in schools at Larteh circuit

Figure 24a and 24b present the mean microorganisms in the various food samples analyzed in Larteh circuit in the morning. There were no yeast counts in wakye, fried fish groundnut soup, fufu, kenkey and banku. The rest of the food had different levels of contamination of yeast and counts below 1.0 log$_{10}$ cfu/g. Fufu had the highest \textit{B. cereus} counts (3.3 ± 0.00 log$_{10}$ cfu/g) followed by vegetable salad (2.7 ± 0.82 log$_{10}$ cfu/g.) and red pepper (2.1 ± 0.47 log$_{10}$ cfu/g. In the morning. Macaroni, sausage, fried fish and banku had counts less than 2.0 log$_{10}$ cfu/g. In the afternoon, there was \textit{B. cereus} count in food samples including groundnut soup, iced kenkey and kenkey that had no count in the morning. Fufu however recorded the highest count of 3.6 ± 0.00 log$_{10}$ cfu/g. while iced kenkey had the least count of 0.8 ± 1.33 log$_{10}$ cfu/g.

The results in Figure 24 shows that there were \textit{E. coli} counts in all the food samples in the morning except shito, wakye, fried fish, groundnut soup, iced kenkey and kenkey with vegetable salad recording the highest count of 2.6 ± 1.55 log$_{10}$ cfu/g. Apart from kenkey, all other food samples including those with no count in the morning recorded different levels of growth in \textit{B. cereus} count in the afternoon. Vegetable salad however maintained its lead with a count of 3.2 ± 1.66 log$_{10}$ cfu/g. Similarly, while there were no \textit{S. aureus} contamination in banku, groundnut soup, fufu, iced kenkey and kenkey, all other food samples had varied levels of contamination in the morning. Fried fish recorded quite significant \textit{S. aureus} counts of 2.6 ± 1.22 log$_{10}$ cfu/g in the morning and continued the lead in growth in the afternoon with a record of 3.6 ± 2.33 log$_{10}$ cfu/g. In the afternoon all food samples recorded quite a leap of growth in \textit{S. aureus} contamination except kenkey.
Furthermore, the results in figure 24a shows that coliform contamination was recorded in all food samples analyzed except wakye, groundnut soup, fufu, kenkey and banku in the morning. However vegetable salad had quite outstanding contamination level of $2.7 \pm 0.41 \log_{10} \text{cfu/g}$. followed by red pepper with a record of $2.4 \pm 0.96 \log_{10} \text{cfu/g}$ in the morning. Again, coliform counts in iced kenkey, fufu, kenkey and banku continued to be zero in the afternoon as groundnut soup recorded a slight microbial contamination. The rest of the food experienced varying degrees of microbial contamination with vegetable salad maintaining its lead with a count of $3.8 \pm 0.97 \log_{10} \text{cfu/g}$ in the afternoon.

Figure 24a: A bar chart showing the mean distribution of microbes in food samples from schools in Larteh circuit in the morning
Figure 24b: A bar chart showing the mean distribution of microbes in food samples from schools in Larteh circuit in the afternoon.

**Mean distribution of Salmonella in food samples tested in schools within the four circuits in the study area**

Figure 25 presents the mean occurrence of *Salmonella* in food samples analysed. Samples of Shito, waakye, macaroni, sausage, fried fish, groundnut soup, iced kenkey, kenkey and banku had no *Salmonella* present in them. However, the rest of the food samples notably red pepper sauce, vegetable salads and fufu tested positive (Table 7) and recorded various levels of *Salmonella* contamination in all the food samples from the circuits. Generally, samples of fufu had the highest contamination level of *Salmonella* among the three food samples. Meanwhile,
cooked food is supposed to have no *Salmonella* or zero cfu/g (ICMSF, 1996 and GSA, 2003). The presence of *Salmonella* species in cooked foods in the canteen regardless of their level thus implies non-adherence to good personal hygiene.

Figure 25: A bar chart showing the mean occurrence of *Salmonella* in food samples in all the circuits.
4.4.1 Biochemical confirmation

As shown by Table 7 *Salmonella* species isolates were confirmed biochemically by Triple sugar iron agar, Lysine decarboxylase, and urea agar base. According to Table 14, the biochemical confirmation of the *Salmonella* spp. using urea agar base, Lysine Decarboxylase and glucose TSI all tested positive. This is an indication of the presence of *Salmonella* spp. in the food samples.

<table>
<thead>
<tr>
<th>Test or substrate</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose (TSI)</td>
<td>+</td>
</tr>
<tr>
<td>Lysine decarboxylase</td>
<td>+</td>
</tr>
<tr>
<td>Urease</td>
<td>+</td>
</tr>
</tbody>
</table>
CHAPTER FIVE

DISCUSSION

5.0 Microbial load in the food samples analyzed in the selected schools’ canteens

High levels of microbial contamination at varying degrees were detected in most of the food types analyzed. Generally, samples of macaroni, vegetable, salad, fufu, red pepper sausage and fried fish from all the circuits recorded levels of contamination higher than the acceptable reference value of Ghana Standard Authority which prescribes values of $<5.0 \log_{10}\text{cfu/g}$ (GSA, 2003).

The results from the study showed that fufu, macaroni, red pepper, vegetable salads sausage and fried fish (Plate 8) carried the greatest risk of foodborne pathogens since they recorded relatively higher microbial load. Red pepper sauce recorded a rather high contamination with PCA counts of $5.7 \pm 0.14 \log_{10} \text{cfu/g}$ and $7.0 \pm 0.77 \log_{10} \text{cfu/g}$ in the morning and afternoon respectively. These microbial contamination were far above the national reference value of $< 5.0 \log_{10}\text{cfu/g}$. This phenomenon is expected since red pepper sauce is usually prepared from fresh vegetables and water and consumed with no further heating. All pathogenic microbes introduced via contaminated vegetables and water therefore survive and multiply if held for a longer time at ambient temperature (Ghana Standard Authority, 2003). Consumers who patronize this food are thus highly predisposed to foodborne diseases.

The results from the study also showed rather high levels of total microbial contamination in groundnut soup and Shito sauce in the afternoon. The relatively high microbial load in these sauces in the afternoon is somehow expected since most of the food vendors hardly heated their
cold food in the afternoon. When sauces are not stored well and reheated adequately, microbial contaminants can multiply. The above observation is therefore in consonance with that of Roberts (1982) who reported that preparation of foods long before consumption, storage at an ambient temperature, inadequate cooling and reheating and undercooking are recipes for food poisoning/foodborne disease outbreaks. The result from this study is comparatively higher than that of Mensah et al. (2002) who reported contamination level of $5.1 \pm 1.73 \log_{10} \text{cfu/g}$ in this kind of food in a study in Accra.

Although there were relatively moderate microbial contamination in macaroni in the morning and afternoon, there were certain circuits which had counts as high as $7.0 \pm 0.76$ in the afternoons. These figures were higher than the national reference value of less than $5.0 \log_{10} \text{cfu/g}$ and a value of $6.0 \pm 1.64 \log_{10} \text{cfu/g}$ recorded in similar study in Accra (Mensah et al., 2002). The high mean microbial contamination recorded in macaroni was not surprising because after boiling, a stew is stirred into the macaroni and serving of the food done with bare hands and fork or spoons. The continuous touch of the macaroni with bare hands is bound to cause cross-contamination. Similar to macaroni, vegetable salad recorded high mean PCA count in the mornings and afternoons respectively among the circuits. The level of microbial contamination in vegetable salad (higher than the national reference value of $<5.0 \log_{10} \text{cfu/g}$) was not surprising because in Ghana all kinds of waste water are used to irrigate the vegetables in places with no natural water bodies. When such vegetables are not treated well during preparation of food they persist on the vegetable and cause all manner of sickness including foodborne diseases. The finding from this study is consistent with that of Ohiokpehai (2000) who reported in a study that the use of waste water in vegetable production causes a lot of health problems. In this study
as many as 60% of the food vendors indicated that they washed their vegetables with only water before it is added to the salad. The high PCA count in vegetable salad is consistent with that of Mensah et al. (2002) who in a study of street foods in Accra reported a microbial contamination of $6.3 \pm 0.78 \log_{10} \text{cfu/g}$ in vegetable.

Sausage had a mean microbial load within the range of $2.4 \pm 0.24 \log_{10} \text{cfu/g}$ to $4.1 \pm 0.34 \log_{10} \text{cfu/g}$ and $4.9 \pm 0.42 \log_{10} \text{cfu/g}$ to $6.7 \pm 0.56 \log_{10} \text{cfu/g}$ in the mornings and afternoons respectively. Although the figures recorded in the morning were quite tolerable, those recorded in the afternoons were quite high compared to the national reference value. The relatively high counts recorded in the afternoon might be as a result of repeated touching of the sausage with the bare hands. In this study, about 93% of the food vendors indicated that they sometimes touch their cooked foods with bare hands and this might account for the high microbial load in the food. Fried fish recorded quite a low PCA count in the morning. The mean afternoon PCA count ($5.8 \pm 0.18 \log_{10} \text{cfu/g}$) was however higher than the national reference value of $5.0 \log_{10} \text{cfu/g}$ and this should be a cause for concern. Jiwa et al., (1981) reported that fish and other fish and meat related meals had been implicated in food poisoning outbreaks. The high mean PCA count in fried fish can also be attributed to the constant touch it receives from the bare hands of food handlers during serving and non adherence to standard hygienic practices in food handling.

