UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

MICROBIOLOGICAL QUALITY OF FOOD CONTACT SURFACES IN SOME SELECTED SENIOR HIGH SCHOOLS' KITCHENS IN THE BONO REGION OF GHANA

BEATRICE NAA ADJELEY QUAO

JUNE, 2020

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200027524

A thesis in the Department of HOSPITALITY AND TOURISM EDUCATION, Faculty of Vocational Education, submitted to the school of Graduate Studies in partial fulfilment of the requirements for the award of the degree of Master of Philosophy (Catering and Hospitality) in the University of Education, Winneba

JUNE, 2020

DECLARATION

STUDENT'S DECLARATION

I, **BEATRICE NAA ADJELEY QUAO**, declare that this thesis with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE.....

DATE.....

SUPERVISOR'S DECLARATION

I hereby declared that the preparation and presentation of this thesis was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: GILBERT OWIAH SAMPSON (PhD.)

Signature.....

Date.....

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I give all the glory to God Almighty for the stenght g iven me throughout the course of my studies. Secondly,

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DEDICATION

This work is dedicated to my family for their love and support through out the course of my education.

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ABSTRACT

A high occurrence of acute infections and chronic sequelae will cost billions of dollars in medical expenses, lost productivity, and repeated recalls if no preventative steps are taken. The main goal of this study is to look into the microbiological quality of food contact surfaces in various Senior High Schools in Ghana's Bono Region specifically to evaluate the microbial load on the food contact surfaces, to classify the microorganisms that live on food surfaces and to to compare the contamination levels in the schools that were chosen. The study used an experimental design to test the microbiological consistency of food touch surfaces. The schools were categorized into three groups: A, B, and C, which served as strata. The study's findings were quantitatively analyzed. The Food Standard Code was used to determine the microbial quality of food, which was classified as adequate, fine, or unsatisfactory based on the microbial load. Comparing Levels of Microbial Contamination among the selected School Categories/Surface types were analyzed. The largest concentration of colony forming units of bacteria was found on wooden surfaces of food processing sites (school kitchens), due to gaps on the surfaces where food particles hide and ferment if not adequately washed.The study revealed that averagely E. Coli had the highest microbial count (3.69) followed by Staphylococcus (3.60), and Salmonella (3.41) respectively. Statistically, majority of microorganisms were found on wooden surfaces (4.05 log10 cfu/g),followed by iron and plastic surfaces which were almost identical (3.73 log10 cfu/g and 3.71 log10 cfu/g, averagely), while the kitchen staff's hands had the lowest count of 2.77 log10 cfu/g.Total Viable Count (TVC) and Total Coliform Counts (TCC) were highest in Category C schools with an average values of 4.33 and 3.34 log10 cfu) , indicating poor sanitation and the prevalence of microorganisms on food served in dining halls. It is recommended that, school administration should establish functional school health sanitation committees to supervise and report issues relating to food safety and hygiene practices in the schools' kitchens in order to promote good environmental cleanliness and personal hygiene.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Consumption of contaminated food containing pathogenic microorganisms and their toxins is one of the leading causes of death, illness, hospitalization, and economic losses (Azevedo, Albano, Silva & Teixeira, 2014). However, the vast majority of food-borne diseases that occur around the world go unreported. Every year, millions of people suffer from food-borne diseases, according to a study by the World Health Organization (WHO) (Estrada, Alcaraz, Satorres, Manfredi & Velazquez, 2014). One of the key goals of national and international food protection initiatives is to reduce the spread of these diseases (Abu, Abdul & Sani, 2018). This includes implementing a food safety management scheme focused on HACCP, Good Agricultural Practices (GAP), Good Hygiene Practices (GHP), and Good Manufacturing Practices (GMP), among other standards.

Foodborne illnesses continue to be a global issue, with developed countries experiencing higher rates of occurrence (Konecka-Matyjek et al., 2012). In 2010, the World Health Organization's Food-borne Disease Burden Epidemiology Reference Group recorded 582 million food-borne disease outbreaks and 351,000 deaths worldwide (WHO, 2015). Every year, contaminated food causes 1.5 billion cases of diarrhea in schoolchildren worldwide, resulting in more than three million premature deaths (WHO, 2015).

Ghana has an annual hospitalization rate of 420,000 people due to food-borne diseases, with a death rate of 65,000 people (Odonkor & Ampofo, 2013). Also, caterers who are well-versed in food hygiene have a hard time connecting dirty hands to the transmission of diarrheal pathogens in Ghana. Because of their possible contribution to foodborne illness, the hygiene and cleanliness of food contact surfaces inside food serving institutions

pose a health risk to children. While insufficient cooking, temperature abuse, and the use of contaminated raw ingredients have been linked to many cases of foodborne illness, cross-contamination between raw and cooked foods through food contact surfaces has also been identified as a significant risk factor (Djekic et al., 2016).

Utensils, hands of the worker, clothing of the worker, cooking equipment, facilities, and packaging material are all examples of food contact surfaces. Food contact surfaces are a major concern for food service facilities when it comes to preventing the spread of food-borne pathogens. These surfaces have been discovered to be a constant source of microbe transmission and also contribute to cross-infection (Huslage et al., 2013). During food preparation and consumption, large amounts of pathogenic microorganisms can contaminate food, water, and surfaces, resulting in illnesses.

Sani & Siow (2014) add to the debate about food contact surfaces and their link to foodborne diseases, stating that food contact surfaces are a major concern for food service facilities when it comes to controlling the spread of pathogens. Furthermore, according to Sani and Siow (2014), food service areas are considered vital to health, so the microbiological consistency of these surfaces, as well as non-food service surfaces in food service facilities like hospitals and schools, must be surveyed and assessed. While insufficient cooking, temperature abuse, and the use of contaminated raw ingredients have been linked to many cases of foodborne illness, cross-contamination between raw and cooked foods through food contact surfaces has also been identified as a significant risk factor (Estrada, Alcaraz, Satorres, Manfredi & Velazquez, 2014). Raw meat, poultry exudates, and other food residues can remain on kitchen surfaces without adequate cleaning and sanitizing, posing a risk of microbial contamination for raw vegetables or other foods (Abu, et al., 2018). Cross-contamination between raw and cooked foods via

food contact surfaces has also been identified as a significant risk factor for foodborne illness (Abu, et al., 2018). (Gurmu & Gebretinsae, 2013). The spread of bacteria between foods, surfaces, or equipment is known as cross-contamination. Raw food touching (or dripping onto) other food, raw food touching (or dripping onto) equipment or surfaces, or people touching raw food with their hands and then touching other surfaces or foods are the most common causes. Several studies have found that bacteria such as E. coli, Staphylococcus aureus, and Salmonella can survive on hands and equipment for hours or days after first coming into contact with them (Gurmu & Gebretinsae, 2013). As a result, the cleanliness of food contact surfaces could be used to assess the level of sanitation at a food establishment.

Food safety and consistency are ensured by testing foods and food contact surfaces for the presence of both pathogenic and spoilage bacteria (Estrada et al., 2014). Cross-contamination and foodborne illness are more likely if microorganisms can live and thrive on food contact surfaces. There are a variety of microbiological sampling methods available to detect the presence of microorganisms or soil on food contact surfaces in order to ensure that they have been properly cleaned and sanitized.

Microbiological monitoring of food processing environments may be done to ensure that cleaning and disinfection practices are successful, to assess the frequency of cleaning and disinfection, and to check for the existence of foodborne pathogens in the setting (Sunday, Nyaudoh & Etido, 2011). Microbiological surveillance may also be used to identify environmental sources of spoilage species, specify the frequency of special maintenance procedures, and assess the hygienic nature and fabrication of food processing equipment and facilities, according to Melonie (2010).

To detect bacteria on food contact surfaces, methods such as swabbing and plating on microbiological media or agar contact plates have been used in the past. The Swab/Swab-Rinse Process and the Contact Plate Method are the most widely used methods for food contact surface assessment in food operations (Jay et al., 2005).

A domestic bursar (senior matron), a group of assistant matrons, cooks and pantry men, and a procurement unit were all part of the catering system in Ghana's public senior high schools. The Food and Drug Administration (FDA), the Regional, Local, and District Assemblies, and the Environmental Health Protection Units (EHPU) are the state agencies in charge of regulation and surveillance to ensure that the primary hygiene standard is the Codex Alimentations hygiene requirements.

Students in Ghanaian senior high schools (SHS) are served three (3) square meals per day at school. As a result, SHS students rely heavily on school community feeding programs designed to support their growth, well-being, and overall healthy lifestyle, and their lives are at stake. Any big food contamination event would be catastrophic. In this regard, the study was carried out in a few senior high schools in the Bono Region to look into the microbiological quality of food contact surfaces in a few senior high schools.

1.2 Statement of the Problem

Despite the fact that Ghana has adopted many policy measures to regulate food contamination, there are still a number of sources of contamination that appear difficult to control (Sunday, et al., 2011; Van et al, 2010). There have been several reports over the years of various degrees of food poisoning epidemics in senior high school boarding houses in Ghana. A typical study included a case of food poisoning at Archbishop Porter Girls Senior High School, which resulted in incapacitation and death, prompting the

school's closure (Odonkor & Ampofo, 2013). Due to food poisoning, about 100 students in the same senior high schools experienced stomach pains, vomiting, diarrhea, and general fatigue after meals. Furthermore, in the same year, there was a record of 35 University of Ghana students who were hospitalized due to food poisoning.

According to Odonkor & Ampofo (2013), about 20 students from Awudome Senior High School were rushed to the hospital in Ho early Sunday morning for suspected food poisoning. On Thursday, December 5, 2019, officials from the Ghana College of Physicians and Surgeons visited Accra High School to investigate cases of alleged food poisoning among the students. This came after the Ghana News Agency (GNA) reported that 27 students had been hospitalized after eating in the school's dining hall.

Despite the fact that the vast majority of food-borne disease cases are minor, a large number of them are fatal. A high occurrence of acute infections and chronic sequelae will cost billions of dollars in medical expenses, lost productivity, and repeated recalls if no preventative steps are taken. As a result, possible outbreaks among schoolchildren are a major concern, as pathogenic bacteria illnesses can last up to 3–5 days. There is a lot of literature on evaluating foods served in our senior high school dining halls, but there is still a lack of research on the microbial quality of food contact surfaces in the Bono Area.

1.3 Objectives of the Study

The main goal of this study is to look into the microbiological quality of food contact surfaces in various Senior High Schools in Ghana's Bono Region.

1.3.1 Specific objectives

Specifically, the study sought to:

1. To evaluate the microbial load on the food contact surfaces.
2. To classify the microorganisms that live on food surfaces.
3. To compare the contamination levels in the schools that were chosen.

1.4 Research questions

The following research questions were posed as a guide towards the achievement of the stated objectives:

1. What is the microbial load on food contact surfaces?
2. What characteristics are linked to microorganisms found on food surfaces?
3. What is the difference in microbial contamination between the surface types in the chosen areas?

1.5 Study hypothesis

It was hypothesized for the study that:

1. (H1) Microorganisms found on wooden surfaces vary significantly from those found on other surfaces.
2. (H1) The microorganisms found on plastic surfaces vary significantly from one another.
3. (H1) The microorganisms found on cast iron surfaces show major differences.

1.6 Significance of the Study

The study will be used as a guide for policymakers in government departments, school administrators, and other key stakeholders in the development of policies regulating food safety, as well as the assessment and enhancement of school food services. The study's results would provide critical information to relevant agencies such as the Food and Drug Administration, the Health and Sanitation Directorate, and the general public in order to ensure that nutritious food is served at Sunyani Municipality's senior high schools. As it contributes to the stock of literature in the field of food safety and hygiene, this study report will be a point of reference for future relevant academic studies.

1.7 Organization of the Study

The research was divided into five parts. The first chapter provided background information, as well as the study's main goal, goals, and hypothesis. It also outlined the research questions that motivated the achievement of the research goals, as well as the study's reach and significance. The second chapter examined previous applicable literature in order to provide a thorough understanding of the topic. This chapter included a summary of the theoretical framework that served as the foundation for this study and was expanded to include different principles and empirical studies from other authorities.

