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EVALUATING THE QUALITY, MICROBIAL LOAD AND PESTICIDE RESIDUE ON SOME SELECTED VEGETABLES IN THREE MAJOR MARKETS IN THE HO MUNICIPALITY OF THE VOLTA REGION OF GHANA

BY

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DECLARATION

I hereby do declare that except for literature reference, to other peoples work which I have duly acknowledged, this work submitted to the school of Graduate Studies, Kwame Nkrumah University of Science and Technology Kumasi Ghana as a thesis for the Master of Science (Post Harvest Technology) Degree is the result of my own original work and that this thesis has not been presented for any degree in this University or elsewhere.

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DEDICATION

This work is dedicated to God Almighty, Family, my parents Mr. Prosper Kumah and Miss. Adeline Gbadegbe, auntie Vida Oyiadzo and my cousin, Eunice Mawufemor Kotoku.

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ABSTRACT

The study was carried out to analyse the vitamin content, microbial load and pesticide residues on vegetables sold in three major markets in the Ho municipality. Twelve (12) samples made up of four (4) vegetable types were randomly sampled from three (3) local markets and were analysed for vitamin content, microbial loads and pesticide residues using appropriate technique, media and Gas chromatography method. (Vitamin A) was highest among (vitamins A, C and D) content in vegetables sampled from the three markets with vegetables from Shia market having the highest (Vitamin A) content of (78.40mg/g). Among the vegetables, cabbage recorded the highest (vitamin A) content of (91.97mg/g) with cabbage from Ho Dome market having the highest (Vitamin A) content. Tomatoes from the Ho central market however recorded the lowest (Vitamin A) content of (51.84mg/g). Lettuce from Ho Dome market had the highest (Vitamin C) content of (45.21mg/g). (Vitamin D) was lowest among the vitamins tested in vegetables selected from the three markets. Ho central market recorded the highest faecal enterococci load of (6.04 log cfu/g) on vegetables whiles Ho Dome market recorded the least. Cabbage from Ho central market recorded the highest faecal enterococci loads of (8.92 log cfu^{-1}) with tomatoes from the Ho central market recording the lowest faecal enterococci load of (2.58 log cfu^{-1}). In all faecal coliform were highest on vegetables from shia market meaning the dirties; with lettuce from shia market having the highest load of (6.95 log cfu^{-1}) and the least load of (5.41 log cfu^{-1}) on tomatoes from Ho dome market. Cabbage recorded the highest *E*.coli loads of (5.38 log cfu^{-1}) with tomatoes having the lowest load of (4.35 log cfu^{-1}). Lettuce from Ho central market had the highest *E*.coli loads of (5.55 log cfu^{-1}). Lettuce from Ho Dome was found to be highest in total mould count. Lettuce was again highest in total viable count having a total viable count of (5.58 log cfu^{-1}).

All microbes detected on vegetable samples were above the recommended level of ($1x10^3$ 100g-1) fresh weight. Pesticides like delta HCH, Heptachlor, Aldrin, p,p'-DDT and p,p'-DDE were also detected on all vegetable sampled; and all delta HCH, Aldrin, Heptachlor, p,p'-DDT, o,p-DDT, p,p-DDE pesticides detected on interaction effects of market and vegetable type were all above MRL recommended. The survey further revealed (80%) of farmers added fertilizer (organic and inorganic) to the soil; 28(93%) applied pesticides at preharvest level and 18(60%) re-used fertilizers containers as packaging material. The results also give an indication that vegetable growers in the study area use some of the restricted/banned pesticides to control pests on their vegetable farms. Education should be intensifying on safe and proper handling of food to ensure food safety. There should be tougher laws to regulate imports and use of pesticide in the country.

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LIST OF ABBREVIATIONS

CFU	Coliform forming unit
DDD	Dichloro Diphenyl Dichloroethane
DDE	Dichloro Diphenyl Dichloro Ethylene
DDT	Dichloro Diphenyl Trichloroethane
FAO	Food and Agriculture Organisation
GC-ECD	Gas Chromatography Electron Capture Detector
HCB	Hexachloro Benzene
MRL	Maximum Reside Level
POP	Persistent Organic Pollutants
SPE	Solid Phase Extraction

CHAPTER ONE

1.0 INTRODUCTION

The food we consume brings all form of microbial association (Adams, 2000). The microorganisms that are found in fruits and vegetables direct reflection of the hygienic quality of the cultivation water, harvesting, transportation, storage and product processing (Beuchat, 1996: Ray and Bhunia, 2007). A microorganism which affects food comes from natural micro flora or is introduced by manufacturing steps ranging from cultural practices, harvesting, processing, storage and distribution. Contamination of food can also occur during post-harvest handling, also through contamination by food hawkers, food providers and at home. Contamination by virus or parasites can also occur through contact with sewage water and faeces (Spear 1997: Cliver, 1997). In some cases, this micro flora has no impact on the food and can be consumed without consequences, but those that are introduced during processing, and depending on the type and degree of contamination, can spoil food and cause food borne illnesses.

The quality of fruit during storage to a great extent depends on the storage environment and fruit microorganisms, since the activity of microorganisms can cause fruit decay, as a result reducing their quality. Kader (1997) on surveys of raw fruits and vegetables indicate that there are capabilities for wide range of these products becoming infected with microorganisms, especially the pathogenic ones. Scientists suggest that everyone eat five to nine servings of fruit and vegetables every day in order to promote good health. The improved availability of fresh produce all year round and increased varieties of items on the supermarket shelves should certainly help consumers to meet this target of fresh produce consumption. Raw fruit and vegetables, however, have the potential of becoming infected with microorganisms, including human pathogens and pesticide residue. In order to minimise the loss and maintain the quality of fruits and vegetables harvest, pesticides are used together with other pest management techniques during cropping to destroy pests and prevent diseases. The use of pesticides have increased because they produce rapid result, decrease toxins produced by food infecting organisms and are less labour intensive than other pest control methods. However, the use of pesticides during production, often results in the presence of pesticide residues in fruits and vegetables after harvesting. Some pesticides are persistent and thus remain in the body causing long-term exposure. Gilden et al, (2010) also mentioned that the main concerns of pesticides are their toxic effects, such as disruption of the reproductive organs and the developing foetus, as well as the ability to result in cancer and asthma. In developing countries, like Ghana, limited data is on pesticide residues in fruits (Bempah and Donkor, 2010), fruits and vegetables (Bempah *et al.*, 2011). Employee's health and hygiene is very critical at harvest time. In addition, farm tools, utensils, and packaging could possibly contaminate the product. Since fruits and vegetables contribute immensely to human health and are often eaten raw, there is need to ensure the safety of these produce by addressing common areas of concern in growing, harvesting, sorting, packing and distribution of fresh produce. This prompted the study to evaluate vegetables usually consumed raw without heat treatment to see the level of microbial load and level of pesticide contamination.

1.1 PROBLEM STATEMENT

Despite the nutritional and health benefits of fruits and vegetables, outbreaks of human infections associated with the consumption of fresh or minimally processed fruits and vegetables have increased in recent years (Altekruse and Swerdlow, 1996; Beuchat, 1996, Beuchat, 2002).

In Mexico, intestinal illnesses due to consumption of contaminated food are among the first five causes of disease in the country. Despite periodic quality control checks and closure of shops, outbreaks of gastroenteritis caused by pathogenic E. coli, Salmonella and Shigella are common in these areas although a specific correlation has not been shown between outbreaks of gastroenteritis and consumption of these juices (Lewis *et al.*, 2006, Mensah *et al.*, 2002).

Buck *et al.*, (2003) reported that, enteric pathogens such as *Escherichia coli* and *Salmonella* are among the greatest concerns during food-related outbreaks. Several cases of typhoid fever outbreak have been associated with eating contaminated vegetables grown in or fertilized with contaminated soil or sewage (Beuchat, 1998). It was further reported that these increases in fruits and vegetables-borne infections may have resulted from increased consumption of contaminated fruits and vegetables outside the home as most people spend long hours outside the home.

Since 1960, the use of pesticides in the world has increased tremendously. This led to the "green revolution". The huge increase in food production obtained from the same surface of the land, with the help of mineral fertilizer (nitrogen, phosphorus, potassium). The use of pesticides has helped to hugely reduce crop losses and improve the performance of crops such as corn, vegetables, potato and cotton. Notwithstanding the beneficial effects of pesticides, their adverse effects on environmental quality and human health have been well documented worldwide and constitute a major issue that gives rise to concerns at local, regional, national and global scales (Ntow, 2001). Residues of pesticides contaminate soils and water, persist in the crops, enter the food chain, and finally are ingested by humans with foodstuffs and water.

Given also the widespread use of waste from human and animal faeces, in agricultural practice, it is not surprising that enteric pathogens can contaminate agricultural products and cause outbreaks of disease after eating. All these contaminate food and make the food (fruit and vegetable) unwholesome for consumption.

1.2 JUSTIFICATION

Not long ago, the Food and Agricultural Organization of the United Nations (FAO) estimated that the world population will exceed eight billion by the year 2030. Hence, the demand for food would increase dramatically therefore the need for healthy foods. The consumption and demand of fruits and vegetables is increasing every year in Ghana mainly due to rapid growth in urban population. Consumption of fresh produce has been on the increase (Anon, 2007) mainly because of heightened awareness of benefits of a healthy diet and the impact to human health.

This has led to consumer demand for improved choice, such as minimally processed, pre packed, ready-to-eat fruit and vegetables (Everis, 2004) and availability of out-of-season produce. There have been an increased number of fresh-cut fruits and vegetables available on the market due to consumers demand and preparation of these products is now undertaken by retailers and food processors as well as by consumers in the home. Most of these fruits and vegetables are eaten raw without heat treatment therefore the hygienic safety and quality is being threatened by these contaminates. Microbiological contamination of fresh fruits and vegetables continues to be a serious food safety issue. The present study will therefore reports on the vitamin content, microbial load and pesticide contamination level of some selected vegetables (cabbage, lettuce, carrot, tomatoes) in the study area.

1.3 GENERAL OBJECTIVE

This study investigated the quality of fresh fruits and vegetables sold in three major markets in the Ho Municipality of the Volta Region of Ghana, and assessed the level of microbial and pesticides contamination in four selected fresh produce items. The specific objectives were:

- Determine the nutritional level of vegetables
- Evaluate the microbial load of the various produce on the shelf
- Compare the level of microbial loads on produce from the three major markets
- Estimate the level of pesticide residue on the various produce on the market shelf.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 IMPORTANCE OF FRUITS AND VEGETABLES

A diet rich in fruits and vegetables has been linked to better health. Vegetables and fruits (fresh and frozen) are loaded with vitamins, minerals, fibre and antioxidants, which have been shown to protect against chronic diseases such as heart disease and cancer. According to Nandi and Bhattacharjee (2005), Goldberg (2003), Hyson (2002) and; Prior and Cao (2000), diets high in vegetables and fruits contribute to anti oxidants which are associated with a reduced cancer and cardiovascular risk. Fruits and vegetables are of great nutritional value. They are important sources of vitamins and minerals, thus, essential components of human diet. They play a significant role in human nutrition, especially as sources of vitamins C (ascorbic acid), A, thiamine (B_1), niacin (B_3), pyridoxine (B_6), Folacin (also known as folic acid or folate) (B_9), E, minerals, and dietary fibre (Craig and Beck, 1999; Quebedeaux and Eisa, 1990). Fruits and vegetables are also low in calories, so they are good choice for weight control. Choosing colourful vegetable variety is best, since there are different benefits in different colour spectrum.

2.2 SOME BENEFITS DERIVED FROM FRUITS AND VEGETABLES

2.2.1 Cabbage

The health benefits of cabbage include frequent use as a treatment for constipation, stomach ulcers, headaches, obesity, skin disorders, eczema, jaundice, scurvy, rheumatism, arthritis, gout, eye disorders, heart diseases, aging, and Alzheimer's disease. Cabbage is a great source of Vitamin C. You may be surprised to learn that cabbage is actually richer in vitamin C than oranges, which has always been considered the "best" source of this vital nutrient. Vitamin C is one of the best antioxidants that reduce free radicals in the body. Free radicals are one of the primary causes of premature aging. It also helps in repairing the wear and tear on the body through the course of your life. Therefore, cabbage is very helpful in treating ulcers, certain cancers, depression, immune system boosting, and defending against cough and cold.

2.2.2 Carrot

They are good source of fibre, which helps maintain gut health, lower cholesterol and aid weight maintenance. The orange pigment in carrots are due to the antioxidant beta-carotene, also found in deep orange foods such as sweet potatoes, pumpkin, butternut, papaya and melon. The beta-carotene is converted to vitamin A in the body and helps maintain healthy eyes, supports the immune system, keeps the skin healthy and protect against certain cancers.

2.2.3 Lettuce

Shredded lettuce has only 12 calories for a cup. That is why it is so good for weight loss. Lettuce contains fibre and cellulose, fills your stomach up and improves digestion. Improving your digestion may not sound like a good thing for losing weight, but it is actually essential for long term weight control. Fibre also helps in removing bile salts from the body.