Generally, fufu was contaminated with unacceptable levels of microbes especially in the afternoons. The mean microbial load of fufu among the circuits were in the range of $3.8 \pm 0.23 \log_{10} \text{cfu/g}$ to $4.7 \pm 0.58 \log_{10} \text{cfu/g}$ in the morning and $5.9 \pm 0.01 \log_{10} \text{cfu/g}$ to $6.9 \pm 0.03 \log_{10} \text{cfu/g}$ in the afternoon (Figure 20, 22 and 24) with overall mean microbial count of $6.4 \pm 0.41$
The unacceptably high contamination of fufu is expected since its preparation involves using the bare hand in turning dough repeatedly in a mortar with occasional washing of the hand in a container of water. If food handlers do not practice good personal hygiene (which were seen in most cases) microbial pathogens on the hand, in the water, the pestle and from the surroundings may be introduced into the food. Upon storage at ambient temperature or temperature danger zone (37°C to 60°C), the microorganisms multiply and cause foodborne disease in the unsuspecting consumer after consumption. A similar study by (Mensah et al., 2002) in Accra reported high bacteria count of $6.2 \pm 1.57 \log_{10} \text{cfu/g}$ in fufu. In addition, groundnut soup generally had quite acceptable microbial counts in all circuits except Larteh which recorded $5.1 \pm 0.49 \log_{10} \text{cfu/g}$. This value was higher than the national reference value, and it might be due to storage at ambient temperature and inadequate reheating of the soups which are usually prepared in the previous day. This finding is consistent with the observation by Foriwaa and Dedo (2012) in a study in Kumasi (Ghana) noted that the high risk foods included soups, sauces with meat, chicken and fish.

Furthermore, waakye, iced kenkey banku and kenkey had relatively acceptable levels of PCA counts with overall mean PCA counts of $2.9 \pm 0.94$, $3.8 \pm 0.53$, $2.7 \pm 0.90$ and $3.8 \pm 1.01 \log_{10} \text{cfu/g}$ respectively in the afternoons. These counts are below the national reference values of $5.0 \pm 0.35 \log_{10} \text{cfu/g}$. These findings are expected because wakye, kenkey and banku were in most cases served hot although there were instances where the food vendors used bare hands to serve them. The relatively high temperature within which these foods were served made it difficult for microbial growth and might have accounted for low microbial load in them. This finding is in
consonance with the observation made by Mensah et al. (2002) who reported relatively low microbial levels among street foods served hot in a study in Accra.

Analysis of variance among all the four circuits indicated that there were no significant differences between them (circuits) so far as the microbial load recorded in the food sampled in the morning were concerned. There is therefore no appreciable difference in the total microbial contamination among the circuits in the foods sampled in the morning. This might be probably due to the fact that in the morning all cooked foods in the schools were generally hot and hence their low microbiological contamination among all the circuits. The quality and safety of most of the cooked foods sold in the school canteens were therefore high in the morning.

However, the analysis of variance of mean microbial contamination in the foods sampled in the afternoon revealed significant differences in mean microbial load among the circuits. The implication is that significant differences existed between at least two of the circuits so far as the total microbial load in the foods sampled in the afternoon were concerned. This trend was expected because the temperature and hygienic condition under which the cooked foods were stored in the canteen after the morning differed from one circuit to another circuit.

Yeast and moulds usually produce mycotoxins which are not totally destroyed through processing. In this study yeast counts in the food samples were generally low compared to the international reference standards value of $2.7 \log_{10} \text{cfu/g}$ (New Zealand Food Safety Authority, 1995). The mean yeast count ranged between $0.0 \pm 0.01 \log_{10} \text{cfu/g}$ to $1.8 \pm 0.54 \log_{10} \text{cfu/g}$ and $0.0 \pm 0.67 \log_{10} \text{cfu/g}$ to $2.2 \pm 0.54 \log_{10} \text{cfu/g}$ in the mornings and afternoons respectively.
These values were quite lower than the international reference standard for cooked foods. Although yeast in lower doses may not cause health hazard, FDA (2012) reported in a study that their metabolic activities may shift the pH of the cooked food and permit the multiplication of other harmful bacteria. The spores of yeast are ever present in the environment and they get into foods through infected equipment and air. Their presence in cooked foods therefore indicates poor hygienic practices of food handlers (not covering foods) and undercooking. The above values obtained for the food samples analysed were lower than the value $(4.9 \log_{10} \text{cfu/g})$ reported by Beatriz and Eliana (2000) in pre-cooked pizza in Rio Grande de Sul, Brazil.

Generally, there were negligible or relatively acceptable counts of *B. cereus* in all food samples in the morning and afternoon except in macaroni and vegetable salads (Appendix G). These two food samples had an overall mean counts ranging between $2.6 \pm 0.75$ to $2.9 \pm 0.48 \log_{10} \text{cfu/g}$ in the morning and $3.1 \pm 0.97$ to $3.2 \pm 0.49 \log_{10} \text{cfu/g}$ in the afternoon. There were also instances where macaroni and vegetable salads recorded values as high as $3.6 \pm 0.23 \log_{10} \text{cfu/g}$ and $4.1 \pm 0.76 \log_{10} \text{cfu/g}$ in the afternoon. The values obtained for macaroni and vegetable salads were quite high compared to the international reference value of $3.0 \log_{10} \text{cfu/g}$ (ICMSF, 1996). These levels of *B. cereus* contamination are high enough to produce emetic toxin in food, causing vomiting and diarrhoea or both in some cases. Turnbull (1996) observed in a similar study that *B. cereus* foodborne diseases occur because of the ability of the bacterial endospore to survive in undercooked foods. The high levels of *B. cereus* in the vegetable salad are not surprising because all manner of untreated water and animal manure are used in the cultivation of vegetables in most localities in Ghana. When such vegetables are not treated well during preparation, *B. cereus* which is common in the environment may persist in the food. Also, that there were high levels of
B. cereus contamination might be due to inadequate cooking of the macaroni nodule, improper handling of cooked foods and temperature abuse. This finding is consistent with the observation made by Bergdoll (1981) who reported that B. cereus is ubiquitous organism (found in soil, skin, water and dust) and can contaminate cooked food when good food hygiene is not practiced.

Further, the relatively low B. cereus counts in most of the food sampled might be due to their mode of preparation and storage. For instance the preparation of kenkey, banku and wakye, involves subjection of the food to temperatures exceeding 100°C for more than one hour. Under such conditions, most bacteria including B. cereus do not survive. Germination and growth of B. cereus generally occurs within the temperature range of 10-50 °C (Roberts, et al, 1996). It is therefore imperative that cooked foods are served hot in the canteen to avoid B. cereus contamination.

In general, S. aureus was present in almost all the food sampled in various levels of contamination except in kenkey and banku. Although red pepper sauce, fried fish and iced kenkey had relatively higher counts of S. aureus, the values were below the international limit. Vegetable salads however had a mean count of S. aureus (3.1 log_{10} cfu/g) higher than the international reference value of less than 3.0 log_{10} cfu/g in ready-to-eat foods (ICMSF 1996). Koneman et al., (1988) identified that the growth of S. aureus in foods produces heat stable toxin capable of causing foodborne illnesses. The bacteria counts in this study is quite consistent with a study on cooked food in Accra that showed that main meals (salads, macaroni, shito and fried fish) had high counts of pathogenic bacteria including S. aureus (Mensah et al., 2002). Since S. aureus is largely found in man's respiratory passages, skin and superficial wounds (Burt et al.,
2003), their presence in cooked foods implies non-adherence to standard hygienic practices during food preparation and handling (Ghana Standard Authority, 2003) and the contaminated nature of water used in preparing the food (Muleta, 2001). *S. aureus* are usually isolated from humans and their environments and their presence in cooked foods may connote human contact with food (NSW/FA. 2009).