The study's methodological methodology was explored in Chapter Three. The study design, sample and sampling technique, and data collection methods were all described. The chapter went on to clarify the data collection process, data processing system, and ethical concerns to ensure high-quality work. The fourth chapter centred on the findings' interpretation and discussion in relation to previous scientific evidence and the study's goals. The final chapter, Chapter Five, summarized the study's key findings, outlined conclusions, and provided suggestions for all stakeholders to consider.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Undertone

The thesis is built on the basis of a review of current theory in a field of inquiry that is related to the analysis. Theoretical structures, according to Polong, Tombe, and Begani (2012), are "critically underpinning an empirical thesis by providing vision and guidance for the study." The theoretical framework must demonstrate an interpretation of theories and principles applicable to the research subject and apply it to the study area's wider fields of knowledge. To underpin the present research, the theory of expected behavior (TPB) is extensively reviewed.

2.1.1 Theory of Planned Behaviour

The theory of planned actions (TPB) is an expansion of the theory of rational action that was necessitated by the original model's shortcomings in dealing with behavior over which people have only partial volitional influence. TPB was first proposed by Ajzen in 1985, and it was refined in 1991. According to the theory, the desire to execute the behavior is the most significant element that precedes it. Ahmad et al. (2013) sees the individual's intention to perform a given activity as the key factor in the theory of expected behavior, much as they did in the original theory of reasoned action. Intentions are thought to capture the motivating factors that affect a behavior; they are indicators of how much people are willing to work, and how much effort they want to put in to execute the behavior.

One of the most commonly used models for interpreting and modifying health attitudes and habits is the Theory of Planned Action (TPB) (Gurmu & Gebretinsae, 2013). Iintention is influenced by three independent variables, according to Polong, Tombe, and

Begani (2012): perceived behavioral influence (PBC), behaviors, and subjective norms. The PBC construct is used to describe a person's volitional influence over an action, and it is interpreted as a measure of how easy or difficult it is to execute the desired behavior. The degree to which the person believes he or she has influence over the behavior determines this behavioral intention (Lahou, Jacxsens, Daelman, Van Landeghem & Uyttendaele, 2012). Personal views about how difficult or convenient it is to execute the behavior influence perceived behavioral regulation. The attitude component depicts an individual's positive or pessimistic assessment of the potential effects of engaging in a desired behavior. The degree to which an individual has a favorable or unfavorable assessment or appraisal of the action in question is referred to as attitude by Abayneh, Nolkes, and Asrade (2014). Subjective norms underlying the success of the behavior, as well as the individual's mindset toward the behavior, are other influences that influence behavioral intentions. Subjective norm, as described by Ahmad et al. (2013), is an individual's view of whether or not significant others believe the behavior should be done. Finally, subjective standard refers to how people view normative norms and how motivated they are to meet those expectations. According to Holck, Axelsson, McLeod, Rode, and Heir (2017), the greater a person's desire to partake in an action, the more likely the behavior would be performed. However, it should be clear that a behavioral purpose can only be manifested in actions if the action is under volitional influence, that is, if the individual can choose whether or not to execute the activity.

2.2 Epidemiological importance of Microbial food borne diseases

Due to microbial infection, food is one of the most significant transmission pathways of diseases globally (Abu, Abdul, & Sani, 2018; Abayneh, Nolkes, & Asrade, 2018). (2014). The global introduction and reemergence of foodborne pathogens has elevated the

relevance of microbiological food safety and quality of public and health concerns. More than 250 foodborne disease sources have been reported worldwide (Lahou et al., 2012). Several food safeties controls have been introduced in different countries as a result of the rise of foodborne infectious diseases. According to Gurmu & Gebretinsae (2013), there is a scarcity of knowledge in developed countries about foodborne diseases. Bacteria, protozoans, viruses, and fungi are also exampling of microbial infection of food.

Food polluted with foodborne pathogens and microbial by-products including toxins may cause severe illnesses and financial losses (Bomfeh & Tano-Debrah, 2008). Foodborne infections cause more than 2 million deaths per year in developed nations, and over 2 billion illnesses worldwide (Amissah & Owusu, 2012). The elderly, babies, teenagers, and individuals with immune-compromised immune systems as a result of a defective immune system are the people who are most affected. As a result, it is important that developed countries give careful attention to public health.

According to a study conducted by the World Health Organization (WHO) in 2012, over 91 million people in Africa are affected. It was also reported that 2.2 million children die of diarrhea each year in developed countries, with more than 600,000 children dying each year in Southeast Asia as a result of consuming unhealthy food (Holck et al., 2017). Food derived from animals, new fruit, and street-vendered foods are among the foods linked to foodborne diseases in developed countries.

Foodborne disease outbreaks attributed to unsafe raw food, abused temperature, poor storage infrastructures, inadequate cooking, poor personal hygiene, improper handling methods, and cross-contamination of cooked food with uncooked raw food have increased the safety and quality of food produced for human consumption in developing countries over the years (Amissah & Owusu, 2012; Bomfeh & Tano-Debrah, 2008; Annan-Prah,

Amewowor, Osei-Kofi, Amoono, Akorli, Saka & Ndadi, 2011). In developed countries, food is produced primarily at home and in other facilities such as schools and hospitals. To avoid diseases, food handlers must maintain good personal hygiene (Annan-Prah et al., 2011).

The majority of foodborne disease outbreaks in developed countries are underreported or exaggerated. Nigeria, for example, has a population of over 170 million inhabitants. Foodborne disease outbreaks, on the other hand, are estimated to be just 90,000 a year. As opposed to Nigeria, Australia is a developing world with just 24 million inhabitants, or a ratio of 1:7. Despite the high quality of living, adequate water supply, constructive government policies, and food safety programs, foodborne diseases affect more than 5.2 million Australians per year. This reality suggests that at least 36 million people (75.2 million) in Nigeria are potentially affected each year. As a result, underestimating the prevalence of foodborne diseases in developed countries would have an effect on the types of interventions and strategies12 used to combat outbreaks.

Bomfeh & Tano-Debrah, 2008) provide a summary of microbial food protection and hygiene in Ghana, revealing that the majority of microbial food research was concentrated in Ghana's provincial capitals, with a special focus on the capital cities. The most attention has been directed at commercial food operations, especially street foods. However, information on institutional catering and other types of food hazards is minimal. According to the study, Enterobacter spp., Escherichia spp., and Staphylococcus spp. were the most common bacteria isolated in Ghanaian foods. as well as Pseudomonas spp (Foriwaa-Ababio, 2014).

According to a 2007 study by the Ministry of Food and Agriculture and the World Bank, one out of every 40 Ghanaians suffers from foodborne illness each year, with over 420,000 cases registered all year (Lahou et al., 2012). Despite major attempts to minimize the occurrence of such disease-causing pathogens in foods by proper farming practices and dietary controls, the problem persists. Food and Drugs Law, 1992 (PNDCL 305B), Animals (Control and Importation) Ordinance (Cap 247), Diseases of Animals Act, 1961 (Act 83), Food and Drugs (Amendment) Act, 1996 (Act 523), Tourist Board Decree 1973 (NRCD 224), Ghana Tourist Board (Amendment) Decree, 1977 (SMCD 80), and the Local Government Act, 1961 (Act 54); 1993 (Act 462) are among the laws and regulations (Marzano, Balzaretti 2011). The new hygiene principles are not legally binding (Ghana Standard Authority, 2013), but they are guidelines that the industry is expected to follow in order to ensure food safety.

Mensah, Yeboah-Manu, Owusu-Darko, and Ablordey (2012) found that the microbial content of sampled salads, macaroni, "fufu," "omo tuo," and red pepper had excessive amounts of pollution, according to a study conducted in Accra. Mesophilic bacteria were found in 69.7% of the foods tested. Bacillus cereus was found in 5.5 percent of the foods, while S. aureus was found in 31.9 percent. Enterobacteriaceae is included in 33.7 percent of the samples. Shigella sonnei and entero-aggregative E. coli are also present. Salmonella arizonae was isolated from light soup and E. coli was isolated from macaroni, potatoes, and tomato stew.

According to the Ghana Health Service Annual Report from 2011, there were 125,074 diarrhoea cases reported among people over the age of five. There were 1,832 cases of extreme dehydration and 71 deaths among them (Ackah, Gyamfi, Anim, Osei, Hansen & Agyeman, 2011). The Ashanti Area has the largest number of cases of acute watery diarrhoea (1,010.4 per 100,000 populations). The Central Region had the second highest

rate (766.2 per 100,000 populations). In comparison to the national average of 609.4 per 100,000 people, both regions had higher indices. Ghana has seen many significant cholera outbreaks in the last three decades. In 2014, the first case of cholera was reported on 10 June, but in less than three months, 16, 527 cases had been reported from eight regions, with 128 deaths (CFR: 0.8%). (Annan-Prah, Amewowor, Osei-Kofi, Amoono, Akorli, Saka & Ndadi, 2011).

Food touch surfaces, such as knives, chairs, and cutting boards, may be called direct sources of infection if the cleaning procedure is not performed correctly or the dishes and appliances are not dry after washing (Holck et al., 2017). Thorough sanitation and hygienic procedures are recommended as important strategies to minimize cross-contamination and the occurrence of food-borne diseases (Abu, Abdul, & Sani, 2018). Food touch surfaces in food processing and catering facilities are the primary concern due to the importance of monitoring the outbreak of pathogenic microorganisms. Given the significance of this question, the current study aimed to evaluate the microbiological quality of food contact surfaces in the kitchens of boarding senior high schools in Ghana's Brong region.

2.3 Food Bacteria of Health Concern

Pathogens in our ecosystem are life-threatening and have significant consequences. Because of their diversity and sophistication, they pose a health risk. Some of their abilitiesto live and/or proliferate in the presence of refrigeration and low oxygen concentrations, and the low numbers of certain pathogens do not prevent them from causing disease (Gurmu & Gebretinsae, 2013). Because of its high nutrient content, refined and preserved food can promote the development of a wide variety of microorganisms when not treated properly. Pathogens must successfully enter certain areas of the body and either produce more of themselves or develop a toxin that interferes

with normal body processes, according to Gurmu & Gebretinsae (2013). (Sharon, Peter, George, & Joseph, 2015).

Microbial infection shortens the shelf life of food and increases the risk of food poisoning. Foodborne disease outbreaks have resulted in widespread infection and even death. Every year, between 24 and 81 million cases of food-borne illness are registered in the United States, with meat and poultry accounting for 50 percent of all cases (Polong et al., 2012) Salmonella, Campylobacter, and Shigella are responsible for the majority of foodborne illness cases tracked by Food Net (a monitoring method used by public health authorities in the United States that captures food-borne illness in over 13% of the population). The total number of cases and mortality rate of food-borne disease caused by these pathogens is high, with Salmonella accounting for 31% of all food-borne deaths, followed by Listeria (28%), Campylobacter (5%), and E. coli O157:H7 (3%). (Amissah & Owusu, 2012).

Bacteria are the cause of 60% of foodborne illnesses that need hospitalization. The real occurrence of foodborne disease is underreported in the science world, and the international effects of foodborne illness is impossible to quantify (Center for Disease Control and Prevention (CDC), 2014). Despite this, approximately 2.1 million children in developed countries suffer each year from diarrheal diseases. Many of these diseases are thought to be transmitted by food or drink (WHO, 2010). Food is biological in nature and capable of providing nutrients to consumers, but it can also promote the growth of contaminating microorganisms.

Intoxications, parasites, and toxic-infections are the three forms of bacterial foodborne diseases. According to Sharon et al. (2015), foodborne bacterial intoxication is caused by ingesting food that contains preformed bacterial toxins, such as those created by Staphylococcus aureus and Clostridium botulinum, as a result of bacterial development.