2.2.4 Tomatoes

Tomato is an extremely versatile food. They are delicious eaten raw in salads or sandwiches and taken on a wonderful sweetness when cooked. Tomatoes are such an important part of the Ghanaian diet that it's hard to believe that they were once considered toxic. It wasn't until the mid 1800's that they become a staple food. One medium whole tomato contains around 22 calories, 0 grams of fat, 5 grams of carbohydrates, 1 gram of dietary fibre, 1 gram of protein and 6 milligrams of sodium. It also provides 40 percent of the recommended daily allowance of vitamin C. Numerous studies have concluded that, the more tomatoes people eat the lower their risks of certain cancers, especially lung, stomach and prostate cancers. Eating tomatoes with a little bit of fat, such as olive oil, helps lycopene to be better absorbed by the body. Consequently, tomatoes may help to ward off age related disease such as atherosclerosis and diabetes. High consumption of tomatoes and tomato products has been linked to reduced carcinogenesis, particularly prostate cancer, and has been thought to be due to the presence of lycopene, which gives red tomatoes their colour (Giovannucci, 2002).

2.3 QUALITY ASSURANCE IN FRUIT AND VEGETABLES

Good and effective quality assurance system throughout the handling steps between harvest and sales display is important to provide a consistently good quality supply of fresh horticultural crops to the consumers and to protect the reputation of a given marketing label. Care taken in harvesting and handling are required to minimize physical injuries. Postharvest handling at each step has the potential to either maintain or reduce quality and in a few cases (such as ripening of climacteric fruits) improve eating quality.

According to Barrett (1996), processed fruit and vegetable product quality is determined by the quality of the raw materials utilized (e.g. cultivar, maturity, cultural practices) and the efficiency and care taken during handling, processing, storage and distribution. As with fresh horticultural commodities, it is important to establish quality standards and to ensure their fulfilment through the use of a quality assurance program at the processing facility.

2.3.1 Quality Attributes in fruits and vegetables

Quality of fresh produce includes appearance i.e. Shape, colour, size and freedom from decay, texture (firmness, crispness, dietary fibre). Kader (1992), reports that the relative importance of each quality component depends on the commodity and the individual interest. Most postharvest researchers, producers, and handlers are product-oriented in that quality is described by specific attributes of the product itself, such as sugar content, colour or firmness. Shewfelt (1999), in contrast indicates that consumers, marketers, and economists are more likely to be consumer - oriented in that quality described by consumer wants and needs.

Kader (1988) explains that although consumers purchase fresh produce based on appearance and textural quality, their repeat purchases depend upon their satisfaction with flavour (taste and aroma). They are also interested in the health-promoting attributes and nutritional quality of fresh fruits and vegetables.

2.3.2 Food Safety and Fresh Produce

Recent spread of food borne illness has increased a lot of people's concerns about the safety of fresh fruits and vegetables. The awareness of the health benefits from fresh produce has increase the demand for vegetables and fruits. These foods contain nutrients that help decrease the risk of many illnesses, with cancer and macular degeneration. Improper washing of fruits add bacteria to extracts thus, leading to contamination. Foodborne microbial pathogens that can lead to human diseases, the focus of food security will continue to be major concerns. Estimates of the costs of human illnesses and costs to the food industry ascribed to foodborne pathogens are well-documented (Buzby *et al.*, 1996; Crutchfield and Allhouse, 1998; Goodwin and Shiptsova, 2002; Unnevehr, 2003).

2.4 POSSIBLE POINTS OF CONTAMINATION IN FOOD SUPPLY

2.4.1 Dangers in Production

2.4.1.1 Land use and ranch history

Nicholson, *et al.* (2005) reported that, pathogens may be naturally present in soil, for example *Listeria* spp., or may become incorporated in the soil matrix from organic wastes added as fertilizer. Pathogens within soil may contaminate crops directly when heavy rain or water gun irrigation causes leaf splash. It was further reported that the ability of the pathogen to survive in the environment will impact on the likelihood of crop contamination and pathogen viability at harvest and through to consumption. Initially, the pathogen must survive in the propagation environment until crops are planted out, or in organic wastes applied to the land. Table 2.1 lists survival times for each enteropathogen from a number of studies.

Table 2.1: Survival time of enteropathogens in the field environment

Pathogen	Environment	Survival (day)
Escherichia coli O157:H7	Soil + animal manure	30
E. coli	Slurry + dirty water	968
Salmonella	Soil + bovine slurry	30
Listeria	Slurry + dirty water	180
Listeria	Soil + animal manure	30

Source: Nicholson *et al.* (2005)

Buzby *et al.* (2003) explained that, the soil/ground where vegetables are grown play an important role in safety of the product. They further explained that, if the area in the past was used for chemical waste or for the processing of bio-solids, this would present a likely source of contamination of crops. Buzby and Unnevehr (2003) again stated that, it is important to know the land history and the time required for the area to lay fodder, thus reducing the level of contamination in the soil. What is done on the adjacent land also have effects on the safety of the crop grown. There is the likely hood that, fruits and vegetables grown next to an animal-rearing operation become contaminated by animals.

2.4.1.2 Animals

Buzby and Unnevehr (2003) reports that, Fruits and vegetable growers and packers are discouraged from keeping animals for the reason being, they represent a source of product contamination. Domestic animals such as dog, goat, chickens and horses can contaminate crop with faecal droppings whenever they pass through the field. Non farm animals such as deer, other mammals, and birds can serve as reservoirs for pathogens (Moncrief and Bloom, 2005).

2.4.1.3 Manure and Soil Enrichment

According to Buzby *et al.* (2003), an increased demand for organically grown produce promotes the use of alternative measures to protect plants from pests, mites, and fungi. They argued that organic fertilizers such as animal manure could introduce faecal pathogens to fresh produce if manure is not aged and treated before application. Fresh manure applied to growing vegetable could cause contamination of produce. Hipping manure close to growing vegetable could also cause contamination due to run off. Blaine and Powell, (2004) also suggested that organic growers must be vigilant not to use fresh manure, because this would increase the potential for product contamination. Among the groups of bacteria commonly found in vegetation are those who tested positive for coliforms or faecal coliforms, such as Klebsiella and Enterobacter (Splittstoesser *et al.*, 1980; Zhao *et al.*, 1997).

2.4.1.4 Water

Water can be used throughout the growing and harvesting of fresh fruit and vegetables. The source of agricultural water could determine the final safety of the food product. Beuchat, (1998) mentioned that the scope of the microorganisms associated with spoilage or contamination fruits and vegetables includes bacteria, parasites, protozoa and viruses, and these are often associated with contaminated water and/or food handlers. However, there are certain factors which contribute to microbiological contamination as a result of treatment of soil with organic fertilizers like manure and sewage sludge and irrigation water (Ward and Irving, 1987).

In developing countries such as Nigeria, continued use of untreated waste water and manure as fertilizers for the production of fruits and vegetables is a major contributing factor to contaminations (Olayemi, 1997; Amoah *et al.*, 2009). Many growers also draw water from open water systems in areas where water is scarce. If effluent water from sewage plants is used in hydroponics plant production, the quality of this water is a concern for introduction of pathogens in edible food.

2.5 POST-HARVEST HANDLING OF FRESH PRODUCE

Post harvest treatment of fruits and vegetables includes handling, storage, transportation and cleaning. During these practices conditions may arise which lead to cross contamination of the produce from other agricultural materials or from the workers. Environmental conditions and transportation time will also influence the hygienic quality of the produce prior to processing or consumption. Poor handling can damage fresh produce, rendering the product susceptible to the growth and survival of spoilage and pathogenic microorganisms. This damage can also occur during packaging and transport. The presence of cut and damaged surfaces provides an opportunity for contamination and growth of microorganisms and ingress into plant tissues (Francis and O'Beirne, 1999).

2.5.1 Pack houses

Packing facilities should be cleaned and well maintained to reduce the introduction of harmful microorganisms to product. Some growers move product from the field in large bins, which are taken to the pack house for selection, grading, and repacking. No matter what method of packing is used, care must be taken with product. Pack houses, whether open or enclosed, should be cleaned and protected to deter pest entry and possible product contamination. Harvest storage facilities, containers, or bins should be cleaned regularly. Good sanitation practices enhance a company's food-safety program. An important step is to provide training in sanitation to a wide base of employees, even those outside the sanitation department (Redemann, 2005).

2.5.2 Retail and Food Service Operations

The mishandling of food during preparation in food service operations or in the home is thought to be the cause of food borne illness in the United State (Gorny, 2005). Consumers could be a source of fresh produce contamination in retail outlets. Consumers touch fruit and vegetables as they make a decision on whether to purchase product. Mensah *et al.*(2002) on a study conducted on the safety of street foods in Accra concluded that, unacceptable quantity of microbes were found on salads, macaroni, fufu ,"omo tuo" and red pepper, whiles shigella sonnei and enteroaggregative Escherichia coli were isolated from macaroni, rice, and tomato stew , and salmonella arizonae from light soup.

2.5.3 Consumers way of Handling of Fruits and Vegetables

Fruit and vegetables, besides being perishable items, could be the source of mishandling by consumers, eventually leading to food borne illness. Beuchat, (1998) asserted that, consumers sometimes mishandle produce by cross-contamination with meat items being placed in the same bag or cart. Several cases of typhoid fever outbreak have been associated with eating contaminated vegetables grown in or fertilized with contaminated soil or sewage.

In the home, food-safety practices such as hand washing before handling fresh produce, or after handling meat, may not be observed. Another reservoir for pathogenic microorganisms is the kitchen sink. Consumers may place fresh produce items in the sink without washing or sanitizing the area. This causes cross-contamination from items previously placed in the sink.

Consumers may not always wash fruits and vegetables, but even the simplest washing with running water is sufficient to cause one log10 cfu/g reduction in microbes.

2.6 TOTAL, FAECAL AND E. COLI BACTERIA

2.6.1 Yeasts and Moulds

Yeasts and Moulds are both fungal species. They are common spoilage agents, disease causing agents and they are also used for the benefit of mankind in the production of many different substances such as antibiotics, foods and alcohol. Many species which generally do not cause problems, can as with other microorganisms cause serious infections of the immune system. Oliveira, *et al.*, (2010) reported that yeasts and moulds (YM) mean counts were 4.74 +/- 0.83 log (10) cfu g^{-1} and 4.21 +/- 0.96 log (10) cfu g^{-1} from organic and conventional lettuce, respectively in a study to examine the microbiological quality of fresh lettuce from organic and conventional production.

2.6.2 TVC: Total Viable Count

A TVC is not a specific micro-organism but rather a test which estimates total numbers of viable (for the purposes of this data sheet viable means living) individual micro-organisms present in a set volume of sample. The TVC count may include bacteria, yeasts and mould species. There are different test parameters for different types of samples. For example, for drinking water samples Yeast Extract Agar is used by the laboratory and incubation temperatures of 37 and also 22 deg C are used to grow the micro-organisms. For cooling tower waters a single temperature of incubation is used of 30 deg C. For food samples a different medium is used which is slightly different to Yeast Extract Agar.

2.6.3 Coliforms

Coliforms are used to identify the "cleanliness" of food and water. Coliform species are abundant in faeces but are also found in soil and vegetation. Although the group does contain some pathogenic species the coliform test is generally carried out to indicate potential contamination with other pathogenic spp.

2.6.4 Faecal enterococci

Previously known as group *D. streptococci*, *Enterococcus spp* contain the organisms Enterococcus faecalis (formerly faecal streptococcus) and *Enterococus faecium*. These organisms are commonly used faecal indicators in water analysis.

2.6.5 Escherichia coli (*E. coli*)

E.coli is a member of the coliform group which is particularly associated with faecal matter and as such is a good indication of faecal contamination. Many people are confused about the significance of E.coli because of recent cases of food poisoning that have been caused by the species. Within species are smaller groups known as serotypes and these groups may have different characteristics. For example, serotype 1 may not cause food poisoning but serotype 2 might. With the recent outbreaks it is serotype 0157 that has been responsible.

2.7 FOODBORNE PATHOGENS CONNECTED WITH FRESH FRUITS AND VEGETABLES

According to Acheson, (2000) food borne illness is defined as "any illness that is contracted from the consumption of or exposure to food''. Burnett and Beuchat (2001) stated that, bacterial food borne outbreaks have been associated with raw fruits and vegetable product.

2.7.2 Pathogens of Most Concern and Where They can be found

2.7.2.1 Salmonella

According to Aoust, (1997) animal husbandry practices in poultry, meat and fish industries and recycling of offal and inedible raw materials used in animal feed, has favoured the continued prominence salmonella in the global food chain. There are reports of human salmonellosis associated with melon (Ries *et al.*, 1990). Application of night soil, sewage sludge or untreated wastewater, irrigation with untreated wastewater in fields and gardens can lead to contamination of fruits and vegetables with salmonella and other pathogens. Washing fruits and vegetables with contaminated water and handling of produce by infected workers, vendors and consumers in the marketplace can result in the spread of pathogenic microorganisms, including Salmonella. Salmonellae have been isolated from many types of raw fruits and vegetables (Beuchat, 1996; Wells and Butterfield, 1997).