Coliform are a yardstick of microbial contamination of cooked foods. High levels of coliform contamination in cooked foods thus connotes poor handling, processing and possible transmission of enteric pathogens (Wood *et al.*, 1983). In this study, groundnut soup, iced kenkey, fufu, kenkey and banku had lower levels of contamination both in the morning and afternoon. The relatively low level of coliform contamination in banku, groundnut soup and kenkey are expected judging from the high temperature these foods are subjected to during preparation. The rest of the food samples had relatively high levels of coliform contamination in the morning and afternoon. Moreover, vegetable salad recorded the highest mean level of contamination ($4.2 \pm 1.13 \log_{10} \text{cfu/g}$) among the circuits. These values were high relative to the international reference value of zero cfu/g (ICMFS, 1996) and the national reference value of 0.5 log$_{10}$ cfu/g but lower than $4.7 \log_{10}$ cfu/g found in cooked vegetable salad in Mexico (Hoonmo *et al.*, 2008). The presence of coliform in the food samples in this study indicates a substantially increased risk of the presence of pathogens (Moore and GriYth, 2002) and portrays possible health hazard. The implication is that food vendors do not practice good personal hygiene during preparation and handling of the cooked food in the canteen.
Transmission of pathogenic *E. coli* often occurs via faecal-oral transmission and common routes of transmission include unhygienic food preparation, farm contamination due to manure fertilization, and irrigation of crops with raw sewage (Heaton and Jones 2008, Gehlbach *et al.*, 1973). All samples of banku and kenkey had no *E. coli* count but the rest of the food samples had varying degrees of contamination of the bacteria both in the morning and afternoons. *E. coli* (which is indicative of faecal contamination) is found in the intestinal tract of humans and their presence in ready-to-eat foods implies poor hygiene and sanitation practices or poorly cooked foods (NSW/FA, 2009). That *E. coli* were present in food samples in the morning might be due to the fact that food handlers used contaminated water in preparing their foods and cross-contaminated it with faecal matter themselves. Meanwhile according to GSA (2003) there should be zero coliform and *E. coli* forming units per gram in cooked foods. High counts of *E. coli* in the range of \(2.1 \pm 0.43\) to \(2.6 \pm 0.01\), \(2.5 \pm 0.57\) to \(3.2 \pm 0.44\) and \(2.6 \pm 0.90\) to \(3.2 \pm 0.20\) \(\log_{10}\) cfu/g were however recorded in the mornings and afternoons in macaroni, red pepper and vegetable salad respectively. These values were highly unacceptable compared to the Ghana reference value of zero cfu/g (Ghana Standard Authority, 2003) and international reference value of less than \(2.0 \log_{10}\) cfu/g (ICMSF, 1996). The presence of *E. coli* in these food samples is an indication of faecal contamination probably at one stage of preparation or from the raw materials used. Other contributing factors may include wearing of dirty clothing, improper cleaning of dishes (Figure 11 and plate 1), unhygienic handling and serving practices, contaminated hands of food vendors and probably inadequate knowledge on food and personal hygiene (Fang *et al.*, 2003).
Salmonella sp. was generally not present in most of the food sampled. However fufu, pepper sauce and vegetable salad sample tested positive when confirmed biochemical (Table 7). These food samples may harbour Salmonella sp. microorganisms because of the way they are prepared. The mean Salmonella sp. load ranged from 0.2 to 0.9 log$_{10}$ cfu/g and 1.1 to 1.9 log$_{10}$ cfu/g in the morning and afternoon, respectively among the three food samples. According to the Centre for Food Safety (2007), any trace of Salmonella sp. in cooked food no matter the count makes the food highly unacceptable for human consumption. In Ghana, the maximum acceptable limit in cooked food for Salmonella sp. is zero cfu/g (Ghana Standard Authority, 2003). It implies therefore that these food samples (red pepper sauce, fufu and vegetable salad) sold in some of the school canteens were unacceptably contaminated with Salmonella sp. and hence unsafe for human consumption. Meanwhile Salmonella sp. is noted to be among the most dangerous foodborne bacterial pathogens in terms of human health and disease and remain the most frequently reported cause of foodborne outbreaks in the world (Olsen, 2000).

The Salmonella sp. contamination in the vegetable and red pepper sauce in the morning might be attributable to poor treatments of Salmonella sp. infested vegetables and the use of contaminated water in preparation of the sauce. Once these foods are not usually subjected to heat of high temperatures, any bacteria on the raw ingredients may persist and grow in their numbers.

Further, that fufu had quite high level of Salmonella sp. contamination was not unexpected. The preparation of fufu involves excessive use of the bare hand that is dipped periodically into a bowl of water to turn the cooked cassava dough in the mortar. The contamination may thus originate
from the water in the bowl; the untreated water used in washing the pestle and the mortar or improperly washed microbial infested bare hands of the food handler. It could also be possible that those food vendors who handled these food items were not clean and were probably carriers of the *Salmonella* *sp.* This argument is supported by Mensah *et al.* (1999) who reported in a study in Accra that food vendors are carriers of variety of enteropathogens including *Salmonella* *sp.* and defective personal hygiene facilitate the transmission of the pathogens via food to human.

**5.1 Knowledge of food vendors on food hygiene and foodborne diseases**

Generally, most of the food vendors were females with little or no formal education. This observation confirms the findings by Mensah *et al.* (2002) who reported in a study in Accra that most food vendors were women and had high illiteracy rate. Such illiterate food vendors are likely to engage in practices that may compromise the microbial quality and safety of cooked food in the school canteen. The study also revealed that food vendors had inadequate knowledge on hygienic practices of handling ready-to-eat foods. This was evidenced by the observation made in some of the school canteens. Hardly did food vendors change the bowl of water used in washing the dirty utensils and cutlery. Under such conditions, certain foodborne pathogens that can tolerate the dirty soapy water may grow and cause cross-contamination. Students who eat from such serving plates are highly prone to contract foodborne diseases.

Also, the study showed that although some food vendors treated raw vegetables with vinegar or salt solution, majority of them either washed the fresh vegetable with water or wiped them with napkins. This trend of affair might partly be attributed to the fact that most of the food vendors had their training in food handling from the home where probably they learnt from their parents
who had little or no knowledge on food and personal hygiene. Some pathogens are bound to remain on fresh vegetables and cause foodborne diseases when ingested under these conditions. Adams and Moss (1995) reported in a similar study that *Salmonella sp.* is resistant to various environmental factors, thrive at various temperature ranges and infect individuals who ingest food or water containing them. Fresh vegetables should therefore be treated well with vinegar or salt solution before they are used in the preparation of salad.

According to Mitakakis *et al.* (2004) food handling and storage practices in the home are major risk factors for gastroenteritis. This study revealed that although quite a good number of the food vendors stored their leftover cooked food in refrigerators, some of the vendors either stored their food in cupboards or openly in the kitchen. These conditions predispose the stored food to microbial contamination in situations where the leftover food is not well heated before consumption the following day. This finding is in line with the observation made by El-Sherbeeny *et al.* (1995), Bryan *et al.* (1992) and Lianghui *et al.*, (1993) who reported that food vendors prepare ready-to-eat food in bulk and store them for several hours after cooking including overnight holding at ambient temperatures.

Furthermore, the study showed that majority of the food vendors were not aware of the symptoms of foodborne disease as about 52% of them indicated that convulsion is a common symptom of foodborne diseases. Also, quite a few of the vendors (32%) indicated the passage of more than three liquid stools in a day as symptom of diarrhoea while a greater percentage of them chose other symptoms. This observation connotes sheer ignorance of the food vendors on the signs and symptoms of foodborne diseases. Likewise, on diseases that might prevent them from selling in the school canteen, majority of the food vendors chose malaria. This finding
demonstrates the food vendors’ rather low level of knowledge on foodborne diseases and food hygiene. There is therefore a high possibility that they may ignorantly sell unwholesome or contaminated food to the students in the canteen. The findings above are in consonance with the observation made by Walker et al. (2003) and Tebbutt (1992) who reported in a study that there is rather low level of knowledge of food handlers on hygienic and microbial safety of ready-to-eat food.

It was also obvious from the study that most food vendors (93%) touch ready-to-eat foods with their bare hands in the course of dishing out the food. In some instances, food vendors were seen using the same bare hands used in counting money to fetch pieces of cooked meat to unsuspecting students. This unhygienic practice can easily cause cross-contamination of food with pathogenic microbes such as *S. aureus* and is a clear indication of sheer lack of knowledge on food hygiene. Also, most of the food vendors (63%) did not wash their hands after blowing their noses in the course of serving food. Although almost all the respondents (99%) washed the hands after visiting the toilet, quite a few of them did it the right way. This practice has a negative implication for food safety since certain pathogens such as *S. aureus* mostly inhabit the hands, fingertips and skin of healthy individuals (Bergdoll, 1979) and can be easily transferred from the hands to cooked foods in the canteen.

It was also observed that majority of the vendors had little knowledge on personal hygiene and the hygienic way to handle cooked foods in the canteen. In general, the personal hygiene and the premises of most of the school canteens were quite poor and unsightly. Surroundings of most school canteens were closer to gutters and bush and were littered with all manner of waste.
materials. All these made the surroundings of the school canteens in the study area unsightly and attracted flies of all kinds that hovered on cooked foods (Plate 2, 5 6 and 7), a condition which contravenes food safety regulations. The above findings are consistent with the observation made by Rheinländer et al. (2008), Mensah et al. (2002) and Addo et al. (2007) who reported that ready-to-eat foods are generally prepared and sold under unhygienic conditions and food vendors are unaware that they could cause contamination to cooked food.

Regarding cooking utensils and the human hand being a possible source of contamination of cooked food, results from the study showed that most of the food vendors were uninformed. The above finding is corroborated by Nichol and Salek (2007) who asserted that most often food handlers are unaware of their role as a reservoir of infection. Besides, Barza (2004) reported in a similar study that the transmission of enteric-related pathogenic microorganisms via the hands of food handlers continues to be a problem in the food industry in recent times. In fact, majority of the food vendors (82 %) did not know that cooking utensils and the human hand can contaminate cooked food. This phenomenon is quite worrying in food safety since empirical evidence shows that cooking utensils and the human hand could be possible sources of foodborne illnesses (Mensah et al., 2002).