In contrast, foodborne infection is caused by the consumption of food containing viable bacteria such as Salmonella or Listeria, which then develop and establish themselves in the host, resulting in sickness. Foodborne toxic infections, according to Sharon et al. (2015), occur when bacteria found in food, such as Clostridium perfringens, are swallowed and develop a toxin in the host. Pathogens can be found in the digestive tracts of healthy animals and, in some cases, humans. In nature, such microorganisms can be found on soil and plants, in animal waste, and on animal carcasses. Staphylococci are found on human skin surfaces and nasal passages. When infected with feces, water sources can contain pathogens (Amissah & Owusu, 2012). Foodborne pathogens have been linked to a variety of outbreaks, with Listeria monocytogenes, Salmonella spp., Escherichia coli, Staphylococcus aureus, Lostridium botulinum, Aeromonas hydrophila, Yersinia enterocolitica, and Campylocbacter jejuni being the most common (Dzotsi, Odoom, Opare & Davies-Teye, 2014).

Listeria Monocytogenes

Listeria Monocytogenes is a rod-shaped gram-positive bacterium. Meningitis, cepticemia, stillbirths, and abortion are all diseases caused by this pathogen in humans (Boaten, 2014). The ability of Listeria Monocytogenes to grow at 4°C under refrigeration is a significant concern; the optimal temperatures for growth are estimated to be -0.4°C (Adjzitey et al., 2011). It's also a facultative anaerobe capable of living and growing in low-oxygen environments like vegetable food packets (Adjzitey et al., 2011). Listeria Monocytogenes is found in the soil, on people's faces, in sewage, in water, in hay, in livestock feeds, in dust, in plants, and in humans (Polong, Tombe & Begani, 2012). It's also found in shrubs, wild grasses, corn, cereals, and dead vegetation, as well as a variety of entire vegetables like cabbage, cucumber, and lettuce (Boateng, 2014). L. Monocytogenes is found naturally on many vegetables since it is common in soil and the farming climate in general.

Escherichia coli

Escherichia coli, also known as E. coli, is a type of bacteria. The term coli refers to a wide number of bacteria that are usually present in the environment.

in the flora of humans and animals' intestines Gram-negative, aerobic rods, Escherichia coli with pathogenic strains that contain an enterotoxin, but many of its strains aren't

Minnesota Department of Health deems it to be "harmless" (Boye, Hope & Dwomoh, 2015). And when the bacteria invade tissues outside of their usual intestinal or other less common normal flora sites do they become pathogenic. Infections are spread by consuming infected food, drinking contaminated water, or coming into close contact with a sick person or animals carrying the bacteria. When incubated at 35-37oC, they are classified as rod-shaped gram-negative non-spore forming organisms that ferment lactose and produce acid and gas (Boye, 2015).

Coliforms can be present in abundance in the feces of warm-blooded animals, as well as in the marine climate, soil, and on plants. Citrobacter, Enterobacter, Escherichia, Hafnia, Klebsiella, Serratia, and Yersinia are some of the most common genera. So, Escherichia coli (E. coli), a rod-shaped coliform, can be differentiated from most other coliforms by its ability to ferment lactose at 44°C, as well as its development and color reaction on specific types of culture media. E coli, unlike the rest of the coliform community, is almost entirely derived from feces, and therefore their appearance is a reliable indicator of fecal infection (Bekele, Zewde, Tefera, Feleke & Zerom, 2014; Boye, 2015).

Since the bovine gastrointestinal tract is thought to be the primary source for E coli, contamination of related food items with feces is a major risk factor. Contamination and the organism's ability to survive in natural water sources make them possible sources of

contamination, particularly if untreated water is ingested directly or used to wash raw foods.

E. coli infection symptoms normally appear three to four days after exposure, but the incubation period will last anywhere from one to ten days. The illness that is most often linked to travelers has a wide range of signs that differ from person to person. Extreme stomach cramps, diarrhea, vomiting, and fever are common symptoms. To prevent the spread of all foodborne illnesses, including E. coli, proper hygiene and safe food handling techniques, such as good slaughtering techniques, hygiene during slaughtering and dressing, and prompt adequate cooling, are essential.

Salmonella

Salmonella is a Gram-negative, noncore-forming, rod-shaped bacterium that belongs to the Enterobacteriaceae family. Salmonella typhimurium, S. enteritidis, S. Heidelberg, S. saint-Paul, and S. Montevideo are some of the pathogenic Salmonella bacteria. They are commonly distributed in nature, and typical gastroenteritis signs include diarrhea, nausea, stomach pain, vomiting, moderate fever, and chills (Bradeeba & Sivakumaar, 2012). Salmonellosis is a form of food poisoning caused by the enteric bacteria Salmonella. Salmonella germs have been believed to cause sickness for over a century. Infections will travel from the intestines to the bloodstream, and to other parts of the body, resulting in death unless antibiotics are administered promptly. The elderly, children, and those with compromised immune systems are the most seriously affected (Bradeeba & Sivakumaar, 2012).

Salmonellosis may also be caused by cross-contamination in the food service industry or at home during food preparation or handling. Salmonella bacteria can live and contaminate foods that haven't been cooked thoroughly. As a result, cross-contamination of foods after cooking is normal. As a result of unsanitary practices such as poor hygiene,

food handlers can pass salmonella from raw products to cooked or other uncontaminated foods. Salmonella is sensitive to heat, and ordinary cooking is sufficient to kill it in high-moisture foods. There are a number of steps that can be taken to reduce the incidence of Salmonella contamination of foods, but the most common method of eliminating Salmonella from food products is heating.

Salmonella are mesophiles, meaning they prefer temperatures between 35 and 430 degrees Celsius to rise. At 15 °C, the growth rate is significantly decreased, while at 70 °C, most Salmonella cannot develop. Salmonella can be found of large quantities in feces, waste, and waste-polluted water, and they can contaminate soil and crops as they come into contact with them. Sewage sludge can contain high levels of Salmonella, which can spread the bacterium when used in agricultural practices. It will survive for months after being released into the world (Polong et al., 2012). Many mammals, animals, cattle, birds, reptiles, fish, amphibians, and insects have been found to carry this microorganism. Salmonella enters humans primarily through food, especially foods derived from animals. Salmonella has also been isolated from a variety of raw, uncooked foods (Annor & Baiden, 2011).

Staphylococcus aureus is a type of bacteria.

Staphylococcus aureus has long been regarded as one of the most dangerous bacteria.

that causes disease in humans (Buccheri, Mammina, Giammanco, Giammanco, La Guardia & La Guardia & La Guardia & La Guardia & La Guardia & La Guardia & La Guardia & La Guardi 2010 (Casuccio). Many skin and soft tissue diseases, such as abscesses (boils), furuncles, and cellulitis, are caused by it (Buccheri et al., 2010). With the right environment for development, as well as other factors like temperature, pH, water activity (aw), and enough time, many strains of contaminating Staphylococcus

aureus will replicate and develop enterotoxins when the population is greater than 105 cells per gram. Individuals with respiratory infections' coughs and sneezes can bear droplets that can easily spread to the air and food being treated. As a result, any food that needs handling during cooking is susceptible to contamination. Contamination can also come from food handlers' infected cuts, lesions, and boils. However, the two most common causes of food poisoning are nasal carriers and people with boils and carbuncles on their arms and hands that are allowed to touch food (Hassan, Brit & Frank, 2010). Staphylococcus aureus is commonly found on the human body, particularly in moist environments such as the pits of the arms, the nose, mouth, and skin It contains a lot of poisons, one of which is deadly. Staphylococcal intoxication is the most common cause of food poisoning. Rapid heartbeat is one of the symptoms. Onset with vomiting (1–8 hours), often with diarrhea, which is normally self-limiting resolving in less than a day (Hassan et al., 2010). The organism's growth must be extremely rapid before enough toxin is created to induce illness in the food. The poison has a high heat tolerance. As a result, moderate pasteurization temperatures of 70°C, which can kill the cell, cannot be used to influence the poison (Annor & Baiden, 2011). Human skin colonizes Staphylococcus aureus, which causes inflammation in cuts and sores and is linked to boils. Staphylococcus aureus infection may also be caused by personnel handling activities and raw materials, especially met. The microorganisms are hindered by pH values of 4 and cannot expand in chilled conditions (10°C). If all other conditions are met, it can withstand very low water activity (aw) and emit enterotoxin at aw 0.86. (Bradeeba & Sivakumaar, 2012).

Nausea, vomiting, retching, stomach cramping, sweating, chills, prostration, slow heartbeat, shock, shallow breathing, and low body temperature are also common signs of staphylococcal intoxication. Staphylococcus aureus can thrive in a variety of foods, but proteinaceous foods like meat and meat products, poultry, fish and fish products, milk

and dairy products, cream sauces, salads, puddings, custards, and cream-filled baking products help development the most (Bradeeba & Sivakumaar, 2012). Staphylococcus aureus intoxications are often associated with institutions such as schools, where food is often cooked in vast amounts and stored before consumption. Contamination of the substance and development of the microorganism to levels at which toxin is formed is often caused by worker negligence and incorrect time-temperature combinations.

2.4 Review of Microbiological Food Safety

Despite the fact that certain foods are easily polluted with naturally occurring pathogenic microorganisms, safe food is a fundamental human right. Those pathogens cannot be detectable through sight, scent, or taste, but they may trigger disease of varying magnitude, even death, particularly if the way they are stored during service allows certain microorganisms to develop and contaminate significant amounts. As a result, food safety concerns are critical to global health (Dzotsi, Odoom, Opare & Davies-Teye, 2014). The global prevalence of foodborne illnesses is difficult to quantify, but Bradeeba & Sivakumaar (2012) say that 2.1 million people died from diarrhoea diseases in 2000 alone, with a large proportion of these cases due to food and drinking water poisoning. In today's world, illness caused by tainted food has been one of the most common public health issues.

Food provides humans with the energy and nutrients they need to survive, but it also acts as a pathway for pathogens to travel and evolve. Foodborne disease in humans and animals is caused by these pathogens. Foodborne pathogens may induce flu-like gastrointestinal symptoms like diarrhoea and vomiting, which are only a couple of the symptoms caused by foodborne pathogens. Foodborne illnesses continue to cause economic casualties and deaths in all countries around the world (Hassan et al., 2010).

According to Djekic, Kuzmanovic, Anelkovi, Saraevi, Stojanovi, and Tomaevi (2016), foodborne pathogens are the leading cause of sickness and death in developed countries, killing an estimated 1.8 million people per year. Systemic complications, such as kidney failure, fever, anaemia, headache, and death, are caused by bacteria invading deeper tissues or by the development of toxins that are then absorbed. Foodborne infection is expected to cause 76 million cases each year, with 325,000 hospitalizations and 5,000 deaths, according to the Centres for Disease Control and Prevention (CDC). Any foods are harmful to some people because they are likely to contain a certain pathogen. Infecting a pregnant woman with Listeria monocytogenes, for example, affects the developing foetus and can kill it, despite the fact that Listeria monocytogenes seldom causes disease in the general population (Djekic et al., 2016).

Food protection, which refers to the planning, preservation, and processing of food in ways that avoid foodborne illness, must continue to be one of the most pressing needs of the global food industry's survival. Food microbiological protection can be achieved by continuously monitoring both the manipulators (WHO, 2002) and the foods (Doménech-Sánchez, Laso, Pérez, & Berrocal, 2011).

Post-process pollution is a typical way for chemically produced goods to get polluted from the factory environment (Kornacki, 2000; Allan et al., 2004; Reij and Den Aantrekker, 2004). Pathogenic and spoilage microorganisms can develop in ready-to-eat food due to post-cook handling procedures, food additives, and the state and length of food storage at sale points (Khairuzzaman et al., 2014).