The pathogen can grow on the surface of alfalfa sprouts (Jaquette *et al.*, 1996), tomatoes (Zhuang *et al.*, 1995) and perhaps on other mature raw fruits and vegetables, making it absolutely essential to use hygienic practices when handling them.

2.7.2.2 Escherichia coli

Escherichia coli are common in the normal micro flora in the intestinal tract of humans and other common warm-blooded animals. Leafy vegetables are most commonly linked to *E. coli* infection, but apple juice (cider in the USA) is an interesting vehicle, as the acidity of the product is considered inhibitory to bacterial proliferation. *Escherichia coli* O157:H7 is commonly recovered from the faeces of ruminants; therefore, livestock grazing in orchards may contaminate fallen apples with faeces and, as *E. coli* O157:H7 can proliferate in damaged apple tissue (Stopforth *et al.*, 2004); this can result in the contamination of unpasteurized fruit juices/ciders. Contaminated raw vegetables are thought to be a common cause of traveler's diarrhoea. *E. coli* O157:H7 may occur when cattle, and perhaps other ruminants such as deer, inadvertently enter fields, or when improperly composted cow manure has been applied as a fertilizer. The potential for contamination may be enhanced when fruits or vegetables have fallen from the plant to the ground and are then picked and placed into the handling and processing chain.

2.7.2.3 Staphylococcus aureus

Staphylococcus aureus is known to be carried in the nasal passages of healthy food handlers and has been detected on raw produce (Abdelnoor *et al.*, 1983) and ready-to-eat vegetable salads (Houang *et al.*, 1991). However, enterotoxigenic *S. aureus* does not compete well with other microorganisms normally present on raw fruits and vegetables, so spoilage caused by nonpathogenic micro flora would probably precede the development of the high populations of this pathogen that would be needed for production of staphylococcal enterotoxin.

2.7.2.4 Bacillus cereus

Spores of enterotoxigenic strains of Bacillus cereus are common in most types of soil. Some strains can grow at refrigeration temperatures. Foods other than raw fruits and vegetables are generally linked to illness implicating B. cereus. Portnoy *et al.* (1976) argued that, illness associated with eating contaminated soy, mustard and cress sprouts has, however, been documented. Human illness tends to be restricted to self-limiting diarrhoea (enterotoxin) or vomiting (emetic toxin). However, emetic toxin-producing strains have produced liver failure and death by the food borne route.

2.7.2.5 Viruses

Although viruses will not grow in or on foods; raw fruits and vegetables may serve as vehicles for infection. Many food-associated outbreaks of hepatitis A have been recorded (Cliver, 1997). Hepatitis A infection has been linked to the consumption of lettuce (Rosenblum *et al.*, 1990), diced tomatoes (Williams *et al.*, 1995), and raspberries (Ramsay and Upton, 1989; Reid and Robinson, 1987). Hernandez *et al.* (1997) suggested that lettuce contaminated with sewage could be a vehicle for hepatitis A virus and rotavirus.

2.8 PESTICIDES

A pesticide is defined as any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pests or used as a plant growth regulator, defoliant or desiccant.

2.8.1 Pesticide Residue

Residue refers to the amount of a pesticide chemical or ingredients in the pesticide mixture found in or on a raw agricultural commodity or in a processed food. The definition also includes residue of degradation products of the pesticide chemical, whether those products are the result of plant metabolism or some other degrading process. Thus the residue of concern may be the parent compound, a metabolite of the parent compound or a combination of the two.

2.8.2 Pesticide Tolerance

Tolerance is the amount of residue legally allowed to remain on or in the commodity at harvest.

2.8.3 Pesticides Usage in Food Production

Fruits and vegetables are significant components of food for human, as they provide the nutrients which are necessary for most reactions within the body. Like other plants, fruits and vegetables are attack by plant pests and diseases during production and storage, resulting in damage and reduction in the quality and performance. To reduce the loss and storage of harvest quality of fruits and vegetables, pesticides are employed in conjunction with other pest management techniques during farming to eliminate pests and prevent disease. Dinham (2003) reported that, about 87% of the farmers who grow vegetables in Ghana use pesticides. Bull (1982) argued that, if crops are sprayed shortly prior to harvest without an appropriate waiting period, even organophosphate residues can persist up until the food is in the hands of the consumer. Ntow *et al.* (2006) asserted that many of these farmers spray the same wide range of pesticides on all vegetables and ignore pre-harvest intervals.

In Ghana there are already some levels of contamination of pesticides in water, sediment, crops and human fluids in areas of highly intensive vegetable production (Ntow, 2001). The presence of pesticide residues is a concern for consumers, because pesticides are known to have potential adverse effects on other pests and diseases, non-target organisms.

2.8.4 Pesticide Management and Control Policies in Ghana

Several government agencies are currently involved in the development, management and pesticide control and implementation. Pesticide Control and Management Act of Ghana (528) was enacted in 1996 to ensure effective control and management of pesticides. The law requires the registration of all distributors of agrochemicals and pesticides.

Act 528 of 1996 defines four classes of pesticides: (1) general use, (2) restricted use, (3) suspended pesticide and (4) banned pesticide. Pesticides in classes (2), (3) and (4) are subject to the Prior Informed Consent (PIC) procedure as laid down in the international procedures for exchanging information. A pesticide may be suspended or restricted if its use can result in adverse effects on humans, animals or the environment (EPA 1994, 1997).

Table 2.2a: Provisional List of Banned Pesticides in Ghana

Name	Active ingredient	Reason for ban
Aldrex T	Aldrin and Parathion	persistent, highly toxic
Aldrin	Aldrin	Persistent
Dieldrin	Dieldrin	Persistent
E-605 combi	Parathion	highly toxic
Parathion methyl	Parathion Methyl	highly toxic
Heptachlor C10	Heptachlor	not in use
DDT	Dichloro Diphenyl Trichloro Ethane	safer alternatives
EDIB	Ethylene Dibromide	highly toxic
D-D	Dichloropropane	banned internationally
Bidrin	Dicrotophos	banned internationally

Source: **EPA of Ghana**

Currently, ten pesticides have been banned in Ghana (Table 2.2a). The reasons for the ban are either the persistence of the pesticide in the environment or high toxicity. This list is in line with international conventions. Eight more pesticides have restricted application (Table 2.2b).

Table 2.2b: Provisional List of Severely Restricted Pesticides in Ghana

Product Name	Active Ingredient
Azodrin	Monocrotophos
Unden	Propoxur
Lindane	Gamma BHC
Elocron	Dioxacarb
Gramaxone	Paraquat
Furadan	Carbofuran
Thiodan	Endosulfan
Atrazine	Atrazine

Source: EPA of Ghana

2.8.5 Persistent organic Pollutants (POP)

These are a group of toxic chemicals that persist in the environment, accumulate in the food chain and are a danger to human health. Twelve substances were initially classified as POPs under the Stockholm Convention, namely; aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex, toxaphene, polychlorinated biphenyls (PCBs), hexachlorobenzene, dioxins and dibenzofurans.

2.8.6 Maximum Residue Level of Pesticides on Fruits and Vegetables

Maximum residue levels are the highest levels of residues expected to be in the food when the pesticide is used according to authorised agricultural practices (EFSA, 2010). The MRLs are always set way below levels considered to be safe for humans. It should be noted that MRLs are not safety limits, a food residue can have higher level than MRL but can still be safe for eating.

2.8.7. Evidence of pesticide residue on food

There are evidence of widespread contamination of various components of the environment with dichlorodiphenyltrichloroethane, and their hexachlorocyclohexane

(BHC) residues in several developing countries (Bempah, 2008; Baird and Cann, 2005). According to Chowdhury *et al.* (2011**)**, most market vegetables and fruits contain pesticide residues because of their overuse in the field, which cause harmful effect for the human health. Ntow (2008) reported of relatively high residue concentration of methoxychlor in vegetables. The use of pesticides in vegetable production, often end up with pesticide residues in fruits and vegetables after harvesting.

The presence of 48 pesticides (13 organochlorine, 17 organophosphorus, 10 syntetic pyrethroids and 8 herbicides triazine, triazole, organochlorine, dinitroaniline, and phenylpyrazole) in 20 types of fruits collected from local markets in Lucknow, India, were determined by multi-residual method, during 2009 (Srivastava *et al.*, 2011). Pesticides numbering 23 at the level of 0.005-12.35 mg/kg (HCH, dicofol, endosulfan, fenpropathrin, permethrin II, beta-cyfluthrin-II, fenvalerat, dichlorvos, dimethoat, diazinon, malathion, chlorofenvinfos, aniliphos, dimethachlor) were detected. Residues content above MRLs were detected in radish, cucumbers, cauliflower, cabbage and okra. Low level of pesticides detected was the result of replacement of persistent organochlorine pesticides with easy degradable organophosphorus and synthetic pyretroids, over the last decade in India.

Lindane was detected in 33.3%, 50% and 25% of cucumber samples (conventionally grown, grown in greenhouses, and organically grown, respectively) and insecticide methamidophos in 66.7%, 41.7% and 50.0%; of cucumber samples (the same order of production of cucumbers as above) bellow the MRL. The highest residue content was found in cucumbers from greenhouses (1.016 mg/kg), followed by organically grown (0.442 mg/kg) and conventionally produced ones (0.415 mg/kg).

In a study conducted by Bempah *et al.* (2012), to investigate the organochlorine, organophosphorus and synthetic pyrethroid pesticide residues in fruits and vegetables from markets in Ghana, 9.8% of the samples were above the MRL.

2.8.7 Toxic and Health Effects of Pesticides

The foreign substances entered into a human body by inhalation, adsorption through a skin, and indigestion, alter cell functions and consequently lead to the appearance of various diseases (Coman *et al.*, 2006). Pesticides after application are widely distributed in environmental compartments, contaminating the air, soil and water (Verstraeten *et al.*, 2002; Pucarević *et al.*, 2003; Pucarevic and Sekulić, 2004; Pucarević *et al.*, 2010). Fenik *et al.* (2011) argued that the widespread use of pesticides, their stability and tendency of bio-accumulation, make them particularly dangerous for a man, hence, exposure through consumed fruits and vegetables must be pointed out as a special risk to human health. Great number of diseases and pathological conditions of man are associated with exposure to pesticides, such as demyelization and paralysis of nervous system, asthma, hematuria, proteinuria, leukemia, anemia, multiple myeloma. Furthermore, recent epidemiological studies have brought up possible relationship between human exposure to pesticides and origin and development of different malignant diseases.

Moreover, exposure to pesticides badly affects parent reproductive health which is especially prominent in undeveloped countries (Aktar *et al.*, 2009). The use of DDT and many other organochlorine compounds were banned or restricted in the USA and Europe at the second half of the last century (Vassilev and Kamburova, 2006). Unfortunately, natural products often cannot adequately respond to the market demands towards biological activity, stability, produced quantity and quality.

Therefore, they are mainly used as lead structures for the development of new synthetic compounds with improved characteristics. Synthetic analogues of natural fungicides, strobulirins have shown a higher level of biological activity and photochemical stability in the field conditions than analogue natural compounds (Hutter, 2011).

2.9 SUMMARY

Little or no work has been done on the microbial and pesticide levels on vegetables in the Ho-municipality. And presently, pesticide residues in food are not controlled in Ghana and there is little information on the levels of pesticide residues in food even though few works has been done in this area. Consequently, little information is also available on the intake of dietary pesticides by the Ghanaian population. Therefore, the only way to assess the intake of microbes and pesticides is in food which the average consumer in Ghana consume (Bempah and Donkor, 2011).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY AREA LOCATION

The Ho municipality lies between latitude 6°207 N and 6°55;N and longitudes 0°127 E and 0°53;E and covers an area of 2.660sqkm. The municipality shares boundaries with the Adaklu- Anyibge District to the south, Hohoe municipal to the north, south –Dayi District to the west and the republic of Togo to the East. By location, Ho municipality can have economic co-operation with neighbouring Districts. The Ho municipality is also home to the regional capital of Volta Region. This, of course, makes it the largest urban centre in the region.