Notwithstanding the relatively high percentage of the food vendors who were aware of cross-contamination of ready-to-eat food through ingredients and water, the fact that some of them were oblivious of that fact put the health of students who patronize cooked food prepared by such food handlers in danger. Moreover, although majority of the food vendors (82 %) clearly demonstrated their awareness that garbage or refuse dump closer to cooked foods could cause
contamination, in practice it was observed that most school canteens were closer to dumping sites, open garbage bins, toilet and urinal with very weedy surroundings (Plates 5, 6 and 7). This shows that their level of awareness on sanitation issues did not match their actual practice in the school canteen. There is a very high tendency that food served under such conditions would be contaminated from the activities of flies and insect, a situation which compromises the microbial quality and safety of cooked foods. This finding contradicts the observation made by Monney et al., (2003) who reported in a study in Ghana that food vendors generally adhered to good hygienic practices so far as food handling and sanitation is concerned.

The results of a chi square test revealed that there was no significant relationship between the food vendors’ experience in food vending or handling and their knowledge on cooking utensil and garbage closer to the canteen as a possible source of contamination. This indicates that experience in food handling does not necessary guarantee good knowledge of food vendors on transmission of foodborne diseases.

**Students’ knowledge on food hygiene and foodborne disease**

The results from the study indicated that most students were aware of the existence of foodborne diseases. On the symptoms of foodborne diseases, the study revealed that majority of the students (75 % SHS and 69 % JHS students) had sufficient knowledge that will help them in the identification of foodborne diseases. The study also showed that majority of the students knew of symptoms of foodborne disease and were aware that foodborne diseases are caused by pathogens. This is evidenced by the fact that as many as 77 % SHS and 71 % JHS of the students indicated that they had ever suffered from diarrhoea accompanied with vomiting before.
The findings from this study are supported by the observation by Oyibo (2012) who reported high level of knowledge on basic personal hygiene and diseases among the school children in Nigeria. The students’ high level of knowledge on foodborne diseases may be ascribed to the teaching of health education in basic schools.

Regarding hand washing with soap before eating and eating with well washed spoon so as to prevent foodborne diseases, majority of both the SHS and JHS students showed a high level of awareness through their responses. The above findings are in consonance with the observation made by Steiner-Asiedu et al. (2011) who reported that students had quite a good knowledge on modes of transmission of diseases especially through dirty hands. This finding is also in support of that of Ejemot et al. (2008) who observed that students were aware that hand washing is among the range of hygiene promotion interventions that can break off the transmission of diarrhoea-causing pathogens. It follows therefore that once children acquire that knowledge it remains with them for life.

On the possible transmission of foodborne pathogen through water and dusty environment, majority of the students demonstrated high level of knowledge. However in practice, some few students were seen eating close to a dumping site in the school canteen. This unhygienic practice is a real recipe for disaster as cross-contamination of food from flies, insects and dust were imminent. The above observation is in line with the findings made by Tomlins et al. (2002) who reported in a survey conducted in Accra (Ghana) that most consumers did not know the association between poor hygiene and foodborne diseases.
CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.0 Conclusion

This study was set out to investigate the microbial quality and safety of food sold by food vendors in the various school canteens in the study area. Specifically, the study sought to assess the level of knowledge of food vendors and students on foodborne diseases and food hygiene and ultimately to determine the microbial levels of vended foods sold in the study area.

Most of the food samples analysed had $E. \text{ coli}$, coliform, $B. \text{ cereus}$, $S. \text{ aureus}$ and yeast present in them. $Salmonella \text{ sp.}$ contamination was only detected in fufu, pepper sauce and vegetable salad. The presence of $Salmonella \text{ sp.}$, $E. \text{ coli}$ and $S. \text{ aureus}$ in the food samples suggest that there was a risk of school children being exposed to contaminated food in the school canteens.

The microbial contamination of most of the cooked food was high in the afternoons compared to the morning in the study area. All the circuits recorded levels of contamination higher than the acceptable values of Ghana Standard Authority in food samples such as macaroni, vegetable salad, fufu, red pepper, sausage, and fried fish in the afternoon. Consumption of such cooked food in the canteens in the study area during the afternoons might therefore lead to contracting of foodborne diseases.

Food samples such as waakye, iced kenkey, banku and kenkey recorded relatively acceptable microbial contamination both in the morning and afternoon in the study area. The consumption
of these foods by students both in the morning and afternoon are therefore quite safer relative to the other cooked food in the school canteens.

Further, the study depicted that there was no significant difference in the total microbial contamination among the four circuits so far as cooked food sold in the mornings are concerned. However, there was significant difference in the microbial contamination in food sold in the school canteen during the afternoon among the four circuits. There is thus a high microbial load and health hazard in cooked food sold in the study area during the afternoon.

Almost all the food vendors in the study area were female and majority of them had no formal education. Generally the food vendors exhibited a rather unsatisfactory level of knowledge on foodborne disease and how it is transmitted. The high illiteracy rate coupled with low level of knowledge on disease transmission could lead to contamination of cooked food in the canteens unconsciously.

Food vendors also exhibited unsatisfactory level of knowledge on food hygiene and personal hygiene and operated under insanitary conditions. The potential therefore exist for disease outbreaks to occur due to consumption of food of low microbial quality in the school canteens.

Generally, most of the students had good level of knowledge on foodborne disease, food hygiene and personal hygiene. Students in the study area are therefore bound to abstain from purchasing food from food vendors who do not observe good hygienic practices so as to avoid contracting foodborne diseases.
6.1 Recommendations

Based on the results and discussion of the study, the following recommendations are made:

- It is important to put measures in place to assure the quality and safety of cooked foods served in the school canteens.

- It is recommended that monitoring of foods sold in the various school canteens be conducted by the regulatory authorities (e.g. municipal environmental and sanitation directorate) as quality checks. Also the municipal SHEP officers should frequently monitor school canteens to help improve upon the conditions under which food is prepared and sold.

- To ensure that food vendors comply with basic hygienic practices in the canteen, coordinators of the School Health Education Programme (SHEP) at the school levels should be educated on the rudiments of hygiene relating to foodborne diseases through workshops and in-service training.

- There is the need to ensure that food vendors are registered and educated regularly on food quality.

- There should be policies to regulate and ensure that school canteens are strategically located and not close to filthy location such as dumping sites and toilets.

- It is also recommended that massive education of food vendors on some basic concept on food and personal hygiene be embarked upon by the regulatory authorities to ensure quality and safety of food in the school canteens. In this connection, food vendors with
no certificate of fitness should be weeded out from the system. Moreover, food vendors should be advised to cook quantities of food just sufficient for the students from the morning to the afternoon so that the possibility of storing leftover cooked foods at ambient temperatures and their subsequent microbial contamination is avoided.

- In addition, measures should be put in place so that different groups of food vendor are made to sell their food in the morning and afternoon separately. This will ensure that food is sold and consumed in a hot state in the school canteen.

- It is further recommended that the teaching of health education be integrated in all subjects by teachers in our pre-tertiary schools to ensure that students acquire basic concepts and knowledge in personal hygiene and on foodborne diseases.

- Food vendors should be educated on the need to go for medical checkups at least once a year. The vendors should be made to appreciate the menace of diseases such as tuberculosis, cholera, typhoid fever and how they are transmitted.

- Further studies be conducted into the assessment of microbial contamination and critical control points (CCP) in the preparation and handling of vended foods in the homes of food vendors in the municipality.

- Further studies be conducted into assessment of causal link between hygienic practice of food vendors and foodborne disease transmission.

- Further studies be conducted into the assessment of the chemical and physical quality of cooked food sold in school canteens in the study area.
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APPENDICES

APPENDIX A: SAMPLE OF FOOD VENDORS’ QUESTIONNAIRE

Introduction

Dear respondent,

I am an M. Phil. student of University of Ghana, Legon pursuing a Master’s Degree in Science (Institute of Environmental and Sanitation Studies). I am currently conducting research on the “microbial quality of foods sold in schools in Akuapem North Municipality”. You have been chosen to be part of this study as a respondent. I therefore request you to kindly give your honest views on the questions below. The questionnaire is anonymous because we do not need your name so your views will remain confidential. Where you feel you cannot answer, feel free to skip. Thanks in advance.

Specific Instruction

Please tick (√) the appropriate boxes or fill in the blank spaces where necessary.

Section A: General information

1. Age
   (a) Below 20
   (a) 20-29
   (b) 30-39
   (c) 40-49
   (d) Above 50
2. Gender:  
   (a) Male  
   (b) Female  

3. What is the highest level of education you attained?  
   (a) Primary School  
   (b) Middle school  
   (c) Secondary School  
   (d) Vocational School  
   (e) No formal Education  
   (f) Arabic school  

4. How long have you been selling in the school?  
   (a) Less than 3yrs  
   (b) 3yrs -6yrs  
   (c) 7 yrs -10yrs  
   (d) More than 10yrs  

5. Have you ever received training in food hygiene and safety?  
   (a) Yes.  
   (c) No  

6. If your answer to 5 is yes where did you receive the training?  
   (a) From home (from mother)  
   (b) From formal training (vocational school)  
   (c) From health professionals / environmental and sanitation officers
7. Have you ever been screened and given health certificate?
   (a) Yes.  
   (b) No.  