Food workers often mishandle food by exposing it to unsanitary environments, which are most often seen on the street (Bradeeba & Sivakumaar, 2012; Muinde and Kuria, 2005; Ghosh et al., 2007). Nutritious foods, such as beef, offer a favourable intrinsic

environment for contaminating pathogenic and spoilage microorganisms to colonize (Clarence et al., 2009). Foodborne pathogens such as E. coli 0157:H7, Listeria monocytogens, Camphylobacter jejuni, Clostridium perfringens, Salmonella spp., and Staphylococcus aureus have all been linked to animal products (Clarence et al., 2009). In addition, the use of infected food ingredients and kitchen appliances in the home may be a significant cause of a large number of foodborne pathogens (Medeiros et al., 2001; Beumer and Kusumaningrum, 2003; Redmond and Grifith, 2003).

Foods are often kept at inappropriate temperatures by caterers, and excessively treated by servers in filthy environments, according to a host of retrospective studies (Doménech-Sánchez, Laso, Pérez & Berrocal, 2011; Muinde and Kuria, 2005; Ghosh et al., 2007). Furthermore, caterers and vendors may have low personal hygiene, making them a possible cause of enteric fever transmission. Most caterers and vendors have either no formal education or just a few years of training, so they are unaware of proper food handling procedures and their role in pathogen transmission (Balzaretti & Marzano, 2013).

Food protection is now a global public health issue, and outbreaks have been recorded recently in Ghana and across Africa (Balzaretti & Marzano, 2013). Diarrhea caused by polluted and unhygienic food is one of the leading causes of illness and death in low-income countries, and many disease outbreaks have been linked to street food Bradeeba & Sivakumaar (2012). Diarrhoea has been identified as one of the leading causes of hospitalization in Ghana, with 16 percent of African children under the age of five dying from it (Soare, Garca-Dez, Esteves, Oliveira, Saraiva) (2013). Poor hygiene practices, particularly in areas where food and drinks are consumed, may lead to food poisoning and other food-borne diseases. When followed, diet and personal grooming have been shown to help avoid a variety of food-borne illnesses. It is widely acknowledged that

intentional or accidental food poisoning as a result of improper food handling can endanger the lives of consumers (Adzitey, Teye, Kutah, & Adday, 2011). Several hygiene habits have been identified as compromising food safety, including insufficient personal and environmental hygiene, insufficient food and beverage storage, and excessive food processing and cooking (Dzotsi, Odoom, Opare & Davies-Teye, 2014).

Some proponents describe food safety culture as a mix of "people + science" (Soare et al., 2013). In this case, science refers to the procedures used to detect and manage food hazards and threats, such as a Listeria environmental inspection program or a raw material segregation scheme. Forming and maintaining an efficient food safety culture necessitates the integration of research and thinking from three different disciplines: corporate culture, food science, and social cognitive science.

2.5 Microbial quality of food and Quality control

Man has always made attempts to prevent illnesses and discover ways to treat emerging ones in order to enhance and prolong life for decades and through different evolutions (Soare et al., 2013). Various illnesses have claimed the lives of people of all ages. Diseases, particularly those caused by our regular intakes and behaviors, such as food and hygiene, continue to be a danger to human health and life, according to Kadariya, Smith, and Thapaliya (2014). Unhygienic food and other sources of pollution of our everyday consumables have resulted in the deaths of millions of people around the world, as is widely acknowledged (Kadariya, Smith & Thapaliya, 2014).

Contaminated food and water are widely recognized as posing significant health risks to human and animal life around the world (Adzitey, Teye, Kutah, & Adday, 2011). As a result, it's no surprise that illnesses like cholera, diarrhoea, typhoid, and hepatitis occur and are a source of worry for public health officials. This is particularly true in Africa,

where a lack of schooling, corruption, weak public health policy, a lack of trained staff, and a poorly funded health system, among other factors, have left Africa, and specifically Ghana, vulnerable to any outbreak caused by unsanitary food (Sharon, Peter, George & Joseph, 2015).

Bacterial pollution of prepared foods has been linked to dirty, insufficiently or inadequately washed cooking appliances. Containers, generators, and tanks used for storing or shipping unprocessed raw materials have been used for manufactured goods without being cleaned or disinfected on occasion (Auad, Ginani, Stedefeldt, Nakano, Nunes, Zandonadi, 2019). To prevent pollution, equipment in the manufacturing establishment that comes into contact with food must be built in such a manner that it can be cleaned, disinfected, and maintained properly.

The transmission of microorganisms by staff, especially from hands, is critical. Bacteria are moved from infected hands of food staff to food and then to other surfaces during handling and preparation (Odey, Mboso, Ujong, Johnson, Gauje & Ategwu, 2013). Hands have been linked to low infectious doses of species like Shigella and pathogenic Escherichia coli as a source of infection (Afreen, Ahmed, Ahmad, Khalid, 2019). The causative mode of transmission has been described as poor hygiene, especially a lack of or absence of hand washing. Contaminated or unsanitary food can cause a variety of problems and diseases.

The sum of microbial contaminants in food is determined by its microbiological quality; a large degree of bacteria means poor food preparation and handling, making it more likely to spread infection, and vice versa (Odey et al., 2013). Various foodborne diseases have been linked to outbreaks of foodborne disease (Auad et al., 2019; Kadariya et al., 2014). However, factors such as handling, refining, storage, and show can affect the

microbiological load of foods at the point of preparation, service, or sale (Tassew, Abdissa, Beyene & Gebre-Selassie, 2010). Foods from canteens, roadside stands, and school kitchens have also been linked to outbreaks of foodborne illness. Since these foods are mostly cooked by hand, there is a higher risk of infection with possible foodborne pathogens including Staphylococcus spp (Afreen et al., 2019). The microbiology of foods prepared in hotels, domestic kitchens, canteens, on street corners by street vendors, and in schools has been studied previously (Tassew et al., 2010).

Food safety inspectors and food business owners have traditionally used three main methods to monitor microorganisms in food: instruction and preparation, facility and service inspections, and microbiological examination (Afreen et al., 2019). These programs aim to improve awareness of the sources and effects of microbial infection, as well as to assess infrastructure, procedures, and commitment to good best practices.

While these are important components of any food safety program, they do have certain shortcomings and flaws. Microbial counts in food are often used in retrospective microbiological quality assessments or to measure the presumptive "safety" of foods (Auad et al., 2019). Food must be sampled, microbiological tests must be conducted, and the results must be compared to previously defined microbiological specifications (Kadariya et al., 2014).

When it comes to inspecting buildings and processes, this is often done with a camera.

Various rules, such as proper hygienic practices and food control regulations, are referenced. The meaning of the different criteria is sometimes expressed in ambiguous words such as "satisfactory," "adequate," "reasonable," "suitable," and "if possible" (Konecka-Matyjek, Mackiw, Krygier, Tomczuk, Stos & Jarosz, 2012). Due to the lack of detail, the description is left to the Food Hygiene Officer, who in most situations uses his

or her discretion. The Inspector may put a low priority on critical issues, increasing costs without actually reducing food safety risks (Konecka-Matyjek et al., 2012).

Pathogenic bacteria (V. aeruginosa) are detected using microbial examinations. microorganisms that show signs of faecal contamination or other forms of general contamination or poor hygienic practices (coliform bacteria, faecal Streptococci) or for microorganisms that show signs of faecal contamination or other types of general contamination or poor hygienic practices (coliform bacteria, faecal Streptococci) (Odonkor, Ampofo, 2013). Furthermore, a negative screening for particular pathogens in a food sample does not guarantee that the whole batch is free of these pathogens (FAO/CDR, 2013). As a result, microbiological studies will only have a very small level of protection.

The other experiments have a host of drawbacks. The number of microorganisms (CFU/g) in a food component collected under optimum culturing conditions is known as Total Viable Count (TVC) or Aerobic Plate Count (APC) (Odonkor, Ampofo, 2013). As a result, the TVC is only a measure of the fraction of the microflora capable of producing colonies in the medium used under the incubation conditions, not a guarantee of the "total" bacterial population. As a result, it is well understood that the conditions of incubation have a significant impact on the number of colonies that emerge from the same sample (Bomfeh & Tano-Debrah, 2008).

When iced fish is sampled and Plates are incubated at 20 °C and 37 °C, for example, the TVC can differ by a factor of 10–100. (Khan, Islam, Chowdhury, Alim, 2015). Furthermore, since the TVC does not distinguish between different species of bacteria, comparable amounts of TVC can be identified even though the bacteria's biochemical

activity varies greatly in the food. Furthermore, high counts caused by microbial growth are far more likely to result in food defects (Khan et al., 2015).

Contamination of Food and Contributory Factors

Consumption of polluted food containing pathogenic microorganisms and their metabolites is one of the leading causes of death, cancer, hospitalization, and economic losses. Every infection caused by consuming food poisoned by disease-causing bacteria, viruses, or parasites; natural toxins in plants or animals is known as food poisoning (Auad et al., 2019). When food contains no dangerous material that could affect human or animal health, it is said to be hygienic (Auad). Despite this, microbiological and chemical risks in ready-to-eat foods, mostly pesticides from farm goods such as fresh vegetables and fruits, have been illustrated (Khan et al., 2015).

Improper handwashing, cross-contamination, and inadequate cleaning and sanitizing have all been reported as contributing factors to the transmission of foodborne diseases in studies. Handwashing has long been recognized as an effective public health measure for reducing the transmission of infectious disease. Handwashing is the single most effective method for avoiding the transmission of infection, according to Konecka-Matyjek et al. (2012). Bacteria, such as the foodborne pathogen Staphylococcus aureus, are naturally found on the human body, and seemingly healthy people may harbor foodborne pathogens like Salmonella or viruses like Hepatitis A. These people may be "carriers," capable of infecting others, but they may not be aware of it because they may not show symptoms or become ill (Ababio, Adi & Commey, 2012).

It is difficult to produce food that is virtually devoid of organisms (Montville and Matthews, 2005). Cheese, raw (unpasteurized) milk, deli meats, lettuce, salmon and smoked fish, ice cream, and hot dogs have all been connected to them (Zulfakar, Sahani, Hamid, 2018; Swaminathan, 2018).

Gerner-Smidt (2007) and Gerner-Smidt (2007). Ready-to-eat foods are often involved in listeriosis outbreaks (Mauro et al., 2008). The explanation for this is that these ready-to-eat foods are consumed without any further processing or care. The most often involved modes of transmission have been described as poultry and meat products (Zulfakar et al., 2018). Ensure food hygiene and safety practices among caterers is a long-standing problem, and the importance of food providers, especially in our boarding schools, adhering to high-standard food safety regulations and hygiene practices cannot be overstated (Khan et al., 2015)

2.6.1 Poor Hygiene Practices

In the home kitchen, the use of infected food ingredients and appliances is a significant cause of food-borne pathogens (Annor & Baiden, 2011; Ababio, Adi & Commey, 2012). Processors and sellers contaminate the meat with unclean water, pots, knives, clothing, and other products. It's also important for the pathogen to contaminate grilled meat sold in unsanitary environments, such as near exposed gutters.

2.6.2 Cross-Contamination

While poor cooking has been blamed for several cases of foodborne illness,

Cross-contamination between raw and cooked foods through food contact surfaces has also been reported as a significant risk factor, as has temperature abuse and the use of tainted raw ingredients (Zulfakar et al., 2018). Before any form of food preparation, it is

important to thoroughly clean and sanitize food touch surfaces in order to minimize or remove the possibility of cross-contamination. Fresh meat, poultry exudates, and other food residues may linger on kitchen surfaces, potentially contaminating raw vegetables and other ready-to-eat (RTE) foods (Zulfakar et al., 2018). Before the sanitizing procedure will begin, all food touch surfaces must be washed and thoroughly rinsed to remove all contaminants.

2.6.3 Environmental hygiene

The physical environment of a child care facility's food preparation areas can have an effect on hygienic food preparation. This, in particular, contributes to the risk of disease transmission. The most important aspects of the food processing areas, mainly found in research (Buccheri, Mammina, Giammanco, Giammanco, La Guardia, & Casuccio, 2010; Annor & Baiden, 2011; Argudin, Mendoza & Rodicio, 2010), are the food touch surfaces and their cleanability. Environmental microbiological experiments conducted in educational institutions have revealed that the use of quickly washed surfaces can help minimize environmental pollution and hence its role in disease transmission (Azevedo, Albano, Silva & Teixeira, 2014).