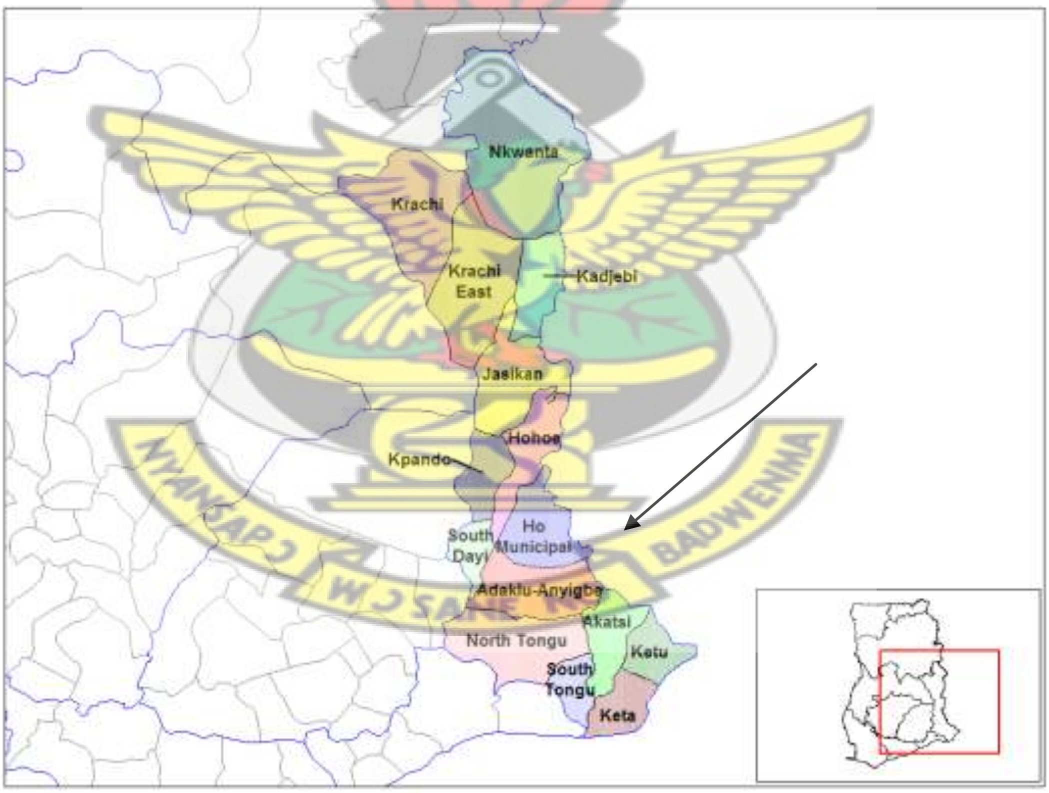

Figure 3.1 Map of the Volta Region showing the various Municipals and districts

3.2 CLIMATE AND VEGETATION OF STUDY AREA

The two types of vegetation in the Municipal are the moist semi-deciduous forests of the hilly areas of the savannah woodland.

3.3 CLIMATIC TEMPERATURE

Generally, mean monthly temperatures in the district ranges between $22^{\circ}C$ and $32^{\circ}C$ while annual mean temperatures range from of $16.5^{\circ}C$ to $37.8^{\circ}C$. In effect, temperatures are generally high throughout the year which is good for plants and food crop farming. During the dry season however, daily temperatures are so high that, except for irrigation and river valleys, food crop cultivation cannot take place.

3.4 METHODOLOGY USED IN SURVEY

A number of methods and strategies were adopted to collect the information needed to meet the study objectives. The methods used were;

a) Visits to homes and farms of selected farmers'

b) Visits to the market centers.

c) Informal personal interviews with Market queens (the study objectives were explained to the market queens so as to get the information needed).

d) Formal individual interviews and discussions were done with farmers, chemical sellers, consumers and traders (whole sale and retailers) of fruits and vegetables with closed ended in a multiple choice structured questionnaires.

In all, a total of 120 questionnaires in the categories of (30) farmers, (30) chemical sellers, (30) traders and (30) consumers were administered at the various markets, farms, restaurants and locations in the municipality.

3.4.1 Experimental materials:

Lettuce, cabbage, carrot and tomatoes were sampled from wholesalers (Market queens) each in all the three major markets in the municipal. Wholesalers were selected based on earlier interviews conducted to make sure their produce were not coming from the same sources to ensure unbiased. All samples were carefully collected, sealed, labelled and put in an iced chest container and were transported to the laboratory for analysis.

3.4.2 Experimental Design

The experiment on Vitamin, microbial loads and pesticides were arranged in a (4 x 3 factorial) with (3) three replications. There were 12 treatments in all this included Tomato (Ho Dome market), Tomato (Shia market), Tomato (Ho central market) Cabbage (Ho Dome market), Cabbage (Shia market), Cabbage (Ho central market), Lettuce (Ho Dome market), Lettuce (Shia market), Lettuce (Ho central market), Carrot (Ho Dome market), Carrot (Shia market) and Carrot (Ho central market).

3.5 LABORATORY WORK

The lab analysis on microbial loads and Vitamin content was carried out at the Kwame Nkrumah University of Science and Technology Biochemistry and Microbiology Laboratory. The pesticide residue analysis was done at the Ghana Atomic Energy Commission.

3.5.1 Data collected on microbial loads and Vitamin content

3.5.1.1 Total and faecal coliforms (TC and FC):

The Most Probable Number (MPN) method was used to determine total and faecal coliforms in the samples. Serial dilution of 10^{-1} t0 10^{-4} were prepared by picking 1 ml of the sample into 9ml sterile distilled water. One millilitre aliquots from each of the dilutions were inoculated into 5ml of MacConkey Broth and incubated at 35°C for total coliforms and 44°C faecal coliforms for 18-24 hours. Tubes showing colour change from purple to yellow and gas collected after 24hours were identified as positive for both total and faecal coliforms. Count per 100ml was calculated from Most Probable Number (MPN) tables.

3.5.1.2 E. coli (Thermotolerant Coliforms)

From each of the positive tubes identified, a drop was transferred into 5ml test tube of trypton water and incubated at 44°C for 24 hours. A drop of Kcovac's reagent was then added to the tube of trypton water. All tubes showing a red ring colour development after gentle agitation denoted the presence of indole and recorded as presumptive for thermotolerant coliforms (*E. coli*). Counts per 100ml were calculated from Most Portable Number (MPN) tables.

3.5.1.3 Faecal enterococci

Serial dilutions of 10^{-1} to 10^{-4} were prepared by picking 1 ml of the sample into 9ml sterile distilled water. One millilitre aliquots from each of the dilutions were inoculated on a Slanetez and Barltey Agar prepared on sterile Petri dishes. The Petri dishes are pre-incubated at a temperature at 37°C for 4hrs to aid bacterial resuscitation. The plates are then incubated at 44°C for further 44 hrs. After incubation all red, maroon and pink colonies that were smooth and convex are counted and recorded as faecal enteroccoci.

3.5.1.4 Total viable count (TVC):

TVC counts of pathogens were enumerated by pour plate method and growth on plate count agar (PCA). Serial dilutions 10^{-1} to 10^{-4} were prepared by diluting 10g of the sample into 90 ml of sterilized distilled water and Pulcifier for 15 seconds. One millilitre aliquots from each of the dilutions were inoculated into on Petri dishes with already prepared PCA. The plates were then incubated at 35°C for 24 hours. After incubation all white spot or spread were counted and recorded as total viable counts using the colony counter.

3.5.1.5 Total Mould count (TMC):

Mould (fungi) were isolated and enumerated by pour plate method and growth on Potato Dextrose Agar (PDA). Serial dilutions of 10^{-1} to 10^{-4} were prepared by diluting 10g of the sample into 9 ml of sterilized distilled water. One millilitre aliquots from each of the dilutions were inoculated into on Petri dishes with already prepared with already prepared PDA. The plates were then incubated at 25°C for 24 hrs. After inoculation all white spot or spread were counted and recorded as mould using the colony counter.

3.5.1.6 Vitamins A, C, and D

Vitamins were determined using the AOAC (2006) official method of analysis.

3.5.2 Data collected on pesticide residues

3.5.2.1 Sample preparation.

Fresh fruit and vegetable samples were thoroughly shredded and homogenized. Approximately 20.0g of the samples was macerated with 40ml of ethyl acetate. Sodium hydrogen carbonate 5.0g and anhyfrous sodium sulphate 20.0g were added to remove moisture and further macerated for 3 minutes using the ultra- turax macerator. The samples were then centrifuged for 5 minutes at 3,000rpm to obtain the two phases. The supernatant was transferred to a clean graduated cylinder (25ml) to measure its volume.

3.5.2.2 Solid-phase extraction

A solid phase extraction was carried out using SPE column according to Netherlands analytical methods of pesticide residues and food stuffs with modification (2007). The florisil column (500mg/ 8ml) cartridge was conditioned with 5ml of a mixture solution of acetone: n –hexane (3:7, v/v) through the column. The sorbent was never allowed to dry during the conditioning and sample loading steps. The extract column was filtered with 20-port vacuum manifold with a receiving flask placed under the column to collect the eluate. Sample loading was performed under vacuum at flow rates of 5ml min-1. After the passage of the extract, the column was dried by vacuum aspiration under increased vacuum for 30min.The pesticides were eluted to 1ml (3, 3, 4ml) of ethyl acetate, concentrated to 1ml using a rotary evaporator and then dried by a gentle nitrogen steam. This was dissolved in 1ml of ethyl acetate, pesticides were then quantified by gas chromatograph equipped with electron capture detector (GC-ECD).

3.5.2.3 Gas chromatography-electron

Capture detector (GC- ECD) analysis Gas chromatograph GC- 2010 equipped with 63Ni electron capture detector (ECD) with split/split less injector that allowed the detection of contaminants even at trace level concentrations (in the lower μg/g range) from the matrix to which other detectors do not respond was employed. The injector and detector temperature were set at 280ºC and 300ºC respectively. A tussed silica ZB-5 (30mx0.25mm,0.25um film thickness)was used in combination with the following oven temperature program: initial temperature 60ºC, held for 1 min, ramp at 30ºC min-1 to 180ºC, held for 3 min, ramp at 30C min-1 to 220ºC, held for 3min, ramp at 10ºC min^{-1} to 300ºC. Nitrogen was used as carrier gas at a flow rate of 1.0ml min^{-1} and make up gas of 29 ml min^{-1}. The injection volume of the GC was 1.0 μl. The residues detected by the GC analysis were confirmed by the analysis of the extract on two other columns of different polarities. The first column was coated with ZB-1 (methyl polysiloxane) connected to ECD and the second column was coated with ZB-17 (50% phenyl methyl polysiloxane) and ECD was also used as detector. The conditions used for these columns were the same.

3.5.2.4 Quality control and quality assurance

Quality control and quality assurance were included in the analytical scheme.

3.6 ANALYSIS OF DATA

Data on vitamin levels, microbial loads and Pesticide residues were subjected to ANOVA using Statistix 9. Count data were $\log_{10}$ transformed for *E. coli*, TC, FC, TMC, TVC and square root transformed for faecal enterococci before analysis. Means were separated using Lsd at 1%.

CHAPTER FOUR

4.0 RESULTS

This chapter contains the findings of the experiment after conducting the experiment. Evaluation of the quality of the vegetables sampled from three market centres is covered under three main headings; vitamins composition of the vegetables, pesticides residues and microbial loads on the vegetables.

4.1 INFORMATIONS ON FARMERS, CHEMICAL SELLERS, TRADERSAND CONSUMERS IN THE STUDY AREA

4.1.1 Socio-demographic Information on Farmers and Farming Activities

4.1.1.1 Age range and Level of education of farmers

The study showed that farmers within the 25-40 years and 41-55years age groups together forming (18 of the total sample size) are in the majority. Majority of the farmers forming 17 of the total sample size have had basic to secondary education. A total of 7 farmers have had tertiary education whiles a total of 5 farmers never had any formal education. It was only 3 farmers interviewed that were below 18 years and 2 farmers were also above 55 years. Table 4.1 gives a detailed description of the age and educational level distribution of farmers in the study area.

Table 4.1 Age range and Level of education of farmers

Age Range	Level of education: No formal Education	Basic Education	Secondary Education	Tertiary	Others	Total
Below 18 years	2	1	0	0	0	3
Between 18 - 24 years	0	4	3	0	0	7
Between 25 - 40 years	1	0	3	4	0	8
Between 41 - 55years	1	1	4	3	1	10
Above 55 years	1	0	1	0	0	2
Total	5	6	11	7	1	30

4.1.1.2 Years of experience in vegetable farming

It was observed that 20 (66.7%) farmers had 6 and above years experience in vegetable farming. Farmers with 2-3 years of experience had the least frequency of 4 (13.3%) of the sample size. Table 4.2 shows a detailed description of the years of experience of vegetable farmers.

Table 4.2: Years of experience in vegetable farming

Year	Frequency	Percent (%)
2-3yrs	4	13.3
4 -5yrs	6	20
6 -7yrs	9	30
Above 7yrs	11	36.7
Total	30	100.0

4.1.1.3 Fertilizer (organic and inorganic) usage by farmers

According to the study, 24 farmers representing 80% agreed using one form of fertilizer (organic and inorganic) or the other. Only 6 of the farmers disagreed using any form of fertilizer.

Table 4.3: Farmers response to fertilizer (organic and inorganic) usage

Response	Frequency	Percent (%)
Yes	24	80
No	6	20
Total	30	100

4.1.1.4 Mode of fertilizer application

According to the study, majority of the farmers of 17 (56.7%) applied fertilizer to crops by side placement. Another group of farmers forming 9 (30%) of the sample size stated they applied their fertilizers through broadcasting. It was observed that, only 1 farmer applied fertilizer through irrigation sprinklers.

Table 4.4: Mode of fertilizer application

Mode of application	Frequency	Percent (%)
side placement	17	56.7
spraying	3	10
Broadcasting	9	30
through irrigation sprinklers	1	3.3
Total	30	100

4.1.1.5 Source of water for watering

The study revealed that 11 (36.7%) of farmers in the sample size used dug well to water their crops. It was also revealed in the study that 8 (26.7%) of farmers interviewed rely on rain water to water their crops. It was only 4 (13.3%) and 3 (10%) of farmer who used irrigation and pipe as a source of water supply to their crops as shown in Table 4.5.