Section B: Knowledge of food vendors on foodborne disease

8. Have you ever heard about food borne diseases?
   (a) Yes.  
   (b) No.  

9. Which of the following is a foodborne disease?
   (a) Malaria  
   (b) Typhoid fever  
   (c) Syphilis  
   (d) Others specify.  

10. What are the common symptoms of foodborne disease?
    (a) Diarrhoea / vomiting  
    (b) Rash  
    (c) Constipation  
    (d) Others specify.  

11. What is diarrhoea?
    (a) Passage of more than three liquid stools in a day
(b) Passage of Mucoid stools

(c) Passage of one liquid stool in a day

(d) Passage of bloody stool

(e) Other, specify

12. Which of the following will prevent you from selling cooked food in the school canteen?

(a) Malaria

(b) Diarrhea/vomiting/headache

(c) Convulsion

(d) Any other, specify

13. Which of the following are possible sources of food contamination in the transmission of foodborne diseases? Tick either ‘yes’ or ‘no’ where appropriate.

(a) Food Ingredients  Yes  No

(b) Drinking water  Yes  No

(c) Cooking Utensils/ serving plate  Yes  No

(d) Human hands  Yes  No

(e) Garbage in food vicinity  Yes  No

Section C: Knowledge of food vendors on hygienic practices of handling ready-to-eat foods

14. How do you clean your dirty serving plates and spoons after they have been used by students?
15. After buying vegetables from the market how do you treat them before they are
served with food?
(a) I wash them with water
(b) I use clean clothing to wipe them
(c) I use vinegar or vinegar to wash them
(d) Other, specify

16. Where do you store the leftover food?
(a) In refrigerator
(b) It is heated and stored in the cupboard
(c) I put it in the kitchen and heat the following day
(d) Other, specify

17. How do you store raw food items and cooked food in the house?
(a) I store them together
(b) I store them separately
(c) Other, specify

18. If you store them separately, why do you do that?
(a) To ensure that flavour of cooked food is maintained
(b) To stop bacteria transfer

(c) Others specify ............................................................................................................

19. How often do you serve or touch cooked food with bare hands in the canteen?
(a) Always □
(b) Sometimes □
(c) Not at all □

20. Indicate whether it is necessary to wash your hands after the following activities?
Tick either “yes” or “no” where appropriate.
(a) After using handkerchief to sneeze / blow the nose □ Yes □ No □
(b) After using the toilet □ Yes □ No □

21. If your answer to 20 is yes, indicate what you use for the hand washing:
(a) I use soap and water to wash my hand □
(b) I use only water to wash my hand □
(c) I use only warm water to wash my hand □
(d) I use warm water and soap to wash my hand □
(e) Others specify ............................................................................................................

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APPENDIX B: SAMPLE QUESTIONNAIRE FOR STUDENTS

Introduction

I am an M. Phil. student of University of Ghana, Legon pursuing a Master’s Degree in Science at the Institute of Environmental and Sanitation Studies. I am currently conducting research on the “microbial quality of foods sold in schools in Akuapem North Municipality”. You have been chosen to be part of this study as a respondent. I therefore request you to kindly give your honest views on the questions below. The questionnaire is anonymous because we do not need your name so your views will remain confidential. Where you cannot answer, feel free to skip it.

Specific Instruction

Please tick (√) the appropriate boxes or fill in the blank spaces where necessary.

Section A: General information

1. Form.
   (a) JHS 1 
   (b) JHS 2 
   (c) JHS 3 
   (d) SHS 1 
   (e) SHS 2 
   (f) SHS 3 
   (g) SHS 4 

Section B: Student knowledge on food borne diseases
2. Have you ever heard about food borne diseases?
   (a) Yes. 
   (b) No

3. What do you understand by the term foodborne disease?
   (a) Any disease one get when one does not eat balanced diet
   (b) Any disease one gets when one does not eat frequently
   (c) Any disease acquired from eating contaminated foods
   (d) Other, specify

4. If your answer to item 4 above is “Yes” where did you hear about foodborne diseases?
   (a) From the mass media (radio, television etc)
   (b) From health professionals
   (c) In school (from my teachers)
   (d) From my parents
   (e) Other, specify

5. Have you ever had any health problems related to food yourself?
   (a) Yes.
   (b) No

6. If your answer to item 7 above is ‘yes’, what was the problem?
   (a) Malaria
   (b) Diarrhoea/vomiting
   (c) Constipation
   (d) Headache
7. What are the cause foodborne diseases?

(a) Germs / pathogens

(b) Witchcraft / wizard / witches

(c) Lack of exercise

(d) Any other, specify

8. How are foodborne diseases transmitted / spread?

(a) Through contaminated foods, hands and water

(b) Through air particles

(c) Through sex

(d) Other, specify

9. Which of the following measures will help to prevent/ avoid transmission/spread of foodborne diseases? Tick either “yes” or “no” where appropriate.

(a) Washing our hands with soap water before eating Yes No

(b) Eating with well washed spoons Yes No

(c) Eating food in hot state Yes No

10. What are the common symptoms of foodborne diseases?

(a) Headache

(b) Diarrhoea / vomiting

(c) Constipation

(d) Other, specify
## APPENDIX C: MEAN $\log_{10}$ CFU/G OF FOOD SAMPLED FROM SCHOOLS IN ADUKROM CIRCUIT

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PCA</th>
<th>Yeast and mold</th>
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<th>Staph. aureus</th>
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Legend: M represents food sampled in the morning and A represents food sampled in the afternoon.
APPENDIX D: MEAN LOG$_{10}$ CFU/G OF FOOD SAMPLED FROM SCHOOLS IN MAMPONG CIRCUIT

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Legend: M represents food sampled in the morning and A represents food sampled in the afternoon.
APPENDIX E: MEAN LOG$_{10}$ CFU/G OF FOOD SAMPLES FROM SCHOOLS IN LARTEH CIRCUIT

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<td>1.6</td>
</tr>
<tr>
<td>Kenkey</td>
<td>0.0</td>
<td>2.4</td>
<td>0.0</td>
<td>0.6</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Banku</td>
<td>0.0</td>
<td>3.8</td>
<td>0.4</td>
<td>0.8</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon.
APPENDIX F: MEAN LOG$_{10}$ CFU/G OF FOOD SAMPLES FROM THE SELECTED SCHOOLS IN AKORPONG CIRCUIT

<table>
<thead>
<tr>
<th>Food Sample</th>
<th>PCA</th>
<th>Yeast and mold</th>
<th>Bacillus</th>
<th>E.Coli</th>
<th>Staph. aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Shito</td>
<td>2.2</td>
<td>3.4</td>
<td>0.8</td>
<td>1.4</td>
<td>0.7</td>
<td>1.9</td>
</tr>
<tr>
<td>Wakye</td>
<td>1.1</td>
<td>2.9</td>
<td>0.3</td>
<td>0.6</td>
<td>0.7</td>
<td>1.8</td>
</tr>
<tr>
<td>Macaroni</td>
<td>4.9</td>
<td>7.0</td>
<td>0.8</td>
<td>1.6</td>
<td>2.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Red Pepper</td>
<td>4.7</td>
<td>7.0</td>
<td>1.6</td>
<td>2.0</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Vegetable</td>
<td>5.4</td>
<td>6.8</td>
<td>1.8</td>
<td>2.2</td>
<td>2.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Sausage</td>
<td>3.2</td>
<td>6.7</td>
<td>1.0</td>
<td>1.6</td>
<td>1.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Fried fish</td>
<td>3.6</td>
<td>5.5</td>
<td>0.3</td>
<td>0.8</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Grndnut soup</td>
<td>3.1</td>
<td>4.9</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>2.7</td>
<td>3.8</td>
<td>0.0</td>
<td>0.8</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Fufu</td>
<td>4.1</td>
<td>6.9</td>
<td>1.7</td>
<td>2.0</td>
<td>2.8</td>
<td>3.1</td>
</tr>
<tr>
<td>Kenkey</td>
<td>1.7</td>
<td>2.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Banku</td>
<td>1.6</td>
<td>2.7</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon
**APPENDIX G: MEAN LOG$_{10}$ CFU/G OF FOOD SAMPLES FROM ALL THE SELECTED SCHOOLS IN THE STUDY AREA**