Primary food processing does not take place in environments where the presence of potentially dangerous compounds will result in an excessive amount of such substances in the food. To ensure sustainable food supply, food vendors should identify potential sources of pollution from the atmosphere. Dangerous microorganisms can be present in dirt, water, animals, and humans, and they are held on palms, cleaning cloths, and utensils, as well as cutting boards, and even the smallest contact with food can cause food borne diseases (WHO, 2012). According to Zulfakar et al. (2018), the following points can be used to ensure a sanitary environment:

1. Protection of food and food ingredients during handling, preparation, and transportation from rodents, environmental, physical, or microbiological pollutants, and other undesirable substances.
2. Food processing, food packaging, and other working environments, as well as the surrounding climate, must not be left to produce waste. Waste storage facilities must be kept clean.
3. Adequate drainage and waste disposal system and facilities should be provided. They should be designed and constructed so that the risk for contaminating food or the portable water supply is avoided (Huslage, Rutala, Gergen, Sickbert-Bennett & Weber, 2013).
4. Cleaning water should come from a protected source or be made safe.
5. Both surfaces and equipment used in food processing should be washed and sanitized (WHO, 2010).

2.6.4 Personal Hygiene

Food handling workers, according to the WHO, play a critical role in maintaining food safety in the food production, packaging, storage, and preparation chain (Bekele, Zewde, Tefera, Feleke, & Zerom, 2007). (2014). Food vendors' poor handling and disregard for hygienic measures can allow pathogens to come into contact with food and, in some cases, thrive and multiply in sufficient amounts to cause illness in the customer. When they have particular diseases, some food handlers can introduce biological hazards through cross contamination after processing raw materials, and physical hazards through careless food handling practices (Huslage et al., 2013).

The degree of interaction that food-handling workers are expected to have with specific types of food is linked to their ability to spread disease. The threats they face are evidently

diverse, raising the question of whether all such workers should be handled equally. Foodborne disease outbreaks are almost all caused by a failure to follow acceptable guidelines in the planning, harvesting, heating, storage, or retailing of food, according to investigations around the world (Ababio & Adi, 2012).

The most effective vehicle for transferring species from feces, nose, skin, and other places to food is the paws. Salmonella typhi, non-typhi salmonellae, Campylobacter, and Escherichia coli has also been shown to live on fingertips and other surfaces for different amounts of time, and in some cases even after handwashing (Huslage et al., 2013). When Staphylococci are part of the resident flora, they cannot be separated from the hands by washing (WHO, 2002).

As a result of humans containing microorganisms that they acquire genetically or from the environment, it is critical to practice proper personal hygiene. (Estrada, Alcaraz, Satorres, Manfredi, & Velazquez, 2014): Important hygienic considerations related to Personal Hygiene include:

1. Before handling food and sometimes during food processing, food vendors wash their hands.
2. When using the restroom, vendors wash their hands.
3. Food vendors' drying hands after and washing procedure.
4. Food vendors wearing clean protective clothing.
5. Food vendors wearing head covering.
6. Food vendors avoiding wearing of personal effects such as jewellery, watches, pins or other items in food handling areas.
7. Food vendors ensuring that cuts and wounds are covered by suitable waterproof dressings.

8. Food vendors refrain from smoking, spitting, chewing, or swallowing, as well as sneezing or coughing on unprotected food.
9. If you know or believe that you are sick from or carrying a disease or infection that is likely to be spread by cooking, food vendors cannot handle it (Estrada et al., 2014).

2.6.5 Materials and Equipment

Biofilms have formed on unclean food processing equipment (Mauro et al., 2008). They will thrive regardless of the temperatures, pH, or salt concentration in these places where the pathogen is found, as far as the processors or venders are concerned. As a result, the pathogen is able to colonize and adapt to a variety of environments (Jay et al., 2005; Mauro et al., 2008). At temperatures between 20 and 25 degrees Celsius, the pathogen also has a peculiar tumbling motility, but not at temperatures above 35 degrees Celsius (Ababio & Adi, 2012).

Micrococcus spp. and Staphylococcus aureus spp. are often found on the vending site's serving utensils, which may have come from the vendors' hands as they touched the food preparation areas, dishcloths, or the water during dishwashing or hand washing, indicating cross contamination of dishwater, food preparation surfaces, and the food itself. Bacteria from dirty dishwashing water and other sources have been confirmed to bind to utensil surfaces, posing a danger during the food vending process (Ameko, Achio, Alhassan & Kassim, 2012).

Stainless steel, plastic laminate, wood, grouted, and tile are some of the popular materials used as food contact surfaces, but stainless steel is the material of choice for food contact surfaces and work surfaces due to its mechanical ability, corrosion resistant, longevity, and ease of fabrication. Several studies (Ameko et al., 2012; Buccheri, Casuccio,

Giammanco, Giammanco, La Guardia, Mammina, 2007) have looked into the persistence of foodborne pathogens on stainless steel and other surfaces, as well as their role in cross-contamination. Pathogens such as Salmonella Enteritidis, Staphylococcus aureus, and Campylobacter jejuni have been shown to survive on stainless steel surfaces for hours or days, according to Kebede, Afera, Taddele, and Bsrat (2014). Furthermore, the presence of residual food waste on the soil, such as milk or chicken remains, is a significant factor in the pathogens' increased survival on the surface. Since pathogens were easily moved from kitchen sponges to stainless steel surfaces and then to foods, long-term survival poses a long-term cross-contamination risk.

When raw vegetables reach the manufacturing stages, they can become infected with pathogens. The number and type of microorganisms present at the outset are often determined by the substance and its source. The finished result is often less polluted than the raw vegetable, according to analysis of different production chains (Ameko et al., 2012). Since pathogen infection may occur during manufacturing and delivery, strict hygiene must be followed at all stages of the process. The properties of food poisoning microorganisms, as well as the inherent properties of the food and the effects of fermentation, storage, and packaging, all influence the production of food poisoning microorganisms on foods. Equipment, treating, slicing, touch, cleaning, packing, and storing are all possible manufacturing measures for each finished object. - of these processes has the potential to influence microbial colonization, survival, and development (Boateng, 2014).

Many raw foods, especially those of animal origin, are polluted with a wide range of microorganisms, and efforts to minimize microbial loads at different stages of development have generally failed (Gutierrez, Delgado, Sanchez, Martinez, Cabo, Rodriguez, Herrera, Garcia) (2012). The right implementation of manufacturing

technology such as pasteurization, irradiation, frying, freezing, and pickling at the agricultural, retail, and domestic levels is therefore critical to the removal of pathogenic species. Thus, the prevention of foodborne disease outbreaks is dependent on the proper implementation of these technologies, especially in terms of time and temperature management, as well as proper storage and cross-contamination prevention (Boateng, 2014).

Djekic, Kuzmanovic, Anelkovi, Saraevi, Stojanovi, &Tomaevi (2016) note in a related debate that basic steps such as washing and peeling the food will reduce the possibility of microorganism contamination from raw food. Furthermore, since proper cooking destroys almost all harmful microorganisms, experiments have shown that cooking food to a temperature of 700°C will help ensure it is safe to eat (Atter, Ofori, Anyebuno, Amoo-Gyasi & AmoaAwua, 2015). If food is kept at room temperature, microorganisms can multiply rapidly. The growth of microorganisms is delayed or stopped by keeping the temperature below 50°C or above 600°C, but certain harmful microorganisms will still grow below 50°C (WHO, 2010).

Depending on the nature of the food operations undertaken, adequate facilities should be available for heating, cooling, cooking refrigerating and freezing food , for storing refrigerated or frozen foods, monitoring food temperatures, and when necessary, controlling ambient temperatures to ensure the safety and suitability of food (Boateng, 2014). Important hygienic aspects related to Food Safety as stated in WHO (2010):

1. Separate raw meat, poultry and seafood from other foods.
2. Using separate equipment and utensils such as knives and cutting board for handling raw foods.
3. Storing food in containers to avoid contact between raw and prepared foods.

4. Washing fruits and vegetables, especially if eaten raw.
5. Removing outer leaves of leafy vegetables.
6. Cooking food thoroughly; make sure that the temperature has reached 700.
7. Reheating cooked food thoroughly.
8. Avoid leaving cooked food at room temperatures for more than 2 hours.
9. Refrigerating promptly all cooked and perishable food preferably below5°C (Boateng, 2014).

2.7 Empirical Review

Food workers have been linked to a series of food-borne disease outbreaks. Carrasco, Morales-Rueda, and Garcia-Gimeno (2012) performed 5-week epidemiological experiments to figure out what caused Texas' biggest Salmonella outbreak. Outbreak surveys, symptom surveys, cohort trials, follow-up surveys, environmental investigations, and lab analyses were among the techniques used. The epidemic, according to Beatty et al., was caused by a food handler's mishandling of food.

In a 2005 epidemic of food-borne norovirus in Barcelona, Spain, Barrabeig et al. (2010) demonstrated the function of an asymptomatic food handler.

Interviews and stool samples were used in a retrospective cohort analysis that targeted both exposed individuals and food handlers. To assess the connection between disease and food intake, the attack rate and relative risks were determined.

The norovirus was found in seven stool samples, according to Barrabeig et al. (2010), including that of an asymptomatic food handler who did not consume the implicated food but prepared and served the meal. Asymptomatic food handlers may be exposed to

infectious agents, necessitating the use of healthy food handling techniques, especially handwashing, at all times.

Chukuezi (2010) conducted a study in Owerri, Ngira, on food safety and hygienic practices among street food vendors. Structured interviews, semistructured questionnaires, and observational methods were used to gather data. The survey was conducted using a descriptive survey design. According to the findings, 23.81 percent of the vendors prepared food in unsanitary conditions, 42.86 percent did not use aprons, 47.62 percent handled food with bare hands, and 52.38 percent wore no hair coverings when serving food, and 61-90 percent handled money.

In Ilorin Secondary School in Nigeria, Carrasco, Morales-Rueda, and Garcia-Gimeno (2012) conducted research on food safety habits of food vendors. According to the report, premedical practice was strong (76%) among 185 respondents, but periodic medical review was low (30%). (16 percent). More than 61 (33 percent) and 72 (39 percent) respondents, respectively, cooked and reheated food prior to sale. Bad utensil treatment, 100 (57%) use of previously used water for washing and drying, lack of covering apron among food vendors 128 (69%) and lack of hand washing basin for immediate cleaning, lack of soap and water to clean their utensils, and the rest 100 (57%) used unhygienic methods to clean the utensils were the most common unhygienic habits found among the food vendors. Unclamp finger nails, skin infections, and inadequate fly safety are some of the food contamination risk factors.

Food pollution in Nigerian fast-food restaurants was investigated by Feglo and Sakyi (2012), who looked at the involvement of food handlers in food contamination. Feglo and Sakyi used a semi-structured questionnaire to gather information from 350 food handlers who were randomly chosen. The majority of food handlers exhibited traits that could

influence food safety, such as a lack of food safety instruction (52.6 percent) and a lack of understanding that microbes can contaminate food (57.4 percent).

Abayneh, Nolkes, and Asrade (2014) conducted a food safety survey and discovered that, worldwide, food and water borne illnesses resulted in 2.2 million deaths in 2012, out of a total of 1 billion cases recorded. In the United States, finfish was the second most often linked to foodborne illness, while fish and fishery goods were ranked seventh in the EU countries. Salmonella contamination was the leading source of FDA food recalls in 2010 (recalls due to biological/pathogen contamination).

Rheinlander (2012) discovered that while vendors and customers had a general understanding of food safety, the research did not focus on basic hygiene activities such as hand washing, utensil cleaning, raw vegetable washing, or ingredient selection. Hand washing, raw material washing, and utensil cleaning were not taken into account in Rheinländer's (2012) report. This gap in their research is being addressed, as hygiene activities such as food vendor hand washing and utensil cleaning behaviors are being considered in this study in Ghana's Bono area.