Table 4.5: Source of water for watering

Water source	Frequency	Percent (%)
dug well	11	36.7
pipe	3	10
river	4	13.3
irrigation	4	13.3
On rain	8	26.7
Total	30	100

4.1.1.6 Pesticide usage at pre harvest

Majority of farmers 28 (93.3%) agreed on applying pesticides at pre harvest, with only 2 (6.7%) who disagreed doing so.

Table 4.6: Pesticide usage at pre harvest

Response	Frequency	Percent (%)
Yes	28	93.3
No	2	6.7
Total	30	100

4.1.1.7 Days of harvest after pesticide application

It was observed in the study that majority of farmers forming 19 (63.3%) of the sample size harvest between 6 – 15 days after pesticide application. The study also revealed that whereas 5 (16.7 %) of farmers wait till after 21days to harvest, 5 (20%) harvest just below 5 days after pesticide application. This is shown in the Table 4.7 below.

Table 4.7: Day of harvest after pesticide application

Day interval	Frequency	Percent (%)
below 5 days	6	20
6-10 days	9	30
11-15 days	10	33.3
above 21 days	5	16.7
Total	30	100.0

4.1.1.8 Types of organic fertilizers use by farmers

Most of the farmers interviewed 18(60%) uses Poultry manure as an organic fertilizer.

Table 4. 8 Organic fertilizers use by farmers

Organic Fertilizer	Frequency	Percent (%)
Cow dung	8	26.7
Poultry droppings	18	60
Compost	4	13.3
Total	30	100

4.1.1.9 Postharvest handling

Table 4.9 Contains information on the number of farmers who agreed or disagreed they wash and use empty fertilizer bags, pesticide containers and fungicides bags as packaging materials, farmers response to whether they clean vehicle or not before loading vegetables and also farmers response to whether produce are loaded together with other goods during transportation.

According to the study, 18 (60%) of farmers in the sample size forming majority agreed using empty fertilizer bags, empty pesticide containers and fungicide bags as a packaging material. Majority of the handlers 19 (63.3%) also agreed cleaning vehicles before loading on vegetables. Most of the handlers 23 (76.7%) in the sample size also agreed they transport vegetable produce together with other goods.

Table 4.9 Postharvest handling

Response	Whether farmers use empty fertilizer, pesticide containers and fungicides bag as packaging materials		Farmers response to whether they clean vehicle or not before loading vegetables		Farmers response to whether produce are loaded together with other goods during transportation	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**	**Frequency**	**Percent (%)**
Yes	18	60	19	63.3	23	76.7
No	12	40	11	36.7	7	23.3
Total	30	100.0	30	100	30	100

4.1.2 Information on Agro chemical Dealers

4.1.2.1 Age group and gender of agro-chemical dealers

Majority of the agro chemical dealers in the sample size falls within the age group of 18 – 40 years, of which 12 are males and 7 females, giving a total of 19 agro - chemical dealers in that age bracket. A total of 9 males and 2 females interviewed were within the age group of 41 and above.

Table 4.10: Age group and gender of agro-chemical dealers

Age group	Gender		Total
	Male	Female	
Between 18 -24 years	3	2	5
Between 25 -40 years	9	5	14
Between 41-55 years	8	1	9
Above 55 years	1	1	2
Total	21	9	30

4.1.2.2 Educational level of agro chemical dealers

The study showed that 15 (50%) representing half of the agro chemical dealers in the sample size have had up to secondary education. It was only 2 (6.7%) of agro dealers who had no formal education, with 6 (20%) having up to tertiary level of education. This is shown in Table 4.11 below.

Table 4.11: Educational level of agro chemical dealers

Educational level of agro chemical dealers	Frequency	Percent (%)
No Formal Education	2	6.7
Basic Education	7	23.3
Secondary Education	15	50
Tertiary	6	20
Total	30	100.0

4.1.2.3 Years of experience in selling agro chemical

This information was gathered to determine the impact of the depth of experience on the ability to better handle, preserve or educate buyers on proper use of chemicals. A total of 15 (50%) of traders from the sample size had (11) or more years of experience in chemical sales as against 6 (20%) of traders who had less than 5 years' experience (Table 4.12).

Table 4.12: Years of experience in selling agro chemical

Years of experience	Frequency	Percent (%)
Less than 5years	6	20
6-10 years	9	30
11 or more	15	50
Total	30	100.0

4.1.2.4 Agro chemical dealers and their interaction with farmers

Table 4.13 Shows number of agro chemical sellers who were either registered or not, number of chemical dealers who do or do not educate buyers (farmers) on health concerns and right usage of chemicals; and dealers' response to the question that, only environmentally acceptable and un-prohibited chemical are sold to farmers. According to the survey, 28 (93.3%) of agro chemical dealers agreed and showed evidence of registration of business.

All the agro chemical dealers 30 (100%) agreed they educate farmers on the health concern and right use of chemicals. All the 30 (100%) disagreed selling acceptable and prohibited chemicals to buyers.

Table 4.13: Agro chemical dealers and their interaction with farmers

Response	Number of agro chemical sellers who were either registered or not		Number of chemical dealers who does or do not educate buyers (farmers) on health concerns and right usage of chemicals		Dealers response to the question only environmentally acceptable and un prohibited chemicals are sold to farmers	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**	**Frequency**	**Percent (%)**
Yes	28	93.3	30	100	30	100
No	2	6.7	0	0	0	0
Total	30	100.0	30	100	30	100

4.1.3 Information on Traders

4.1.3.1 Age range and gender of traders (wholesalers and retailers)

The study showed that majority of the vegetable traders numbering 19 out of 30 traders interviewed, were between the age group of 25- 40years comprising of 17 females and 2 males. A total of 7 traders were between the age group of 18-24 years and 4 traders in the age group 41-55 respectively. In all, out of 30 traders selected randomly and interviewed, there were a total of 5 males and 5 females. This is illustrated in Table 4.14.

Table 4.14: Age range and gender of traders (wholesalers and retailers)

Age range	Sex		Total
	Male	Female	
Between 18-24 years	3	4	7
Between 25-40 years	2	17	19
Between 41-55years	0	4	4
Total	5	25	30

4.1.3.2 Places for storing vegetables

According to the survey results, majority of the traders 16 (53.3%) stored vegetables in kiosks. A total of 12 (40%) of the traders stored vegetables in rooms and other forms of storage respectively. It is only 2 (6.7%) who store in the open.

Table 4.15 Places for storing vegetables

Places of storage	Frequency	Percent (%)
room	8	26.7
kiosk	16	53.3
open	2	6.7
others	4	13.3
Total	30	100.0

4.1.3.3 Safe handling of food

Table 4.16 show details of number of interviewed traders who did or did not use chemical to preserve vegetables, number of traders who either agree or disagrees that the storage provides enough protection from external environment, traders who said their shop is either far or near a toilet facility and number of traders who either used gloves or not during handling of vegetables. According to the study, out of 30 traders interviewed, 8 (26.7%) agreed to the use of chemicals for preservation of vegetables while 22 (73.3%) disagreed to using chemicals for preservation. A total of 21 (70%) agreed that their storage facilities do not provide enough protection from the external environment while 9 (30%) agreed it does. A total of 28 (93.3%) agreed that their shops are far from any toilet facility in the market, whiles 2 (6.7%) of them said otherwise. For gloves, 7 (23.3%) said yes to the use of gloves, whiles 23 (76.7%) forming majority do not use gloves during vegetable handling.

Table 4.16: Safe handling of food

Response	Use of chemical to preserve produce.		Storage provides enough protection from external environment.		The shop is far from a toilet facility.		Use of gloves during handling of vegetables.	
	Freq.	**Percent (%)**	**Freq.**	**Percent (%)**	**Freq.**	**Percent (%)**	**Freq.**	**Percent (%)**
Yes	8	26.7	9	30	28	93.3	7	23.3
No	22	73.3	21	70	2	6.7	23	76.7
Total	30	100.0	30	100	30	100	30	100

4.1.4 Information of Consumers

4.1.4.1 Age range and Gender of consumers interviewed

The survey on consumers' shows that, majority of the consumers contacted was between the age group of 18- 40 years. A total of 30 consumers comprising 17 male and 13 female were contacted during the survey.

Table 4.17: Age range and Gender of consumers interviewed

Age range	Gender		Total
	Male	Female	
Below 18 years	2	2	4
Between 18 -24 years	3	3	6
Between 25 - 40 years	6	6	12
Between 41 - 55 years	6	2	8
Total	17	13	30

4.1.4.2 Level of education of consumers

Majority of the consumers 18 (60.0%) have had up to secondary level of education. A total of 10 (33.3%) of consumers had up to tertiary level of education with 2 (6.7%) having only basic education.

Table 4.18: Level of education of consumers

Level of Education	Frequency	Percent (%)
Basic Education	2	6.7
Secondary Education	18	60.0
tertiary	10	33.3
Total	30	100.0

4.1.4.3 Quality parameters look for in vegetable by consumers

According to the consumers interviewed, 12 (40%) look at appearance as a quality parameter when buying vegetables, 6 (20%) agreed they consider the aroma of the vegetable before buying. A total of 5 (16.7%) consumers who look at colour as a quality parameter, 7 (23.3%) argued they consider texture of the vegetable before buying.

Table 4.19: Quality parameters look for in vegetable by consumers

Parameters	Frequency	Percent (%)
appearance	12	40.0
aroma	6	20.0
colour	5	16.7
texture	7	23.3
Total	30	100.0

4.1.4.4 Consumers awareness on the nutritional and health issues on vegetables

Table 4.20 shows consumers' response on awareness of the nutritional benefits of vegetables, whether consumers clean or do not clean vegetables before using and whether consumers ever experience any form of stomach disorder after vegetable intake. According to the study, 26 (86.7%) of the consumers agreed they are aware of the nutritional benefits of vegetables whiles the rest said otherwise. All the consumers 30 (100%) interviewed agreed they clean vegetables before using, and out of 30 consumers interviewed, only 4 (13.3%) agreed they have had stomach disorder after consuming vegetables.

Table 4.20 Consumers awareness of nutritional and health issues on vegetables

Response	Consumer's awareness of the nutritional benefits of vegetables.		Consumer who either clean or do not clean vegetables before using.		Consumers ever experienced stomach disorder after vegetable intake.	
	Frequency	**Percent (%)**	**Frequency**	**Percent (%)**	**frequency**	**Percent (%)**
Yes	26	86.7	30	100	4	13.3
No	4	13.3	0	0	26	86.7
Total	30	100.0	30	100	30	100

4.2 VITAMINS COMPOSTION

4.2.1 Influence of the Markets effect on Vitamins Composition of selected Vegetables

Table 4.21, 4.22 and 4.23 shows the composition of vitamins in the vegetables. The results showed a very high concentration of vitamin A, followed by vitamin C and vitamin D in order of decreasing.

Table 4.21: Market effect on vitamins composition of four selected vegetables

Markets	Vitamin A	Vitamin C	Vitamin D
Ho Central	75.73 b	32.33 a	27.44 a
Ho Dome	74.73 c	32.45 a	27.00 b
Shia	76.40 a	30.88 a	26.94 c
Lsd (0.01)	0.01	8.52	0.05
CV	0.01	23.22	0.16

4.2.1.1 Vitamin A

Results from Table 4.21 shows vegetables from the three markets recorded significantly, a very high vitamin A and were different in quantities ($p<0.01$). Those from Shia market were significantly richer (78.40 mg/g), followed by Ho Central (75.73 mg/g) and the least in the vegetables from Ho Dome (74.73 mg/g).

4.2.1.2 Vitamin C

However, the vegetables showed no significant difference ($p>0.01$) with regards to vitamin C.

4.2.1.3 Vitamin D

Furthermore, different but highly significant ($p>0.05$) quantities of vitamin D were recorded among the vegetables sampled from the markets. Ho Central market vegetables were very rich in vitamin D (27.44 mg/g), followed by Ho Dome (27.00 mg/g) and Shia (26.94 mg/g) in the decreasing order.

4.2.2 Effect of Vegetable Type on Vitamins Composition on selected Vegetables

Table 4.22: Effect of vegetable type on vitamins composition of four selected vegetables

Vegetables	Vitamin A	Vitamin C	Vitamin D
Cabbage	91.97 a	24.15 b	22.96 c
Carrot	82.50 b	35.90 a	33.74 a
Lettuce	74.04 c	36.64 a	31.12 b
Tomato	53.96 d	30.90 ab	20.68 d
Lsd (0.01)	0.01	9.84	0.06
CV	0.01	23.22	0.16

4.2.2.1 Vitamin A

Composition of Vitamin A as showed in Table 4.22 indicated a highly significant difference ($p<0.01$) among the selected vegetables. In order of increasing, tomato (53.96 mg/g) fruits recorded the lowest quantity of vitamin A, followed by lettuce (74.04 mg/g) and carrot (82.50 mg/g) while cabbage had the highest, of (91.97 mg/g).