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PCA</th>
<th>Yeast and mold</th>
<th>Bacillus</th>
<th>E.Coli</th>
<th>Staph. aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Shito</td>
<td>3.3</td>
<td>4.2</td>
<td>0.7</td>
<td>1.5</td>
<td>1.3</td>
<td>0.0</td>
</tr>
<tr>
<td>wakye</td>
<td>1.6</td>
<td>3.2</td>
<td>0.2</td>
<td>0.3</td>
<td>2.1</td>
<td>0.0</td>
</tr>
<tr>
<td>macaroni</td>
<td>4.3</td>
<td>6.3</td>
<td>1.1</td>
<td>1.6</td>
<td>3.2</td>
<td>2.1</td>
</tr>
<tr>
<td>pepper</td>
<td>4.5</td>
<td>6.5</td>
<td>1.7</td>
<td>2.4</td>
<td>2.9</td>
<td>2.5</td>
</tr>
<tr>
<td>vegetable</td>
<td>5.0</td>
<td>6.5</td>
<td>1.4</td>
<td>2.0</td>
<td>3.1</td>
<td>2.6</td>
</tr>
<tr>
<td>sausage</td>
<td>3.4</td>
<td>5.6</td>
<td>0.9</td>
<td>1.5</td>
<td>2.0</td>
<td>0.3</td>
</tr>
<tr>
<td>fried fish</td>
<td>3.6</td>
<td>5.5</td>
<td>0.4</td>
<td>1.1</td>
<td>2.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Grndnut soup</td>
<td>3.2</td>
<td>4.5</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>3.2</td>
<td>4.0</td>
<td>0.6</td>
<td>0.7</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>fufu</td>
<td>4.3</td>
<td>6.4</td>
<td>1.7</td>
<td>2.0</td>
<td>2.8</td>
<td>1.6</td>
</tr>
<tr>
<td>kenkey</td>
<td>1.5</td>
<td>2.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
</tr>
<tr>
<td>Banku</td>
<td>1.3</td>
<td>2.8</td>
<td>0.1</td>
<td>0.0</td>
<td>0.3</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon
### APPENDIX H: DESCRIPTION OF FOOD SAMPLES ANALYSED IN THE STUDY AND POSSIBLE SOURCES OF CONTAMINATION

<table>
<thead>
<tr>
<th>Food type</th>
<th>Description</th>
<th>Mode of cooking</th>
<th>Handling after cooking</th>
<th>Possible sources of contamination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable Salad</td>
<td>Mixture of fresh vegetables</td>
<td>No cooking</td>
<td>Served with spoon or hand</td>
<td>Fresh Vegetables, hands and equipment</td>
</tr>
<tr>
<td>‘Macaroni’</td>
<td>Extruded wheat flour</td>
<td>Partial boiling</td>
<td>Served with fork or hand</td>
<td>Hands and equipment</td>
</tr>
<tr>
<td>‘Fufu’</td>
<td>Pounded cassava with plantain, yam or cocoyam in mortar with pestle</td>
<td>Boiling and pounding</td>
<td>Placed in mortar and pounded with pestle while turning by hand with water as a lubricant</td>
<td>Equipment, hands and water</td>
</tr>
<tr>
<td>‘Ice kenkey’</td>
<td>Mashed kenkey mixed with milk sugar and refrigerated</td>
<td>No cooking</td>
<td>Packaged into polythene bag by hand</td>
<td>Hands, cold water</td>
</tr>
<tr>
<td>‘Banku’</td>
<td>Fermented maize dough dumplings</td>
<td>Heating with continuous stirring</td>
<td>Dumplings are made by hand in plate or calabash with cold water</td>
<td>Hands, equipment and cold water</td>
</tr>
<tr>
<td>Fried Sausage</td>
<td>A fresh sausage dipped in powderly spices</td>
<td>Frying</td>
<td>Packed into bowls by hand</td>
<td>Hand, spices dust from surrounding</td>
</tr>
<tr>
<td>Red pepper sauce</td>
<td>Fresh vegetables (tomatoes, onion, pepper mixed with water and salt added to taste)</td>
<td>Mashing/grind</td>
<td>Served with spoon</td>
<td>Fresh vegetables and water</td>
</tr>
<tr>
<td>‘Kenkey’</td>
<td>Fermented maize dough dumplings, dough corn husk</td>
<td>Wrapped in hand</td>
<td>Served hot with hand. The hand is occasionally water</td>
<td>Hands and cold water</td>
</tr>
</tbody>
</table>

143
covered with corn husk; or plantain dipped into cold water
boiling leaves and hand to reduce the burning
boiled sensation

Shito (fried) Mixture of pepper, tomatoes Frying Served with spoon Spoon and
black onions dried fish and prolonged storage
pepper) shrimp

Fried fish Fish Frying Stored at ambient Fork , hands and
Frying temperature until sold prolonged storage
Served with hand or fork

Groundnut soup Mixture of groundnut paste Boiling Served with ladle in hot or Fresh vegetable,
with tomatoes, cold state onto main meat/fish and
onions, pepper, fish dishes serving spoon.
or meat added

‘Wakye’ Rice, beans and a herbs to Boiling Poured into bowls and Bowls , hand and
colour served with hand and spoon

Also may be contaminated when stored in temperature dander zone (37-60°C)
### APPENDIX I: FOOD SAMPLES AND MICROORGANISMS ISOLATED IN THEM

<table>
<thead>
<tr>
<th>Food Sample</th>
<th>Microorganisms Isolated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shito</td>
<td>Bacillus Aureus, Yeast and moulds, Coliform, Staphylococcus aureus</td>
</tr>
<tr>
<td>Sausage</td>
<td>Bacillus cereus, Coliform, staphylococcus aureus, Yeast and molds, E. coli</td>
</tr>
<tr>
<td>‘Macroni’</td>
<td>Coliform, Bacillus cereus, E. coli, Staphylococcus aureus, Yeast and molds</td>
</tr>
<tr>
<td>Red pepper</td>
<td>Bacillus cereus, Coliform, Staphylococcus aureus, Yeast and moulds, E. coli</td>
</tr>
<tr>
<td>Vegetable salad</td>
<td>Coliform, E. coli, Bacillus aureus, Staphylococcus cereus, Salmonella, Yeast and molds</td>
</tr>
<tr>
<td>Sausage</td>
<td>Bacillus cereus, Coliform, staphylococcus aureus, Yeast and molds, E. coli</td>
</tr>
<tr>
<td>Fried fish</td>
<td>Coliform, E. coli, Bacillus cereus, Yeast and moulds, Staphylococcus aureus,</td>
</tr>
<tr>
<td>Groundnut soup</td>
<td>Coliform, E. coli, Bacillus cereus, Yeast and moulds, Staphylococcus aureus</td>
</tr>
<tr>
<td>‘Iced kenkey’</td>
<td>Coliform, E. coli, Bacillus cereus, Yeast and moulds, Staphylococcus aureus</td>
</tr>
<tr>
<td>‘Fufu’</td>
<td>Bacillus cereus, Coliform, Staphylococcus aureus, Yeast and moulds, E. coli</td>
</tr>
<tr>
<td>‘Kenkey’</td>
<td>Others</td>
</tr>
<tr>
<td>‘Banku’</td>
<td>Yeast and moulds, Bacillus cereus, Coliform</td>
</tr>
</tbody>
</table>
### APPENDIX J: STANDARD DEVIATION OF FOODS SAMPLED FROM SCHOOLS IN ADUKROM CIRCUIT

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PCA</th>
<th>Yeast and mold</th>
<th>Bacillus</th>
<th>E.Coli</th>
<th>Staph aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>Shito</td>
<td>0.88</td>
<td>0.53</td>
<td>0.66</td>
<td>0.24</td>
<td>0.00</td>
<td>0.65</td>
</tr>
<tr>
<td>Wakye</td>
<td>0.70</td>
<td>0.04</td>
<td>0.00</td>
<td>0.50</td>
<td>0.41</td>
<td>0.35</td>
</tr>
<tr>
<td>Macaroni</td>
<td>0.57</td>
<td>0.76</td>
<td>0.31</td>
<td>0.10</td>
<td>1.64</td>
<td>0.53</td>
</tr>
<tr>
<td>Red pepper</td>
<td>0.49</td>
<td>0.14</td>
<td>0.52</td>
<td>0.33</td>
<td>0.11</td>
<td>0.35</td>
</tr>
<tr>
<td>Vegetable salad</td>
<td>0.47</td>
<td>0.23</td>
<td>0.22</td>
<td>0.08</td>
<td>0.51</td>
<td>0.52</td>
</tr>
<tr>
<td>Fried sausage</td>
<td>0.64</td>
<td>0.58</td>
<td>0.62</td>
<td>0.14</td>
<td>0.20</td>
<td>0.14</td>
</tr>
<tr>
<td>Fried fish</td>
<td>0.57</td>
<td>0.65</td>
<td>0.57</td>
<td>0.29</td>
<td>0.19</td>
<td>0.10</td>
</tr>
<tr>
<td>Groundnut soup</td>
<td>0.49</td>
<td>1.35</td>
<td>2.13</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>0.63</td>
<td>1.62</td>
<td>1.89</td>
<td>0.70</td>
<td>0.50</td>
<td>0.00</td>
</tr>
<tr>
<td>Fufu</td>
<td>0.23</td>
<td>0.01</td>
<td>0.21</td>
<td>0.11</td>
<td>0.02</td>
<td>0.20</td>
</tr>
<tr>
<td>Kenkey</td>
<td>0.34</td>
<td>0.37</td>
<td>1.48</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Banku</td>
<td>0.96</td>
<td>0.24</td>
<td>1.15</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon.
**APPENDIX K: STANDARD DEVIATION OF FOODS SAMPLED FROM THE SELECTED SCHOOLS IN MAMPONG CIRCUIT**