Because of their possible contribution to foodborne disease, the cleanliness and hygiene of food touch surfaces within catering and other food serving facilities pose a health risk to customers. While insufficient cooking, temperature misuse, and the use of tainted raw materials have been linked to several cases of foodborne illness, cross-contamination between raw and cooked foods through food contact surfaces has also been recognized as a significant risk factor (Cosby, Costello, Morris, Haughton, Davereaux & Harte, 2008). The Food and Drug Administration of the United States commissioned a study to determine the prevalence of such food intake and preparation behaviors linked to an elevated risk of foodborne illness. According to the poll, 26% of Americans do not

disinfect cutting boards after cutting raw meat or chicken (Sani & Siow, 2014). Failure to disinfect cutting boards can result in a higher chance of cross-contamination, which can lead to foodborne illness.

Another factor that contributes to foodborne disease is ineffective washing and sanitizing of food touch surfaces. Cross-contamination and, as a result, foodborne disease transmission can be avoided by thoroughly washing and sanitizing food touch surfaces before, during, and after food preparation (Tessema, Gelaye & Chercos, 2014). Cleaning is characterized as the complete removal of food soil under recommended conditions using suitable detergent chemicals. Sanitizing is the process of reducing microorganisms to levels that are considered healthy for public health (Tessema et al. 2014). According to Sani and Siow (2014), thoroughly cleaning and sanitizing food touch surfaces before some form of food processing is important to minimize or potentially remove the possibility of cross-contamination. Fresh meat, poultry exudates, and other food residues may linger on kitchen surfaces, contaminating raw vegetables and other ready-to-eat (RTE) foods with bacteria. Before the sanitizing procedure will begin, all food touch surfaces must be washed and thoroughly rinsed to remove all contaminants.

With the extensive use of stainless steel, laminated plastic-covered cabinets, vinyl tiles, and polyamide wall paint, kitchen surfaces must be durable and cleanable (Sunday, Nyaudoh & Etido, 2011). Several studies have looked at how foodborne pathogens survive on stainless steel and other surfaces, as well as how they contribute to cross-contamination (Kusumaningrum et al., 2003; Bomfeh . & Tano-Debrah, 2008). Pathogens such as Salmonella Enteritidis, Staphylococcus aureus, and Campylobacter jejuni can survive on stainless steel surfaces for hours or days, according to a report by Kusumaningrum and colleagues (2003). Furthermore, the presence of residual food waste

on the soil, such as milk or chicken remains, is a significant factor in the pathogens' increased survival on the surface.

Similar experiments have been carried out in classrooms and assisted-living facilities to assess the microbiological consistency of food touch surfaces. Adams and Moss (2008) completed a microbiological study of 40 school foodservice activities in Iowa, evaluating the efficacy of five food touch surface cleaning and sanitation systems. Food storage desks, cooking appliances, and serving trays were among the surfaces tested for cross-contamination. The best indicator of microbial infestation was included in the preparation tables.

Annan-Prah et al. confirmed the existence of Salmonella and Shigella bacteria on the surface of utensils and knives in a report performed and published in 2011 on street foods: handling, sanitation, and client preferences in Cape Coast, Ghana (Rane, 2011). It's also been documented that during food processing, raw materials are sliced and chopped with the same knife without being cleaned in between, and that such knives are often infested with flies (Rane, 2011).

The handling, vending, and hygienic consistency of street foods accessible to local people, domestic and international tourists in Cape Coast, Ghana's most important tourism hub, were investigated in the report. Meat pie (1.3 105), khebab (5 104), rice with stew (4.1 105), fried fish (8 104), pepper sauce (1.4 105), etsew or banku (3 105), beans with gari (2 104), fufu (1.6 105), waakye (6.6 105), and dakua (2.3 105) had the highest bacterial infection rate. The occurrence of faecal Escherichia coli was found in all of the food samples tested. Bacterial contamination levels of 5 log10 cfu/g were found in khebab, fried fish, and beans with gari.

In a survey conducted in Santa Fe de Bogota, Colombia, it was discovered that over 30% of food handlers tested were carriers of pathogenic bacteria such as Salmonella typhi, Staphylococcus aureus, Salmonella enteritidis, and Shigella sonnei (Sunday, Nyaudoh & Etido, 2011). The location of the stall (surroundings), poor personal hygiene, and poor food hygiene habits during cooking, preparing, and serving, inadequate supply of drinking water, poor storage system, open food bottle, inappropriate practices of taking out water from the pitcher, and long hours of food preparation, among other factors, could all contribute to pollution.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Research design

Using samples swabbed from the kitchens of the chosen senior high schools, the study used an experimental design to test the microbiological consistency of food touch surfaces.

3.2 Categorization of schools

The schools were categorized into three groups: A, B, and C, which served as strata. A school from each of the categories was randomly chosen using the lottery system for justice in terms of research representation from the said categories. The names of the schools in each category were written on pieces of paper, folded, and chosen blindfolded by an individual in this process. The thesis covered every school that was chosen after the act. The thesis enlisted the participation of three (3) colleges, from which samples were obtained for examination.

3.3 Sample Collection Procedures and Tools

To ensure consistent sampling on various surfaces, food handlers' palms were swabbed with sterile cotton swabs for 10-15 seconds on wooden surfaces (such as food storage tables, frying buckets, and chopping boards), plastic surfaces (such as serving cups, dishing out spoons, knives, and serving containers), and cast-iron surfaces (such as dishing out pots and lids). The cotton swabs were wrapped in a stomacher bag and shipped to the lab in an ice chest with ice packs at 10-40C for immediate microbial analysis. Total viable bacteria, aerobic plate count, total coliform, Escherichia coli (E. coli), Salmonella,

and Staphylococcus aureus were counted in food samples obtained from touch surfaces in the kitchens of the chosen senior high schools to assess the extent of bacterial infection.

3.4 Chemical Reagents

OXOID Laboratories, Basingstoke, Hampshire, England, provided the agars used. Plate Count Agar was used to isolate overall viable count; Mac Conkey Agar was used to estimate E. coli; Salmonella-Shigella Agar, peptone water, and selenite broth were used to isolate Salmonella; and Mannitol Salt Agar was used to isolate staphylococcus.

3.4.1 Preparation of Plate Count Agar

Count of Plates Agar (Nutrient agar) was made by suspending 23.5 grams in 1000 ml (1 liter) purified water and boiling it until it totally dissolved. It was sterilized in a sealed container at 121°C for 15 minutes. Until pouring onto sterile Petri dishes, the sterilized agar was allowed to cool to 50°C (Minnesota Department of Health (MDH), 2013).

3.4.2 Preparation of Mac Conkey Agar

The medium was made according to the OXOID form (Abayneh, Nolkes & Asrade, 2014). MacConkey Agar powder (52g) was thoroughly mixed in 1 liter of filtered water. To totally dissolve the powder, the solution was heated with frequent agitation and boiled. It was sterilized for 15 minutes at 121°C. Until plating, sterilized agar was allowed to cool to about 50 °C.

3.4.3 Preparation of Mannitol Salt Agar

Agar powder (111 g) was dissolved entirely after being suspended in 1 liter of purified water and brought to a boil. It was autoclaved at 121°C for 15 minutes to sterilize it (Abayneh, Nolkes & Asrade, 2014).

3.4.4 Preparation of *Salmonella Shigella* Agar (Ss Agar)

To dissolve the agar, 63g of agar powder was suspended in 1liter of purified water and boiled with regular agitation. Until pouring into a sterile Petri dish, it was allowed to cool to about 50°C.

3.5 Microbiological Analysis

Sterilized cotton swabs, socks, stomata containers, ice chests, ice packs, and sterile tubing were used to collect samples from different food contact surfaces in the kitchens of the chosen schools for microbiological research. Microbiological research was eeded to complete the study objective and achieve the ultimate goals (Minnesota Department of Health (MDH), 2013). A 50 cm2 area on all surfaces was swabbed for aerobic plate counts (APC), coliform counts, and E. coli counts using normal microbiological swabbing techniques (Bekele, Zewde, Tefera, Feleke & Zerom, 2014). Swabbing a 50cm2 region with a sterile stainless-steel template allowed for microbiological inspection of surfaces. Swabbing the field horizontally, from one side of the prototype to the other, and repeated vertically and then horizontally was used for sampling. The samples were taken to the lab and plated on Aerobic Count (AC) Plates and E. coli/Coliform Count Plates. By surface sort, the results were presented as mean log APC counts and mean coliform counts. The frequency of E. coli and coliform positive samples was determined based on the surface type. The methods outlined below were used to determine if microorganisms were

present in the samples. A colony counter was used to count colonies on selected plates. To aid grouping and recognition, the morphological characteristics of the colony, such as color, form, and scale, were studied.

3.5.1 Total Viable Count (TVC)

Total Viable Counts were separated and counted using the pour plate process, and Plates were grown.

Agar Count (PCA). Diluting 10g of the sample yielded serial dilutions of up to 10-4.

into 90 mL purified water that has been sterilized aliquots of one milliliter (1ml) from each of the dilutions

PCA has already been prepared and was inoculated into Petri dishes. The contents were tossed around.

To thoroughly mix the agar with the inoculums, turn the mixer clockwise and anticlockwise. The plates were placed on the table.

The cells were then inverted and incubated for 24 hours at 35°C. Using the colony clock, all white spots or scatter were counted and reported as total viable count after incubation (Bekele, Zewde, Tefera, Feleke & Zerom, 2014).

3.5.2 Enumeration of *Staphylococcus species*

Pour plate system was used to isolate and count Staphylococcus species, which were then grown on Salt Mannitol Agar (SMA) (Argudin, Mendoza & Rodicio, 2010). Diluting 10g of sample into 90ml of sterilized purified water yielded serial dilutions ranging from 10-1 to 104. One milliliter aliquots of each dilution were inoculated into Petri dishes containing SMA that had already been prepared. The inoculum was spread thinly with a sterile bent rod and allowed to dry at room temperature for 15 minutes. The plates were

inverted and incubated for 24 hours at 35 degrees Celsius. Using a colony clock, yellow colonies were counted and registered as Staphylococcus counts after incubation (Argudin, Mendoza & Rodicio, 2010).

3.5.3 Enumeration of *Escherichia coli*

Escherichia coli was isolated, counted, and grown on MacConkey agar using the pour plate process. Diluting 10g of beef sample into 90ml sterilized distilled water yielded serial dilutions 10-1 to 10-4. One milliliter of each dilution was inoculated into Petri dishes with MacConkey agar that had already been packed. After that, the plates were incubated for 24 hours at 35°C (Doménech-Sánchez, Laso, Pérez, & Berrocal, 2011). Escherichia coli pink colonies were counted and recorded as E. coli after incubation. The colony counter is used to count E. coli.

3.5.4 Enumeration of *Salmonella*

In a universal container, 10ml of Buffered Peptone Water (BPW), Oxoid CM009 (containing peptone 10.0; sodium chloride 5.0; pH 7.2 0.2 at 25 oC) was prepared and serial dilution of samples was applied. It was incubated for 24 hours at 37 degrees Celsius. Then, in a universal tube, 0.1ml of the BPW sample was put in a 10ml of serenite broth and incubated for 48 hours at 44 oC. SS agar (Salmonella-Shigella agar) was inserted and incubated at 37 oC for 48 hours. Salmonella was detected on the SS agar by cream colonies with black centers. Single cream colonies with black centers were inoculated by stabbing and incubated at 44 oC for 24 to 48 hours for confirmation. Salmonella was confirmed by a yellow ass, a red slant with or without blacking, and a red slant with or without blacking (Domenech-Sanchez, Laso, Perez & Berrocal, 2011).

3.6 Statistical Analysis

The study's findings were quantitatively analyzed. The Food Standard Code was used to determine the microbial quality of food, which was classified as adequate, fine, or unsatisfactory based on the microbial load (Doménech-Sánchez et al., 2011). Statistical Package for Social Sciences (SPSS) version 20.0 was used to perform analysis of variance on the results obtained for overall aerobic plate count, coliform, and fungal counts.