4.2.2.2 Vitamin C

Similarly, there was a significant different ($p<0.01$) concentration of vitamin C in the four different vegetable types. Cabbage (24.15 mg/g) in comparison to carrot (35.90 mg/g) and lettuce (36.64 mg/g) which were not significantly different, recorded the lowest vitamin C content. Likewise, level of vitamin C in tomato is not different from neither of the cabbage, carrot and the lettuce.

4.2.2.3 Vitamin D

Vitamin D in the vegetables were highly different and significant ($p<0.01$). Carrot (33.74 mg/g) recorded the highest vitamin D content, followed by lettuce (31.12 mg/g), cabbage (22.96 mg/g) and tomato (20.68 mg/g) which had the lowest.

4.2.3 Interaction Effect of Market and Vegetable Type on Vitamin Composition of the Vegetables

Table 4.23: Interaction effect of market and vegetable type on the vitamins composition of four selected vegetables

Markets*Vegetables		Vitamin A	Vitamin C	Vitamin D
Ho Central	Cabbage	90.23 c	25.33 ab	22.53 h
Ho Central	Carrot	84.42 d	35.04 ab	34.65 a
Ho Central	Lettuce	76.42 g	39.10 ab	31.84 d
Ho Central	Tomato	51.84 l	29.62 ab	20.73 k
Ho Dome	Cabbage	93.38 a	23.56 b	22.10 i
Ho Dome	Carrot	80.36 f	33.11 ab	34.29 b
Ho Dome	Lettuce	71.38 i	41.21 a	31.44 e
Ho Dome	Tomato	53.78 k	32.07 ab	20.14 l
Shia	Cabbage	92.31 b	23.57 b	24.25 g
Shia	Carrot	82.72 e	39.56 ab	32.27 c
Shia	Lettuce	74.32 h	29.62 ab	30.08 f
Shia	Tomato	56.26 j	30.76 ab	21.15 j
Lsd (0.01)		0.03	17.05	0.1
CV		0.01	23.22	0.16

4.2.3.1 Vitamin A

Table 4.23 reveals a significant interaction effect ($p<0.01$) of the markets and vegetables on vitamins composition. Levels of vitamin A were highly significant and different. In order of decreasing, cabbage from Ho Dome market (93.38 mg/g), recorded the highest concentration of vitamin A, followed by Cabbage from Shia (92.31 mg/g) and Ho Central (90.23 mg/g) markets, then carrots sampled from Ho Central (84.42 mg/g), Shia (82.72 mg/g) and Ho Dome (80.36 mg/g) markets, lettuces sampled from Ho Central (76.42 mg/g), Shia (74.32 mg/g) and Ho Dome (71.38 mg/g) and lastly, tomatoes from Shia (56.26 mg/g), Ho Dome (53.78 mg/g) and Central (51.84 mg/g) markets respectively of which Ho central tomatoes had the lowest vitamin A concentration.

4.2.3.2 Vitamin C

There was however a different trend in the significant level seen with vitamin C content. Except for Ho Dome market Lettuces which had the highest vitamin C content of 41.21 mg/g, and was significantly different from Shia and Ho Dome market cabbages which had the least of 23.57 and 23.56 mg/g respectively, the rest were different.

4.2.3.3 Vitamin D

Similar to vitamin A, difference among the interaction means in term of vitamin D were highly significant. Carrots sampled from Ho Central market had the highest content of vitamin D content of 34.65 mg/g, followed by the same root vegetable from Ho Dome and Shia markets, which had 34.29 mg/g and 32.27 mg/g respectively, then lettuces from Ho Central and Dome as well as Shia with 31.84 mg/g, 31.44 mg/g and 30.08 mg/g in order as listed, cabbages from Shia (24.25mg/g), Ho Central (22.53 mg/g) and Dome (22.10 mg/g) markets, Shia tomatoes (21.15 mg/g), Ho Central tomatoes (20.73 mg/g) and the least, by Ho Dome tomatoes (20.14 mg/g).

4.3 MICROBIAL CONTAMINANTS ON THE VEGETABLES

4.3.1 Markets Influences on Microbial Loads on Four Selected Vegetables

Table 4.24: Market effect on contaminants loads on four selected vegetables

Markets	F. Enterococci	F. Coliforms	T. Coliforms	E. coli	TMC	TVC
Ho Central	6.04 a	6.08 c	7.94 b	4.92 c	5.10 c	5.25 c
Ho Dome	5.31 c	6.11 b	7.89 b	5.19 a	5.16 a	5.27 b
Shia	5.83 b	6.18 a	8.22 a	5.14 b	5.11 b	5.29 a
Lsd (0.01)	0.01	0.008	0.22	0.009	0.008	0.01
CV	0.16	0.12	2.39	0.16	0.15	0.16

4.3.1.1 Faecal enterococci

Faecal enterococci pathogens on the vegetables differed from the various markets. The level was highly significant ($p<0.01$). Ho Central market recorded the highest (6.04 log cfu/g) Faecal enterococci load, followed by Shia market (5.83 log cfu/g) and the least was recorded the vegetables from Ho Dome (5.83 log cfu/g).

4.3.1.2 Faecal coliforms

Similarly, level of faecal coliforms load on the vegetables sampled from the different markets were highly significant and different ($p<0.01$). The load of faecal coliforms on the Shia vegetables was very high (6.18 log cfu/g) compared to that on Ho Central and Dome (6.11 log cfu/g) markets vegetables. Vegetables from Ho Central had the least load of faecal coliforms (6.08 log cfu/g).

4.3.1.3 Total coliforms

Ho Central (7.94 log cfu^{-1}) and Ho Dome (7.89 log cfu^{-1}) markets recorded significantly, a similar load of total coliforms but were significantly different ($p<0.01$) from total coliforms on vegetables from Shia markets (8.22 log cfu^{-1}).

4.3.1.4 Escherichia coli

Pathogens of *E. coil* on the vegetables from the various markets were highly significant and different ($p<0.01$). In the order of increasing, Ho Central market had the least *E. coli* contaminant (4.92 log cfu^{-1}), followed by Shia market (5.14 log cfu^{-1}) and the highest, by Ho Dome (5.19 log cfu^{-1}).

4.3.1.5 Total mould count (TMC)

The various markets recorded significantly, different ($p<0.01$) level of total mould count (TMC). Similarly, Ho Central market had the least total mould count of 5.10 log cfu^{-1}, followed by Shia market with (5.11 log cfu^{-1}) while Ho Dome market had the highest load of (5.16 log cfu^{-1}).

4.3.1.6 Total viable count (TVC)

Total Viable Count (TVC) recorded among the vegetables from the three markets were highly significant ($p<0.01$). Total viable count of pathogenic organisms was highest on Shia market vegetables (5.29 log cfu^{-1}), followed by Ho Dome markets (5.27 log cfu^{-1}) and the lowest, on Ho Central market vegetables (log 5.25 log cfu^{-1}).

4.2.2 Effect of Vegetable Type on Microbial Loads on Four Selected Vegetables

Table 4.25: Effect of vegetable type on contaminants loads on four selected vegetables

Vegetables	F. Enterococci	F. Coliforms	T. Coliforms	E. coli	TMC	TVC
Cabbage	8.05 a	6.24 b	7.94 b	5.38 a	5.00 d	5.11 d
Carrot	4.41 c	6.03 c	8.62 a	5.27 c	5.05 c	5.17 c
Lettuce	7.68 b	6.83 a	8.80 a	5.33 b	5.33 a	5.49 a
Tomato	2.76 d	5.38 d	6.71 c	4.35 d	5.10 b	5.32 b
Lsd (0.01)	0.01	0.009	0.25	0.01	0.01	0.01
CV	0.16	0.12	2.39	0.16	0.15	0.16

4.3.2.1 Faecal enterococci

Highly significance ($p<0.01$) and different loads of faecal enterococci were found on the four vegetables. Cabbage was heavily loaded with faecal enterococci (8.05 log cfu^{-1}), followed by lettuce (7.68 log cfu^{-1}), carrot (4.41 log cfu^{-1}) and tomato which the least load of (2.76 cfu^{-1}).

4.3.2.2 Faecal coliforms

Likewise, difference in faecal coliforms were highly significant ($p<0.01$) among the vegetables. Lettuce recorded the highest level of faecal coliforms contamination (6.83 log cfu^{-1}). Cabbage was second with a load of 6.24 log cfu^{-1}, followed by carrot (6.03 log cfu^{-1}) while tomato again recorded the least load of faecal coliforms (5.38 log cfu^{-1}).

4.3.2.3 Total coliforms

Carrot and lettuce recorded significantly, an equal load of total coliforms of (8.62 log cfu^{-1}) and (8.80 log cfu^{-1}) respective, the highest among the others. They were significantly different ($p<0.01$) from cabbage and tomato which had (7.94 log cfu^{-1}) and (6.71 log cfu^{-1}) respectively in order of decreasing.

4.3.2.4 Escherichia coli

Again, *E. coli* loads on the vegetables were highly significant ($p<0.01$) and different. In order of highest to the least, cabbage came first with *E. coli* load of (5.38 log cfu^{-1}), followed by lettuce (5.33 log cfu^{-1}), carrot (5.27 log cfu^{-1}) and the last, by tomato with (4.35 log cfu^{-1}).

4.3.2.5 Total mould count (TMC)

Total mould count was also highly significant and different ($p<0.010$) among the vegetables. Lettuce had the highest total mould count of (5.33 log cfu^{-1}) while cabbage had the least load of total mould count of (5.00 log cfu^{-1}). Tomato and carrot recorded respectively, the second (5.10 log cfu^{-1}) and third (5.05 log cfu^{-1}) highest of total moulds detected.

4.3.2.6 Total viable count (TVC)

Similarly, Total viable count highly significant and different ($p<0.01$) among the vegetables. Again, lettuce recorded the highest count viable microbial pathogens with a load of (5.49 log cfu^{-1}) and the least was on cabbage with (5.11 log cfu^{-1}) total viable count. Tomato and carrot had (5.32 log cfu^{-1}) and (5.17 log cfu^{-1}) respectively in the decreasing order.

4.3.3 Interaction Effect of Markets and Vegetable Type on Microbial Load of Four Selected Vegetables

Table 4.26: Interaction effect of market and vegetable type on the microbial loads of four selected vegetables

Market*Vegetable		F. Enterococci	F. Coliforms	T. Coliforms	E. coli	TMC	TVC
Ho Central	Cabbage	8.92 a	6.06 g	7.89 de	5.25 f	4.97 h	5.03 i
Ho Central	Carrot	4.85 g	6.10 f	8.48 bc	5.17 g	5.10 e	5.11 gh
Ho Central	Lettuce	7.96 d	6.74 c	8.75 b	5.55 a	5.25 c	5.52 b
Ho Central	Tomato	2.44 l	5.41 j	6.65 f	3.70 l	5.06 f	5.33 d
Ho Dome	Cabbage	6.68 f	6.34 d	7.63 e	5.43 e	5.06 f	5.12 g
Ho Dome	Carrot	4.55 h	6.14 e	8.67 bc	5.14 h	5.01 g	5.10 h
Ho Dome	Lettuce	6.74 e	6.80 b	8.44 bc	5.53 b	5.38 a	5.58 a
Ho Dome	Tomato	3.25 j	5.14 k	6.83 f	4.65 k	5.17 d	5.30 e
Shia	Cabbage	8.54 b	6.33 d	8.29 cd	5.47 d	4.98 h	5.19 f
Shia	Carrot	3.83 i	5.85 h	8.70 bc	5.51 c	5.05 f	5.29 e
Shia	Lettuce	8.35 c	6.95 a	9.22 a	4.91 i	5.36 b	5.36 c
Shia	Tomato	2.58 k	5.60 i	6.64 f	4.69 j	5.07 f	5.32 d
Lsd (0.01)		0.02	0.02	0.44	0.02	0.02	0.02
CV		0.16	0.12	2.39	0.16	0.15	0.16

4.3.3.1 Faecal enterococci

There was a significantly high difference ($p<0.01$) among the interaction means with regards to faecal enterococci. Cabbage collected from Ho Central market recorded the highest load of the faecal pathogens of enterococci (8.92 log cfu^{-1}) while Ho Central market tomato had the lowest load of this pathogen (2.58 log cfu^{-1}). In order of decreasing, Shia market cabbage and lettuce recorded the second and third highest count of the pathogens with (8.54 and 8.35 log cfu^{-1}) respectively, followed by lettuces collected from Ho Central and Dome markets which also had (7.96 and 6.74 log cfu^{-1})respectively, then Ho Dome market cabbage (6.68 log cfu^{-1}), carrot from Ho Central (4.85 log cfu^{-1}), Dome (4.55 log cfu^{-1}) and Shia (3.83 log cfu^{-1}) markets and tomatoes collected from Ho Dome and Shia markets with (3.25 and 2.58 log cfu^{-1}) respectively.