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PCA</th>
<th>Yeast and mold</th>
<th>Bacillus</th>
<th>E.Coli</th>
<th>Staph. aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>Shito</td>
<td>0.84</td>
<td>0.85</td>
<td>0.65</td>
<td>0.85</td>
<td>1.19</td>
<td>0.50</td>
</tr>
<tr>
<td>Wakye</td>
<td>1.77</td>
<td>1.04</td>
<td>0.50</td>
<td>0.75</td>
<td>1.22</td>
<td>0.59</td>
</tr>
<tr>
<td>Macaroni</td>
<td>1.57</td>
<td>0.61</td>
<td>0.56</td>
<td>0.80</td>
<td>1.12</td>
<td>0.20</td>
</tr>
<tr>
<td>Red pepper</td>
<td>1.23</td>
<td>0.79</td>
<td>0.63</td>
<td>0.52</td>
<td>0.20</td>
<td>1.60</td>
</tr>
<tr>
<td>Vegetable salad</td>
<td>0.35</td>
<td>0.17</td>
<td>0.40</td>
<td>0.51</td>
<td>0.59</td>
<td>1.15</td>
</tr>
<tr>
<td>Fried sausage</td>
<td>1.52</td>
<td>1.36</td>
<td>0.66</td>
<td>0.39</td>
<td>0.58</td>
<td>1.05</td>
</tr>
<tr>
<td>Fried fish</td>
<td>1.46</td>
<td>0.90</td>
<td>0.68</td>
<td>0.77</td>
<td>0.86</td>
<td>1.11</td>
</tr>
<tr>
<td>Groundnut soup</td>
<td>1.52</td>
<td>1.78</td>
<td>0.00</td>
<td>0.74</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>0.82</td>
<td>1.19</td>
<td>0.57</td>
<td>0.80</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Fufu</td>
<td>1.58</td>
<td>0.75</td>
<td>0.69</td>
<td>0.60</td>
<td>0.39</td>
<td>0.49</td>
</tr>
<tr>
<td>Kenkey</td>
<td>0.53</td>
<td>0.31</td>
<td>0.00</td>
<td>0.85</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Banku</td>
<td>0.46</td>
<td>0.20</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon
# APPENDIX L: STANDARD DEVIATION OF FOODS SAMPLED FROM THE SELECTED SCHOOLS IN LARTEH CIRCUIT

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PC</th>
<th>Yeast mold</th>
<th>Bacillus</th>
<th>E.Coli</th>
<th>Staph aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Shito</td>
<td>0.49</td>
<td>2</td>
<td>0.98</td>
<td>0.34</td>
<td>0.92</td>
<td>0</td>
</tr>
<tr>
<td>Wakye</td>
<td>0.8</td>
<td>1.6</td>
<td>#NUM</td>
<td>1.3</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Macaroni</td>
<td>0.94</td>
<td>3</td>
<td>0.32</td>
<td>0.39</td>
<td>0.97</td>
<td>0</td>
</tr>
<tr>
<td>Red pepper</td>
<td>0.3</td>
<td>0.4</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable salad</td>
<td>0.15</td>
<td>6</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>6</td>
</tr>
<tr>
<td>Fried sausage</td>
<td>0.52</td>
<td>1</td>
<td>0.89</td>
<td>1.12</td>
<td>0.25</td>
<td>4</td>
</tr>
<tr>
<td>Fried fish</td>
<td>0.21</td>
<td>8</td>
<td>0.00</td>
<td>0.75</td>
<td>0.98</td>
<td>1</td>
</tr>
<tr>
<td>Groundnut soup</td>
<td>0.49</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>0.40</td>
<td>0</td>
<td>0.58</td>
<td>0.85</td>
<td>0.00</td>
<td>3</td>
</tr>
<tr>
<td>Fufu</td>
<td>0.21</td>
<td>7</td>
<td>0.00</td>
<td>0.24</td>
<td>0.00</td>
<td>2</td>
</tr>
<tr>
<td>Kenkey</td>
<td>0.00</td>
<td>5</td>
<td>0.00</td>
<td>0.98</td>
<td>0.00</td>
<td>2</td>
</tr>
<tr>
<td>Banku</td>
<td>0.00</td>
<td>3</td>
<td>0.75</td>
<td>0.75</td>
<td>1.88</td>
<td>2</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon
APPENDIX M: STANDARD DEVIATION OF FOODS SAMPLED FROM THE
SELECTED SCHOOLS IN AKROPONG CIRCUIT

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PCA 10</th>
<th>LOG Yeast and mold</th>
<th>Bacillus E.Coli</th>
<th>Staph aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shito</td>
<td>1.40</td>
<td>0.31</td>
<td>0.92</td>
<td>0.85</td>
<td>1.40</td>
</tr>
<tr>
<td>Wakye</td>
<td>1.01</td>
<td>0.56</td>
<td>0.85</td>
<td>0.56</td>
<td>1.05</td>
</tr>
<tr>
<td>Macaroni</td>
<td>0.99</td>
<td>0.76</td>
<td>0.75</td>
<td>0.75</td>
<td>0.85</td>
</tr>
<tr>
<td>Red pepper</td>
<td>0.84</td>
<td>0.77</td>
<td>0.41</td>
<td>0.41</td>
<td>0.56</td>
</tr>
<tr>
<td>Vegetable salad</td>
<td>1.21</td>
<td>1.18</td>
<td>0.38</td>
<td>0.38</td>
<td>0.56</td>
</tr>
<tr>
<td>Fried sausage</td>
<td>0.41</td>
<td>0.94</td>
<td>0.23</td>
<td>0.23</td>
<td>0.56</td>
</tr>
<tr>
<td>Fried fish</td>
<td>0.26</td>
<td>0.87</td>
<td>0.58</td>
<td>0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>Groundnut soup</td>
<td>0.44</td>
<td>0.68</td>
<td>0.00</td>
<td>0.00</td>
<td>0.56</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>0.17</td>
<td>0.57</td>
<td>0.68</td>
<td>0.68</td>
<td>0.56</td>
</tr>
<tr>
<td>Fufu</td>
<td>0.77</td>
<td>0.03</td>
<td>0.44</td>
<td>0.44</td>
<td>0.56</td>
</tr>
<tr>
<td>Kenkey</td>
<td>0.45</td>
<td>0.62</td>
<td>0.00</td>
<td>0.00</td>
<td>0.56</td>
</tr>
<tr>
<td>Banku</td>
<td>0.65</td>
<td>0.75</td>
<td>0.00</td>
<td>0.00</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon.
## APPENDIX N: STANDARD DEVIATION OF FOODS SAMPLED FROM ALL THE SELECTED SCHOOLS IN THE STUDY AREA

<table>
<thead>
<tr>
<th>Food sample</th>
<th>PCA LOG 10</th>
<th>Yeast and mold</th>
<th>Bacillus</th>
<th>E.Coli</th>
<th>Staph aureus</th>
<th>Coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
<td>M</td>
<td>A</td>
</tr>
<tr>
<td>Shito</td>
<td>0.49</td>
<td>0.42</td>
<td>0.98</td>
<td>0.34</td>
<td>0.92</td>
<td>1.60</td>
</tr>
<tr>
<td>Wakye</td>
<td>0.94</td>
<td>0.79</td>
<td>0.39</td>
<td>0.23</td>
<td>0.30</td>
<td>0.69</td>
</tr>
<tr>
<td>Macaroni</td>
<td>0.75</td>
<td>0.48</td>
<td>0.14</td>
<td>0.00</td>
<td>0.00</td>
<td>0.43</td>
</tr>
<tr>
<td>Red pepper</td>
<td>1.01</td>
<td>0.53</td>
<td>0.35</td>
<td>0.27</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>Vegetable salad</td>
<td>0.97</td>
<td>0.49</td>
<td>0.43</td>
<td>0.19</td>
<td>0.38</td>
<td>0.90</td>
</tr>
<tr>
<td>Fried sausage</td>
<td>0.73</td>
<td>0.77</td>
<td>0.05</td>
<td>0.16</td>
<td>0.19</td>
<td>0.27</td>
</tr>
<tr>
<td>Fried fish</td>
<td>0.45</td>
<td>0.39</td>
<td>0.33</td>
<td>0.27</td>
<td>0.44</td>
<td>0.34</td>
</tr>
<tr>
<td>Groundnut soup</td>
<td>0.83</td>
<td>0.73</td>
<td>0.53</td>
<td>0.32</td>
<td>0.00</td>
<td>0.76</td>
</tr>
<tr>
<td>Iced kenkey</td>
<td>0.58</td>
<td>0.23</td>
<td>0.62</td>
<td>0.12</td>
<td>0.13</td>
<td>0.38</td>
</tr>
<tr>
<td>Fufu</td>
<td>0.41</td>
<td>0.40</td>
<td>0.27</td>
<td>0.13</td>
<td>0.57</td>
<td>0.20</td>
</tr>
<tr>
<td>Kenkey</td>
<td>1.01</td>
<td>0.16</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.52</td>
</tr>
<tr>
<td>Banku</td>
<td>0.90</td>
<td>0.71</td>
<td>0.22</td>
<td>0.00</td>
<td>0.54</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Legend: M represents food sampled in the morning and A represents food sampled in the afternoon.
APPENDIX O: CHI-SQUARE TESTS BETWEEN EDUCATIONAL LEVEL OF FOOD VENDORS AND IDENTIFICATION OF FOODBORNE DISEASES

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>33.461(^a)</td>
<td>18</td>
<td>.015</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>38.082</td>
<td>18</td>
<td>.004</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.041</td>
<td>1</td>
<td>.839</td>
</tr>
</tbody>
</table>

N of Valid Cases 128

\(a\). 21 cells (75.0%) have expected count less than 5. The minimum expected count is .02.