The use of this program for quantitative analysis is backed up by recent experimental studies in the field (Donkor, Kayang, Quaye & Akyeh, 2009; Cresswell, 2003). To assist in the interpretation of the findings, SPSS was used to produce descriptive statistics in the form of mean values and standard deviation. When the ANOVA table shows significant differences among the means, the independent sample T-test was used to assess significant differences between microorganism contaminations among the surface types at the 5% likelihood stage. The microorganisms were often identified in order to determine the bacteria were contaminating the food surfaces individually.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Microbial load of Food Contact Surfaces

The researchers looked for Total Viable Count, which determines the number of microorganisms (microbial load) in the swabbed samples. The number of colonies forming units (cfu) per gram (g) (or per ml) of the sample is represented by this number. Table 4.1 shows the results of the microbial count on different forms of food touch surfaces.

Table 1: Microbial Load for Surface Types from selected schools in Bono Region, Ghana

Bacterial group	Microbial Count	Contact Surfaces			
		Wooden surfaces	Cast Iron surfaces	Food handlers' palms	Plastic surfaces
Total Viable Count (TVC)	+Sample	6	6	6	6
	(log_{10} cfu/g)	5.07 ± 0.3	3.98±0.4	4.21 ±0.04	4.31±0.05
	Range	4.20-5.18	3.70-4.28	3.30-4.56	3.70-5.08
Total Coliform	+Sample	6	6	6	6
	(log_{10} cfu/g)	4.47± 0.1	2.31±0.1	2.33± 0.2	4.14± 0.2
	Range	3.79-4.91	2.00-2.59	2.18-2.31	3.78-4.70

Wooden surfaces had the largest total viable counts of microorganisms (4.72+ 0.3 log10 cfu/g), followed by plastic surfaces (4.33+ 0.5 log10 cfu/g), and cast-iron surfaces had the lowest total viable counts (3.98+ 0.3 log10 cfu/g). This means that microorganisms such as bacteria and fungi are heavily localized on the wooden board, which has the largest concentration of colony forming units. The prevalence of pathogenic bacteria in the food

swab can be shown by high levels of microbial load (Huslage, Rutala, Gergen, Sickbert-Bennett & Weber, 2013).

Table 1 also includes figures for Total Coliform Count, which provides a general measure of the sanitary status of a water or food source. Coliform bacteria can be present in soil, water, and human or animal waste, which were all checked. The total coliform count on wooden surfaces was highest (4.47+ 0.1log10 cfu/g), followed by plastic surfaces (4.14 +0.2log10 cfu/g), and cast-iron surfaces had the lowest total coliform count (3.31+ 0.1log10 cfu/g). Handling by kitchen workers with bare hands could be to blame for the inappropriate coliform counts on wooden and plastic surfaces (Argudin, Mendoza & Rodicio, 2010; Odonkor, Ampofo, 2013). The developed microbial load was further evaluated in relation to the different school categories where samples were taken, with the results presented in Table 2.

Table 2: Microbial Load among School categories

Bacterial group	Microbial Count	Category A school	Category B school	Category C school	Mean
Total Viable Count	+Sample (log_{10} cfu/g)	3.21±0.14	4.72±0.05	5.07±0.1	4.33
Total Coliform	+Sample (log_{10} cfu/g)	3.03±0.07	2.89±0.1	4.47± 0.1	3.34

Table 2 shows that Category C schools have the highest Total Viable Count (TVC) (5.07+0.1 log10 cfu/g), whereas Category B schools have the lowest. As a result, according to the International Commission for Microbiological Specification for Foods, only Category A schools fell below the appropriate limit of Total Viable Count (Argudin, Mendoza & Rodicio, 2010). The presence of higher Total viable counts on touch surfaces

suggested poor cleaning procedures in the kitchens of the schools studied (Tessema, Gelaye & Chercos, 2014).

Table 2 also shows that Category C schools have a cumulative Coliform count of 4.47+0.05 log10 cfu/g that is higher than the appropriate average. The Total Coliform count in Category A schools (3.03+0.07 log10 cfu/g) and Category B schools (2.89+0.1 log10 cfu/g) is both below the appropriate level. In either case, the average Total Viable count of 4.33 log10 cfu/g indicates the prevalence of microorganisms on the food contact surfaces of the different colleges, while the mean Total Coliform count of 3.34 log10 cfu/g indicates that the food contact surfaces are in adequate sanitation. The source of the bacterial load in the vegetable production centers may be field irrigation water (Mensah et al., 2001). Contamination may also be due to inadequate cutting and preparing methods, as well as poor hygienic conditions on the site, which could be caused by garbage, sewage, and other noxious substances in the area (Obiri-Danso et al. 2005).

4.2 Characteristics of Microorganisms present on the Food Contact Surfaces

The research went on to describe the specific bacteria that could potentially contaminate the food served at the various student dining halls after establishing the prevalence of microorganisms and the sanitary standard of touch surfaces among the selected colleges. Escherichia coli, Staphylococcus aureus, and Salmonella were among the microorganisms described, with average counts from different contact surface types outlined in Table 3.

Table 3: Characteristics of Microorganisms present on Surface Types

Microbial group	Microbial Count	Contact Surfaces				Mean
		Wooden surface	Cast iron surface	Kitchen staff's palms	Plastic surface	
Escherichia coli	+Sample (log_{10} cfu/g)	6	6	6	6	
		3.97± 0.14	4.48± 0.3	2.33± 0.10	3.98± 0.21	3.69
	Range	3.06-4.18	3.78-5.91	2.18-2.48	3.70-4.35	
Staphylococcus	+Sample (log_{10} cfu/g)	6	6	6	6	
		4.03±0.2	3.32± 0.10	3.27± 0.05	3.77± 0.4	3.60
	Range	3.00-4.76	3.31-4.34	3.25-4.29	3.05-5.21	
Salmonella	+Sample (log_{10} cfu/g)	6	6	6	6	
		4.15± 0.2	3.39± 0.03	2.72± 0.05	3.37± 0.06	3.41
	Range	3.79-5.34	3.32-3.51	2.70-2.89	3.04-3.70	

Cast iron surfaces had the largest number of Escherichia coli species (E. coli) at 4.48+ 0.3 log10 cfu/g, followed by plastic surfaces at 3.98+ 0.21 log10 cfu/g, and workers palms had the lowest number of Total Coliforms at 2.33+ 0.10 log10 cfu/g. The amounts found suggest potential pollution during post-cooking handling, as well as poor hygiene and sanitation (Doménech-Sánchez et al., 2011). The largest number of Staphylococcus spp was found on wooden surfaces (4.03+0.2 log10 cfu/g), followed by 3.77+ 0.4 log10 cfu/g on plastic surfaces, and 3.27+ 0.05 log10 cfu/g on kitchen staff's hands. Foods were especially heavily contaminated with Staphylococcus aureus on unnecessary handling and cross contamination after frying, similar to the results in Mensah et al's (2002) analysis in Ghana.

Statistics on Salmonella reveal that wooden surfaces have the maximum microbial count of 4.15+ 0.2 log10 cfu/g, while stainless steel surfaces have a count of 3.39+ 0.03 log10 cfu/g and the hands of kitchen workers have a count of 2.72+ 0.05 log10 cfu/g. The prevalence of S. aureus bacteria in this sample strongly demonstrated that the kitchen staff's standard of hygiene was inadequate (Bekele, Zewde, Tefera, Feleke & Zerom,

2014; Odonkor, Ampofo, 2013). For a better understanding, the average counts for the microorganisms studied is shown *on Figure 1*

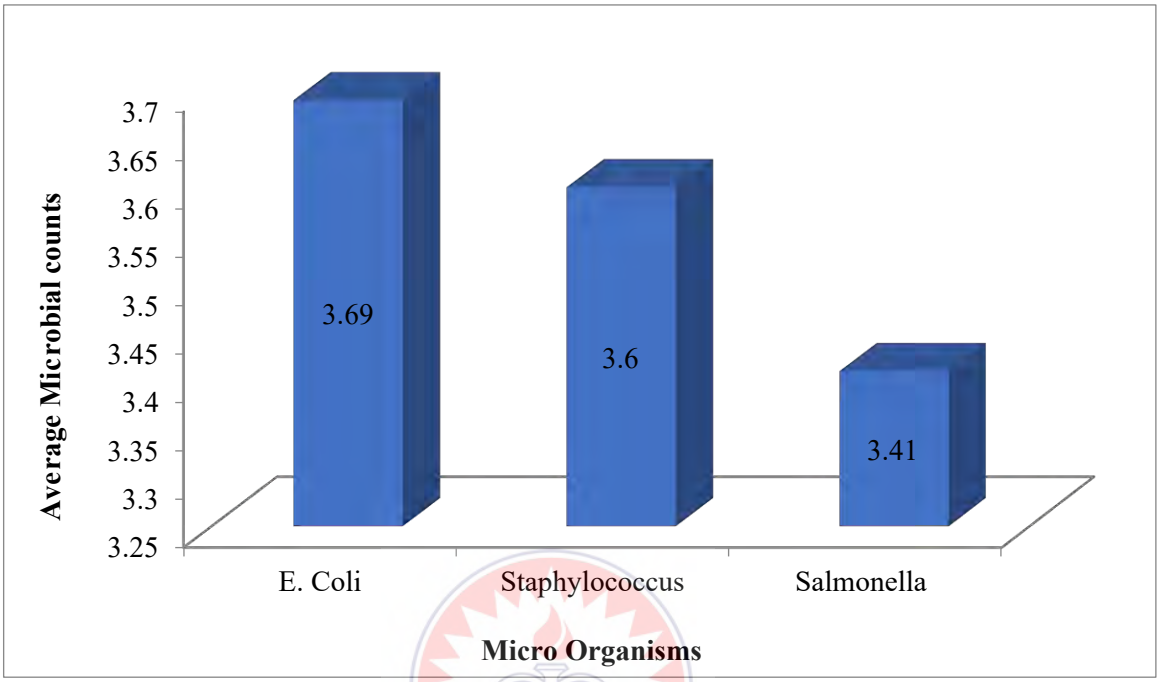

Figure 1: Average Microbial counts on Food Contact Surfaces

The variations in pollution ranges between the three microorganisms are not significant, and none of them fall below the inappropriate range of >106. All of them, however, are approaching the tolerable range of 104 - 105 and therefore need urgent treatment. Microbial counts for the three species studied on food contact surfaces were also summarized in the study, as seen in Figure 2.