4.3.3.2 Faecal coliforms

Similarly, faecal coliforms was distinct and highly significant ($p<0.01$) among the interaction means. Lettuces from Shia (6.95 log cfu^{-1}), Ho Dome (6.80 log cfu^{-1}) and Central markets (6.74 log cfu^{-1}) were heavily contaminated with faecal coliforms in the order of decreasing. They were followed by cabbage with an equal coliforms counts from Ho Dome (6.34 log cfu^{-1}) and Shia market (6.33 log cfu^{-1}), Ho Dome market carrot (6.14 log cfu^{-1}), then Ho Central market carrot (6.10 log cfu^{-1}) and cabbage (6.06 log cfu^{-1}), Shia market carrot (5.85 log cfu^{-1}) and tomato (5.60 log cfu^{-}) and finally, the least on Ho Dome market tomatoes (5.41 log cfu^{-1}) in their respective order.

4.3.3.3 Total coliforms

Unlike the above, a significant difference ($p<0.01$) was recorded among the interaction means. Tomatoes sampled from Ho Dome and Central as well as Shia markets significantly had an equal load of total coliforms of (6.83, 6.65 and 6.64 log cfu^{-1}) respectively. They however different when compared against the second lowest and highest, that is (7.63 log cfu^{-1} and 8.75 log cfu^{-1}) coliforms on cabbage and lettuce sampled from Ho Dome and Central markets respectively. Likewise, lettuce collected from Shia market had the highest contaminant level of coliforms (9.22 log cfu^{-1}) and was significantly different from the rest of interactions. On contrary, the rest of the un-listed interactions means were not different from one another with regard to total coliforms.

4.3.3.4 Escherichia coli

E. coli count as result of the interactions highly differed distinctively ($p<0.01$) from one another. The trend was similar to faecal enterococci and coliforms count except that, lettuce collected from the Ho Central market tend to be heavily contaminated with toxic pathogen (5.55 log cfu^{-1}) while tomatoes from the same market as a source recorded the least of *E. coli* contamination (3.70 log cfu^{-1}). Level of the pathogen occurrence was different, and from the second highest to second lowest, it followed the order of (5.53, 5.51, 5.47, 5.43, 5.25, 5.17, 5.14, 4.91 and 4.69 log cfu^{-1}) for Ho Dome market lettuce, Shia market carrot and cabbage, Ho Dome and Central markets cabbage, Ho Central and Dome markets carrot, Shia market lettuce and tomato as well as Ho Dome tomato respectively.

4.3.3.5 Total mould count

A significant effect was recorded among the interactions with regard to the total mould count (TMC). Except for tomato and cabbage from Ho Central and Dome market as well as carrot and tomato from Shia market which significantly had the same loads of moulds, the rest were different as well as against the group mentioned earlier. Lettuces sampled from Ho Dome (5.38 log cfu^{-1}), Ho Central (5.36 log cfu^{-1}) and Shia (5.25 log cfu^{-1}) markets were highly contaminated with moulds in a falling degree. Cabbages from Ho Central and Shia markets equally had the lowest total mould count of(4.97 and 7.98 log cfu^{-1}).

4.3.3.6 Total viable count (TVC)

Total viable count (TVC) was highly significant and different among the interaction means except for the fact that, carrots collected from Ho Central market (5.11 log cfu^{-1}) statistically recorded the same viable count of pathogenic organisms on cabbages (5.12 log cfu^{-1}) and carrots (5.10 log cfu^{-1}) from the Ho Dome market. All other interactions of the TVC were significantly distinct against one another. Lettuces from Ho Dome market had the highest viable count of pathogens (5.58 log cfu^{-1}) while cabbage sampled from the Ho Central market suffered the lowest (5.03 log cfu^{-1}) total viable count contamination. Lettuce from Ho Central market had the second highest count of viable pathogens (5.52 log cfu^{-1}), followed by the same vegetable from Shia market (5.36 log cfu^{-1}) and then, tomatoes sampled from Ho Central (5.33 log cfu^{-1}) and Shia (5.32 log cfu^{-1}) markets which were not different, tomatoes (5.30 log cfu^{-1}) and carrot (5.29 log cfu^{-}) from Ho Dome and Shia markets respectively but also not different and cabbage picked from Shia market (5.19 log cfu^{-1}) as well as (5.12 and 2.10 log cfu^{-1}) in the decreasing order.

4.4 PESTICIDE RESIDUES ON THE VEGETABLES

4.4.1 Effect of Market Influence on the Level of Pesticides Residue on the Selected Vegetables

Table 4.27: Market effect on pesticide residues on four selected vegetables

Markets	gamma HCH	delta HCH	Heptachlor	Aldrin	*p, p'*-DDT	*o, p'*-DDT	*p, p'*-DDE
Ho Central	0.000 c	0.17 b	0.76 a	0.82 b	1.085 a	0.000 b	0.076 a
Ho Dome	0.008 b	0.18 a	0.40 b	0.49 c	0.412 c	0.042 a	0.066 a
Shia	0.010 a	0.13 c	0.37 c	1.01 a	0.487 b	0.000 b	0.076 a
Lsd (0.01)	0.0004	0.01	0.02	0.03	0.034	0.004	0.015
CV	5.53	6.98	3.01	3.09	4.40	26.19	17.76

4.4.1.1 Gamma HCH

With reference to gamma HCH pesticide residue detected in the vegetables from the three markets, Shia vegetables had the highest concentration of 0.01 mg/kg and then followed by Ho Dome market vegetables. No gamma HCH was however detected on the vegetables sampled from Ho Central market. The level was significantly different ($p<0.01$) from one another.

4.4.1.2 Delta HCH

Similarly, level of delta HCH residue as result of pesticides use was significant and different ($p<0.01$) in the vegetables sampled. The highest concentration of the delta HCH was detected in vegetables collected from Ho Dome market (0.18 mg/kg) and then comparatively high in those from Ho Central market (0.17 mg/kg). Shia market vegetables however had the lowest concentration of (0.13 mg/kg).

4.4.1.3 Heptachlor

The trend did not change with the significant difference ($p<0.01$), in the heptachlor residue in the markets' vegetables. The difference was highly distinct of which Ho Central market vegetables had the highest concentration of (0.76 mg/kg), followed by Ho Dome market vegetables (0.40 mg/kg) and significantly lower in the vegetables sampled from the Shia market (0.37 mg/kg).

4.4.1.4 Aldrin

Aldrin concentrations in the vegetables from the various markets were highly significant and different ($p<0.01$). The concentration was very high in the vegetables picked from Shia market (1.01 mg/kg) and then, high in vegetables from Ho Central market (0.82 mg/kg) as well. The lowest concentration of Aldrin residue was detected in the vegetables from Ho Dome market (0.49 mg/kg).

4.4.1.5 *p,p'*-DDT

The concentrations of *p, p'*-DDT in the vegetables were significantly different ($p<0.01$). The level of *p, p'*-DDT was extremely high (1.085 mg/kg) in Ho Central market vegetables compared to (0.487 mg/kg) and (0.412 mg/kg) detected in vegetables collected from Shia and Ho Dome markets respectively.

4.4.1.6 o*, p'*-DDT

O, p'-DDT was only detected in vegetables from Ho Dome market while the other market vegetation showed no detection.

4.4.1.7 *p, p'*-DDE

Level of *p, p'*-DDE in the vegetables were not significantly different ($p>0.01$) among the markets.

4.4.2 Effect of Vegetable Type on the Level of Pesticides Residue on the Selected Vegetables

Table 4.28: Effect of vegetable type on pesticide residues on four selected vegetables

Vegetables	gamma HCH	delta HCH	Heptachlor	Aldrin	*p, p'*-DDT	*o, p'*-DDT	*p, p'*-DDE
Cabbage	0.012 b	0.23 a	1.05 a	0.90 b	0.741 b	0.060 a	0.034 c
Carrot	0.000 c	0.19 b	0.55 b	0.58 c	0.517 c	0.000 b	0.055 b
Lettuce	0.013 a	0.15 c	0.38 c	1.23 a	0.193 d	0.000 b	0.056 b
Tomato	0.000 c	0.08 d	0.08 d	0.39 d	1.194 a	0.000 b	0.147 a
Lsd (0.01)	0.0004	0.02	0.02	0.03	0.039	0.005	0.017
CV	5.53	6.98	3.01	3.09	4.40	26.19	17.76

4.4.2.1 Gamma HCH

Carrot and tomato had no detection of gamma HCH and were significantly different ($p<0.01$) from the lettuce and cabbage which had (0.013 and 0.012 mg/kg) concentration detected.

4.4.2.2 Delta HCH

Concentrations of delta HCH in the four vegetables were highly significant and different ($p<0.01$). Comparatively, cabbage the highest delta-HCH residue (0.23 mg/kg), followed by carrot (0.19 mg/kg), then lettuce (0.15 mg/kg) and the least, tomato (0.08 mg/kg).

4.4.2.3 Heptachlor

Similar, difference in residual level of heptachlor in the four vegetables were highly significant and different ($p<0.01$). Heptachlor was extremely high in cabbage (1.05 mg/kg), followed by carrot (0.58 mg/kg), then low in lettuce (0.38 mg/kg) and very low (0.08 mg/kg) concentration detected in tomato.

4.4.2.4 Aldrin

Lettuce (1.23 mg/kg) had a very high residue of Aldrin compared to the Cabbage, Tomatoes and Carrot. Aldrin in cabbage (0.90 mg/kg) was quite high compared to carrot (0.58 mg/kg) and tomato which had least concentration of 0.39 mg/kg. They were highly different ($p<0.01$) from one another.

4.4.2.5 *p, p'*-DDT

A significant difference ($p<0.01$) was recorded among the vegetables with the concentration of *p, p'*-DDT. Residual level of the chemical in tomato was very high (1.194 mg/kg) while a very low significant level was detected in lettuce (0.193 mg/kg). Also, a significant high amount of the chemical, second (0.741 mg/kg) and third (0.517 mg/kg) to the highest was detected in cabbage and carrot respectively.

4.4.5.6 *o, p'*-DDT

Except for cabbage which tested for a considerable amount of *o, p'*-DDT, the rest of the vegetables had no *o, p'*-DDT residues.

4.4.5.7 *p, p'*-DDE

There was a significant difference in the level of *p, p'*-DDE residues detected in the four vegetables. Tomato and cabbage recorded the highest and least level of the chemical upon testing. The amount detected in carrot and lettuce was significantly not different yet, they showed a difference against the highest and least recorded.

4.4.3 Interaction Effect of Market and Vegetable Type on the Level of Pesticides Residue on the Selected Vegetables

Table 4.29: Interaction effect of market and vegetable type on the level of pesticide residues in four selected vegetables

Markets*Vegetables		gamma HCH	delta HCH	Heptachlor	Aldrin	*p, p'*-DDT	*o, p'*-DDT	*p, p'*-DDE
Ho Central	Cabbage	0.000 c	0.34 a	1.85 a	1.28 b	0.948 b	0.000 b	0.000 e
Ho Central	Carrot	0.000 c	0.11 f	0.53 d	0.71 e	0.747 c	0.000 b	0.000 e
Ho Central	Lettuce	0.000 c	0.15 de	0.55 d	0.93 c	0.234 h	0.000 b	0.000 e
Ho Central	Tomato	0.000 c	0.07 g	0.13 g	0.35 h	2.410 a	0.000 b	0.305 a
Ho Dome	Cabbage	0.035 b	0.25 b	0.63 c	0.86 d	0.646 d	0.166 a	0.101 d
Ho Dome	Carrot	0.000 c	0.26 b	0.73 b	0.45 g	0.463 f	0.000 b	0.166 bc
Ho Dome	Lettuce	0.000 c	0.16 d	0.13 g	0.23 i	0.000 i	0.000 b	0.000 e
Ho Dome	Tomato	0.000 c	0.07 g	0.12 g	0.45 g	0.538 e	0.000 b	0.000 e
Shia	Cabbage	0.000 c	0.11 f	0.66 c	0.55 f	0.628 d	0.000 b	0.000 e
Shia	Carrot	0.000 c	0.21 c	0.38 f	0.58 f	0.341 g	0.000 b	0.000 e
Shia	Lettuce	0.040 a	0.13 ef	0.45 e	2.55a	0.345 g	0.000 b	0.167 b
Shia	Tomato	0.000 c	0.07 g	0.00 h	0.37 h	0.634 d	0.000 b	0.136 c
Lsd (0.01)		0.0003	0.03	0.04	0.06	0.067	0.008	0.029
CV		5.53	6.98	3.01	3.09	4.40	26.19	17.76

4.4.3.1 Gamma HCH

The results from the above on gamma HCH show a significant difference ($p<0.01$) among the interaction means which had the chemical detected and those that did not. While lettuce (0.040 mg/kg) and cabbage (0.035 mg/kg) from Shia and Ho Dome markets respectively showed a significant level in gamma HCH, there was however no residues (0.000 mg/kg) of the chemical in the other vegetable with their respectively point of sampling in terms of market.