APPENDIX P: CHI-SQUARE TESTS BETWEEN EDUCATIONAL LEVEL OF FOOD VENDORS AND THEIR KNOWLEDGE ON COMMON SYMPTOMS OF FOODBORNE DISEASES

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>35.488(^a)</td>
<td>18</td>
<td>.008</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>32.768</td>
<td>18</td>
<td>.018</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.362</td>
<td>1</td>
<td>.547</td>
</tr>
</tbody>
</table>

N of Valid Cases 128

\(a\). 21 cells (75.0%) have expected count less than 5. The minimum expected count is .04.
APPENDIX Q: CHI-SQUARE TESTS BETWEEN EDUCATIONAL LEVEL OF FOOD VENDORS AND THEIR KNOWLEDGE ON DISEASES THAT PREVENTS MIGHT PREVENT FROM SELLING IN THE SCHOOL CANTEEN

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>30.436a</td>
<td>18</td>
<td>.033</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>25.960</td>
<td>18</td>
<td>.101</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>128</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 21 cells (75.0%) have expected count less than 5. The minimum expected count is .05.

APPENDIX R: CHI SQUARE TEST BETWEEN EXPERIENCE IN SELLING AND FOOD VENDORS KNOWLEDGE ON GARBAGE/REFUSE DUMP CLOSE TO FOOD AS SOURCE OF CONTAMINATION

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.861a</td>
<td>3</td>
<td>.835</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.935</td>
<td>3</td>
<td>.817</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.680</td>
<td>1</td>
<td>.410</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>128</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 2 cells (25.0%) have expected count less than 5. The minimum expected count is 1.89.
APPENDIX S: CHI SQUARE TEST BETWEEN EDUCATIONAL LEVEL OF STUDENTS' VENDORS AND THEIR KNOWLEDGE ON THE CAUSES OF FOODBORNE DISEASES

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>13.196</td>
<td>6</td>
<td>.040</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>15.075</td>
<td>6</td>
<td>.020</td>
</tr>
</tbody>
</table>

N of Valid Cases: 150

a. 5 cells (41.7%) have expected count less than 5. The minimum expected count is 1.87.

APPENDIX T: CHI-SQUARE TESTS BETWEEN EDUCATIONAL LEVEL OF STUDENTS AND THEIR KNOWLEDGE ON COMMON SYMPTOMS OF FOODBORNE DISEASES

<table>
<thead>
<tr>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>15.842</td>
<td>6</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>15.878</td>
<td>6</td>
</tr>
<tr>
<td>Linear-by-Linear</td>
<td>.617</td>
<td>1</td>
</tr>
</tbody>
</table>

N of Valid Cases: 147

a. 5 cells (41.7%) have expected count less than 5. The minimum expected count is 1.90.
APPENDIX U: CHI SQUARE TEST BETWEEN TRAINING OF FOOD VENDORS IN FOOD HANDLING AND THEIR KNOWLEDGE ON CLEANING OF DIRTY SERVING PLATES AND SPOONS

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.551&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2</td>
<td>.759</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.578</td>
<td>2</td>
<td>.749</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.435</td>
<td>1</td>
<td>.510</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>126</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> 1 cells (16.7%) have expected count less than 5. The minimum expected count is 1.78.

APPENDIX V: CHI SQUARE TEST BETWEEN TRAINING OF FOOD VENDORS IN FOOD HANDLING AND THEIR KNOWLEDGE ON STORAGE OF COOKED FOOD ITEMS

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
<th>Exact Sig. (2-sided)</th>
<th>Exact Sig. (1-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.478&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>.489</td>
<td>.629</td>
<td>.334</td>
</tr>
<tr>
<td>Continuity Correction&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.201</td>
<td>1</td>
<td>.654</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.494</td>
<td>1</td>
<td>.482</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisher's Exact Test</td>
<td></td>
<td></td>
<td>.629</td>
<td>.334</td>
<td></td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.474</td>
<td>1</td>
<td>.491</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N of Valid Cases&lt;sup&gt;b&lt;/sup&gt;</td>
<td>125</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.42.

<sup>b</sup> Computed only for a 2x2 table
APPENDIX W: CHI SQUARE TEST BETWEEN TRAINING OF FOOD VENDORS IN FOOD HANDLING AND THEIR KNOWLEDGE ON HYGIENIC MEANS OF WASHING THE HAND

Chi-Square Tests

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>1.094a</td>
<td>3</td>
<td>.778</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>1.123</td>
<td>3</td>
<td>.772</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.591</td>
<td>1</td>
<td>.442</td>
</tr>
</tbody>
</table>

N of Valid Cases 121

a. 1 cells (12.5%) have expected count less than 5. The minimum expected count is 3.07.

APPENDIX X: RESULTS OF ANALYSIS OF VARIANCE FOR THE TOTAL MICROBIAL COUNT (PCA COUNT) IN THE MORNING AMONG THE FOUR CIRCUITS

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1.12915E+12</td>
<td>3</td>
<td>3.76384E+11</td>
<td>1.32858857</td>
<td>0.2772</td>
<td>2.816466</td>
</tr>
<tr>
<td>Within Groups</td>
<td>1.2465E+13</td>
<td>44</td>
<td>2.83296E+11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.35942E+13</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

APPENDIX Y: RESULTS OF ANALYSIS OF VARIANCE FOR THE TOTAL MICROBIAL COUNT (PCA COUNT) IN THE AFTERNOON AMONG THE FOUR CIRCUITS

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
<th>F crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>3.08718E+14</td>
<td>3</td>
<td>1.02906E+14</td>
<td>3.51801344</td>
<td>0.022653</td>
<td>2.8164658</td>
</tr>
<tr>
<td>Within Groups</td>
<td>1.28705E+15</td>
<td>44</td>
<td>2.92512E+13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1.59577E+15</td>
<td>47</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX Z: SCHOOLS AND NUMBER OF STUDENTS USED IN THE STUDY

<table>
<thead>
<tr>
<th>CIRCUIT /SCHOOL</th>
<th>NUMBER OF STUDENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ADUKROM CIRCUIT</strong></td>
<td></td>
</tr>
<tr>
<td>Presby JHS</td>
<td>12</td>
</tr>
<tr>
<td>Methodist JHS</td>
<td>12</td>
</tr>
<tr>
<td>Nifa Sec. Sch JHS</td>
<td>12</td>
</tr>
<tr>
<td>Nifa SHS</td>
<td>20</td>
</tr>
<tr>
<td>Presby SECTEC</td>
<td>20</td>
</tr>
<tr>
<td><strong>AKROPONG CIRCUIT</strong></td>
<td></td>
</tr>
<tr>
<td>Salem JHS</td>
<td>12</td>
</tr>
<tr>
<td>Methodist JHS</td>
<td>14</td>
</tr>
<tr>
<td>PTC Demon. JSS</td>
<td>12</td>
</tr>
<tr>
<td>Okuapemman SHS</td>
<td>20</td>
</tr>
<tr>
<td>High Mount Sinai SHS</td>
<td>20</td>
</tr>
<tr>
<td><strong>MAMPONG CIRCUIT</strong></td>
<td></td>
</tr>
<tr>
<td>Nana Ankobea-Takyi JHS</td>
<td>14</td>
</tr>
<tr>
<td>Methodist JHS</td>
<td>12</td>
</tr>
<tr>
<td>Presby JHS</td>
<td>12</td>
</tr>
<tr>
<td>Mampong Presby SECTEC</td>
<td>20</td>
</tr>
<tr>
<td><strong>LARTEH CIRCUIT</strong></td>
<td></td>
</tr>
<tr>
<td>Presby JHS</td>
<td>12</td>
</tr>
<tr>
<td>Anglican JHS</td>
<td>14</td>
</tr>
<tr>
<td>Roman Catholic JHS</td>
<td>12</td>
</tr>
<tr>
<td>Benkum SHS</td>
<td>20</td>
</tr>
<tr>
<td>Larteh Presby SECTEC</td>
<td>10</td>
</tr>
<tr>
<td>Mamfe High Girls SHS</td>
<td>20</td>
</tr>
</tbody>
</table>