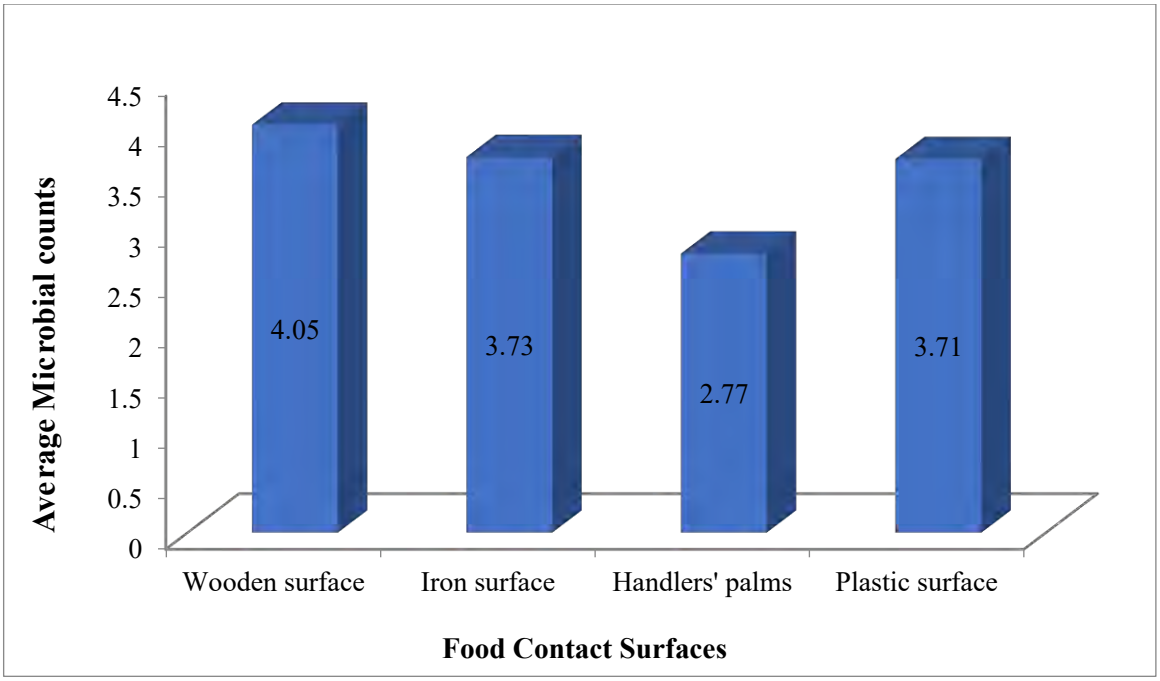

Figure 2 Average Microbial counts for Contact surfaces

The majority of microorganisms are found on wooden surfaces (4.05 log10 cfu/g), as can be seen. Microbial counts for iron and plastic surfaces were almost identical (3.73 log10 cfu/g and 3.71 log10 cfu/g, respectively), while the kitchen staff's hands had the lowest count of 2.77 log10 cfu/g. The three other touch surfaces, with the exception of wooden surfaces, which have a microbial count that exceeds the permissible limits (but is within the tolerable range), are within the acceptable plate count range. As a result, none of the food contact surfaces had microorganism counts that exceeded the reasonable level set by the International Commission for Microbiological Specification for Foods (Bekele, Zewde, Tefera, Feleke & Zerom, 2014).

4.3 Comparing Levels of Microbial Contamination among the selected School Categories/Surface types

For example, the amounts of infection for the three microorganisms (E. Coli, Salmonella, and Staphylococcus) were measured among the school groups. Table 4 summarizes the findings.

Table 4: Microbial load among school categories

Microorganisms	Microbial Count	Category A school	Category B school	Category C school	Mean
Escherichia coli	+Sample (log_{10} cfu/g)	3.41±0.07	2.92±0.2	4.80±0.44	3.71
Staphylococcus	+Sample (log_{10} cfu/g)	3.43±0.10	3.26±0.8	4.41±0.24	3.57
Salmonella	+Sample (log_{10} cfu/g)	4.71±0.11	2.57±0.03	3.13±0.15	3.44

Table 4 shows that Escherichia coli species is most common in Category C schools (4.80+0.44 log10 cfu/g), followed by Category A schools (3.41+0.07 log10 cfu/g), and Category B schools (2.92+0.20 log10 cfu/g). Category C schools have the highest number of Staphylococcus species (4.41+0.24 log10 cfu/g), followed by Category A and Category B, with 3.43+0.10log10cfu/g and 3.26+0.80 log10cfu/g, respectively. However, Category A schools had the highest Salmonella species count of 4.71+0.11 log10 cfu/g, while Category B and Category C had modest counts of 2.57+0.03 log10 cfu/g and 3.13+0.15 log10 cfu/g, respectively. Figure 3 depicts a pictorial depiction of the microbial counts recorded by the selected schools.

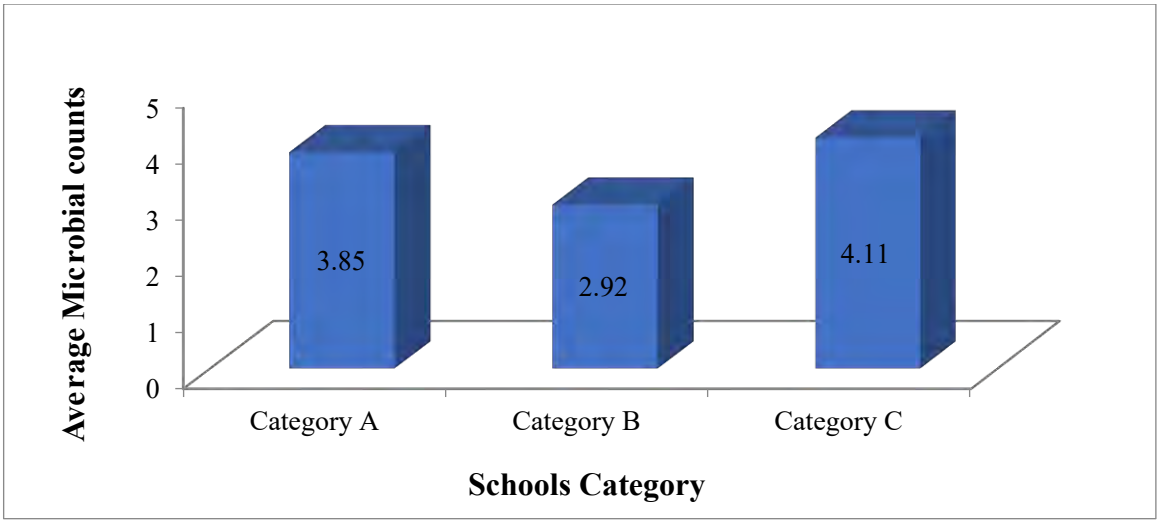

Figure 3: Average Microbial count by Category of schools

According to the results, Category C schools had the highest average microbial count of 4.11 log10 cfu/g, which is inside the acceptable range of 104-105. The minimum microbial counts for categories A and B were 3.85 log10 cfu/g and 2.92 log10 cfu/g, respectively, and were considered to be within the appropriate range.

The report compared major variations in the degree of infection with pathogenic microorganisms across the different types of schools using a Pearson Correlation coefficient of p0.05 at a 95 percent confidence interval. In log10 cfu/g, the findings for Escherichia coli, Staphylococcus species, and Salmonella species are shown in Table 5.

Table 5: Differences in Microbial load among Categories of schools

Microorganism	School Categories					
	Category A		Category B		Category C	
	Mean count	SD	Mean count	SD	Mean count	SD
Escherichia coli	3.48	0.70	2.73[a]	.050	4.46[a]	0.54
Staphylococcus	3.34[c]	0.48	4.06	0.47	4.65[c]	0.54
Salmonella	4.72[b]	0.62	2.57[b]	0.60	3.17[b]	0.58

*Values with same superscript in each row are significantly different

Test of Hypothesis 1 (H_1)

Paired sample T-tests were used to see whether there were any major differences between the microorganisms and the three types of colleges. The highest level of infection of Escherichia coli species (4.46log10 cfu/g) is found in Category C schools, while Category B schools have the lowest count. The amount of Escherichia coli exposure in Category B and Category C schools was found to be statistically substantially different (p0.05). Similarly, Category C schools have the highest levels of Staphylococcus bacteria infection (4.65log10 cfu/g). The rate of pollution in Category A and Category C schools were also shown to be statistically slightly different (p0.05). Despite the fact that Category A has the highest level of Salmonella contamination (4.72 log10 cfu/g), the level of contamination with Salmonella species was found to be statistically different (p0.05) across all school grades.

Only Salmonella species from all three categories of schools will support Hypothesis 1, which says that "there is substantial variation among the microorganisms measured from all categories of schools." Differences in microorganism contamination levels across food contact surfaces were also investigated using a paired sample t-test with mean counts, as shown in Table 6.

Table 6: Differences in Microbial load among Food Contact Surfaces

Microorganism	Surface Types							
	Wooden		Cast iron		Staff Palms		Plastics	
	Mean count	SD	Mean count	SD	Mean count	SD	Mean count	SD
E. Coli	3.79[a]	0.43	4.51	0.77	2.32[a]	0.16	4.04[a]	0.24
Staphylococcus	4.05	0.58	3.42[b]	0.40	3.33	0.41	3.81[b]	0.22
Salmonella	4.32[c]	0.58	3.42[c]	0.09	2.77[c]	0.08	3.31[c]	0.26

Source: Field Data, 2020 *Values with same superscript in each row are significantly different

Test of Hypothesis 2 (H_1)

Iron surfaces (4.51 log10 cfu/g) had the largest observation for E.coli spp, followed by plastics (4.04 log10 cfu/g). The E.coli spp found in the swabs from wooden surfaces, staff palms, and plastic surfaces differed significantly (p0.05), but the levels from cast iron surfaces and staff palms were identical. As a result, the second theory, that "there is a substantial difference in Staphylococcus species infection levels from wooden and plastic surfaces," cannot be supported. Staphylococcus species differed significantly (p0.05) from cast iron and plastic surfaces, but there were correlations between cast iron and wooden surfaces.

Test of Hypothesis 3 (H_1)

For Salmonella species, contamination amounts were slightly different (p0.05) in all four food contact surfaces. As a result, hypothesis 3 can be believed for Salmonella species, which says that "there is substantial variation among the microorganisms measured on all food contact surfaces."

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The largest concentration of colony forming units of bacteria was found on the wooden surfaces of food processing sites (school kitchens), perhaps due to gaps in the surfaces where food particles will hide and ferment if not adequately washed. Total Viable Count (TVC) and Total Coliform Counts (TCC) were highest in Category C schools, indicating the prevalence of microorganisms on food served in dining halls, but the amount of Coliform count was adequate on average.

E.Coli infection is higher on cast iron surfaces, while Staphylococcus spp. and Salmonella spp. contamination indicates poor sanitation standards when it comes to washing food touch surfaces. On average, E.Coli was the most common bacteria found, but all three bacteria had microbial loads of less than 4.0 log10 cfu/g, which was considered appropriate. The microbial counts for E.Coli, Staphylococcus spp, and Salmonella spp were found to be higher to the tolerable level (above 3.0 log10 cfu/g), raising concerns about food storage site sanitation and kitchen worker hygiene activities. Both types of schools have dramatically varying levels of E.Coli, Staphylococcus spp, and Salmonella spp infection. Salmonella spp. infection levels were not comparable on any of the food contact surfaces. As a result, the levels of Salmonella spp accumulation on wooden surfaces, iron surfaces, staff paws, and plastic surfaces vary significantly.

5.2 Recommendations

The following recommendations are made for stakeholders' attention and actions based on the study findings and conclusion:

- To avoid microorganism contamination, all food contact surfaces must be thoroughly cleaned, especially wooden surfaces that may have cracks. Because iron surfaces are easily washed and do not rust, the high level of E. coli contamination on stainless steel is unjustified. As a result, kitchen staff must make every effort to thoroughly clean surfaces with soapy water.

- It's also a good idea for kitchen staff who serve ready-to-eat foods to students to wash their hands thoroughly after handling other items like brooms, money, and rags right before serving the food. Environmental cleanliness, including garbage disposal and water drainage, must be taken seriously in order to discourage insects and pests from using food contact surfaces to carry pathogens and cause microbial contamination.

- School administration should establish functional school health sanitation committees to supervise and report issues relating to food safety and hygiene practices in the schools' kitchens in order to promote good environmental cleanliness and personal hygiene.

- As part of their monitoring and supervisory functions, officials from the local government's department of water and sanitation, as well as the Food and Drug Administration (FDA), must conduct regular checks in the various kitchens of senior high schools to ensure adherence to food safety practices. These authorities should implement sensitization programs (workshops) to equip and maintain staff skills and knowledge in the application of Hazard Analysis and Critical Control Point (HACCP)

principles in order to maintain a consistent level of microbial quality on food contact surfaces at all times.

- Non-governmental organizations should sponsor some of these research projects to determine the environmental sanitation, personal hygiene, and food safety conditions in senior high schools so that the government and school authorities can take appropriate measures to prevent food-borne epidemics.

- A future study into the kitchen staff of Senior High Schools in Ghana's Bono Region adhering to HACCP principles is suggested.

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