4.4.3.2 Delta HCH

A different outcome was however noticed among the interaction means with respect to delta-HCH residues. Amount of the residues detected were significantly different ($p<0.01$). Three significant groups which were not different within a set were noticed. They were lettuce (0.13mg/kg) and cabbage (0.11mg/kg) collected from Shia market as well as carrot from Ho Central market (0.11mg/kg), lettuce sampled from Ho Dome (0.16mg/kg) and Central (0.15mg/kg) markets, and tomatoes from the three markets which had residual level of (0.07 mg/kg). The highest delta HCH residue was detected in cabbage sampled from Ho Central (0.34 mg/kg) while the least detected is (0.07mg/kg).

4.4.3.3 Heptachlor

A significant difference ($p<0.01$) in heptachlor concentration was recorded among the interaction means. Cabbage and tomato sampled from Ho Central and Shia markets respectively recorded the highest (1.85 mg/kg) and no (0.00 mg/kg) heptachlor residues respectively. Cabbages from the Shia (0.66 mg/kg) and Ho Dome (0.63 mg/kg) markets were third in highest, followed by lettuce (0.55 mg/kg) and carrot

(0.53 mg/kg) from Ho Central market that came fourth and then, lettuce (0.13 mg/kg) and tomato (0.12 mg/kg) from Ho Dome as well as Ho Central market tomato (0.13 mg/kg) which were had the least detection of heptachlor but insignificantly within a group.

4.4.3.4 Aldrin

Aldrin residue was also in different and significant level ($p<0.01$) among the interaction means of the market and the vegetable effect. In order of decreasing, Shia market lettuce had the highest level of Aldrin residues, followed by cabbage sampled from Ho Central market, carrot also from Ho Central, Ho Dome cabbage, Ho Central lettuce, then Shia cabbage and carrot, Ho Dome carrot and tomato, tomato collected from Shia and Ho Central markets and the least detected in Ho Dome lettuces. They had (2.55mg/kg, 1.28mg/kg, 0.93mg/kg, 0.86mg/kg, 0.71mg/kg), (0.55mg/kg and 0.58mg/kg), (0.45mg/kg), (0.37mg/kg and 0.35mg/kg) and (0.23 mg/kg) of Aldrin respectively.

4.4.3.5 *p, p'*-DDT

Level of *p, p'*-DDT detected in the vegetables sampled from their respectively markets were significantly different ($p<0.01$). Ho Central market tomatoes (2.41 mg/kg), cabbage (0.948 mg/kg) and carrot (0.747 mg/kg) had the highest, second and third highest concentrations in their respective order. Lettuce from the Ho Dome and Central markets recorded no and the least *p, p'*-DDT residues of (0.00 mg/kg and 0.234 mg/kg) while cabbage from Ho Dome and Central markets as well as Shia markets insignificantly recorded the same of *p, p'*-DDT residues and were fourth highest. Tomatoes and carrots sampled from the same source, Ho Dome market residues of the chemical followed the order of fifth and sixth while Shia market lettuce and carrot together came second to the least of *p, p'*-DDT residues detected among the vegetables.

4.4.3.6 *o, p'*-DDT

Unlike the *p, p'*-DDT, *o, p'*-DDT residue showed a difference ($p<0.01$), yet, was only detected in cabbage sampled from Ho Dome market. That is, no level of *o, p'*-DDT was detected in the other vegetables sampled from their respective source (markets).

4.4.3.7 *p, p'*-DDE

Similarly to the outcome seen in the immediate above, few of the vegetables from some markets showed *p, p'*-DDE and were significantly different ($p<0.01$). The highest level, 0.305 mg/kg of *p, p'*-DDE was detected in tomatoes sampled from Ho Central market. It was followed by (0.167 mg/kg) recorded in Shia market lettuce, then (0.166 mg/kg) in carrots from Ho Dome market but this level was not different from that recorded in Shia market tomato (0.136 mg/kg) as well as (0.167 mg/kg). The least of *p, p'*-DDE, (0.101 mg/kg) was detected in cabbages sampled from Ho Dome market. The following samples; cabbages, carrots and lettuce from Ho Central market, lettuce and tomatoes from Ho Dome market as well as cabbages and carrots from the Shia market showed no (0.000 mg/kg) detection of *p, p'*-DDE residue.

CHAPTER FIVE

5.0 DISSCUSSION

5.1 SOCIO-DEMOGRAPHIC INFORMATION ON FARMERS AND FARMING ACTIVITIES

5.1.1 Age Range and Level of Education of Farmers

This finding suggests that, most of the farmers (25) are in the age range of 18-55 (Table 4.1). This was attributed to the fact that vegetable farming requires a great deal of energy and dedication that can barely be provided by very young and too old people. Hamidu, et al (2006) reported young active farmers are more willing to adopt and practice new agricultural technology than older farmers. The result further revealed that, most of the respondent farmers had basic to secondary education (Table 4.1). This suggests that most of the respondents could read and write. Farming requires some degree of understanding of some basic principles. For example, a farmer with high literacy level would be able to read instructions on Good agricultural practices and appreciate the basic principles of production that can have positive effect on produce. A 1992 study on the value of education in small- scale agriculture in Nigeria found that; an increase in the average education of a farmer by one year increases the value added to agricultural production by 24 percent.

5.1.2 Years of Experience in Vegetable Farming

Majority of respondents (20) had 6 or more years of experience in vegetable farming (Table 4.2).This suggest that most of the farmers have been in the farming activity for quite a long period and had seen much as far as vegetable farming is concern. Long experience in vegetable farming will help farmers avoid mistakes a new grower might make such as; over watering, over application of fertilizer, timing of the season, etc.

5.1.3 Farmers Response to Fertilizer (Organic and Inorganic) Usage

The survey revealed that majority of respondents (80%) used fertilizer (organic and inorganic) on their farms (Table 4.3). Heavy application of fertilizer on vegetable crops leaves produce with high level of chemical residues and microbes from un-decomposed and untreated organic manure on vegetable produce. Several cases of typhoid fever outbreak have been associated with eating contaminated vegetables grown in or fertilized with contaminated soil or sewage (Beuchat, 1998). This finding agrees with earlier published literature identifying the presence and isolation of zoonotic pathogens in manure and on the surface of fresh produce (Moncrief and Bloom, 2005).

5.1.4 Mode of Fertilizer Application

According to the study, (30%) of respondent revealed they applied fertilizer to their vegetable crops through broadcasting (Table 4.4). Broadcasting most of the times may expose plant parts to chemicals which can be harmful when consumed. Careless use of manures can expose fresh produce to human pathogen like E. coli which can cause serious illness.

5.1.5 Source of Water for Watering

The study further revealed that, most of the respondents (76.7%) used water from dug wells, rivers and rain water to water their plants. Only few (10%) used treated pipe water. The scope of microorganism associated with spoilage or a contaminated fruit includes bacteria, parasites, protozoa and viruses; and these are often associated with contaminated water (Beuchat, 1998). If improperly managed, elements of fertilizer can move into surface water through field runoff or leach into ground water. Two main components of fertilizer that are of greatest concern to source water quality (ground water and surface water used as public drinking water supplies are nitrogen (N) and phosphorus (P).

5.1.6 Pesticide Usage at Pre Harvest

Pesticide usage is high among the respondents as revealed by the study. Almost all (93.3%) the respondents agreed using pesticides. This was confirmed in an earlier study by Dingman (2003) that; about 87% of the farmers who grow vegetable in Ghana uses all forms of` pesticides. Pesticides allow consumers to consume high quality produce that is free of insect blemishes and insect contamination. However pesticides are toxic and can cause serious health problems, pollute air, water and soil.

5.1.7 Day of Harvest after Pesticide Application

According to the findings, most of the farmers interviewed harvested within 6-15 days after pesticide application and 20% harvest within 5 days after pesticide application. Depending on the type of pesticide, harvesting can be done anytime. Labels on chemical give direction as to the ‘’ harvest interval ‘to observe. Harvest intervals are intervals set by EPA to allow time for the pesticide to break down in the environment, preventing residues on food. Harvesting before the ‘’harvest interval’’ elapse will leave chemical residues on your food.

Residues of pesticides contaminate soils and water, persist in the crops, enter the food chain, and finally are ingested by humans with foodstuffs and water. In Uganda (Tukahirwa, 1987), Mubuka farmers sprayed phosphamidon on tomato at a frequency of up to once per week to maturity.

5.1.8 Type of Organic fertilizer use by farmers

Majority of the farmers use poultry droppings as fertilizers. Poultry droppings in its excessive land application may lead to water pollution and soil toxicity.

5.1.9 Post Harvest Handlings

According to the study, it was revealed that majority of respondents (60%) used empty fertilizer bags, empty pesticide containers and fungicide bags as packaging materials. This findings agrees with scientists from the National Institute of Preventive and Social Medicine (NIPSOM) Bangladesh report that many farmers do not dispose off empty containers after use instead routinely recycle them. These containers when not cleaned well will contaminate produce and render them harmful for human consumption. Majority of respondent agreed they transport vegetables produce with other goods and also clean their vehicle before loading them with produce (Table 4.9).

A good number of respondents (76.7%) also agreed they transport vegetable produce with other goods. Transporting vegetable with other goods may end up contaminating or causing injuries to vegetable produce making them unsafe for consumption. Microbial cross contamination comes from food and non food sources and contamination may occur during loading, unloading, storage and transportation operations. Sablani, et al (2006) reported that the quality and nutritional value of fresh produce like tomato, is affected by post harvest handling and storage condition.

It was further revealed by the study that (36.7%) of transporters do not cleaned vehicles before loading produce. Vehicles when not cleaned, can serve as a point of contamination of vegetables. During production on the farm and all stages of product handling from harvest to point of sale, produce may be contaminated with pathogens

(Beuchat, 1996). The proper transport of fresh produce helps reduce the potential microbial contamination.

5.2 INFORMATION ON AGRO CHEMICAL DEALERS

5.2.1 Age Group and Gender of Agro-Chemical Dealers

It was revealed in the survey that larger number of the agro-chemical dealers (14) interviewed falls in the age bracket 25-40, with (9) being male and (5) females (Table 4.10).The result indicates that a bit of maturity and trust is needed of chemical handlers and people among this age are dim to posses this qualities by Ghanaian cultural set up. And there is also a local perception that women who have long exposure with chemicals have difficulties conceiving; hence the indication of more male than females among the agro chemical sellers.

5.2.2 Educational Level of Agro Chemical Dealers

Majority of agro chemical sellers had up to secondary education whiles only few do not have any formal education (Table 4.1`). Because of the technical know-how required of chemical sellers, an acceptable level of education is demanded of them to be able to properly handle chemicals and also educate farmers on proper and efficient use of chemicals. This finding agrees with World health Organisation (2001) in agricultural census reported that most of the agro chemical operators are hired farm workers that lack agricultural background and use employment in the agric sector as an entry level job.

5.2.3 Years of Experience in Selling Agro Chemical

The survey revealed that half of the respondents 15(50%) had 11 years or more experience in agro chemical sales. Yearly training programmers' are held for agro chemicals sellers to sharpen their knowledge on agro chemicals, so the more the years in the business the more training workshops you had participated in. In one the training workshop held in Ho, Volta region; a senior programme officer of the (EPA) reported that many agro-chemical sellers have either developed chronic diseases or died from unsafe handling of agro-chemicals(GNA Tuesday 17 May,2011).

5.2.4 Agro Chemical Dealers and Their Interaction with Farmers

Almost all the dealers 28 (93.3%) were legally registered with the authorities to sell chemicals. All the sellers agreed to constantly educate farmers on correct use of chemicals and that they only sell authorized chemicals (Table 4.13). Registering with appropriate authorities will ensure orderliness in the conduct of business, all safety regulations are observed and suitable location of store away from food handlers. Olaleye *et al.* (2013) reported that the most widely practiced safety measure was avoiding ingesting or inhaling chemicals.

5.3 INFORMATION ON TRADERS

5.3.1 Age Range and Gender of Traders (Wholesalers and Retailers)

Ages of the sellers indicates that, no minor (under age 18) is involved in the trade (Table 4.14). About 14(46.7%) of traders had no formal education, however 11(36.7%) had basic education. Minimal education is required of vegetable sellers to be able to appreciate the need for safety practices in food handling.

5.3.2 Places for Storing Vegetables

Most vegetable sellers stored vegetables in kiosks, and only few stored in the open (Table 4.15). One most common challenge in agriculture in developing countries is lack of appropriate storage facilities. Fresh products like fruits, vegetables , meat and fish straight from the farm or after the catch can be spoilt in hot climate due to lack of infrastructure for transportation, storage, cooling and markets (Rolle , 2006;stuart, 2009). Poor storage facilities and lack of infrastructure cause postharvest losses of food in developing countries. Most storage facilities do not provide enough protection from the external environment.

5.3.3 Safety in Food Handling

The study again revealed that most of the storage facilities do not offer enough protection from the external environment. Fresh vegetable become easily contaminated when not well stored in a healthy environment. The survey revealed that most sellers do not use protective gears whiles handling fresh vegetables and also display fresh vegetable produce on open packs. All these could lead to product contamination.

5.4 INFORMATION OF CONSUMERS

5.4.1 Age Range and Gender of Consumers Interviewed

This finding from the survey shows that the entire respondents in the various age groups and gender consume vegetables in one way or the other (Table 4.17). This goes in line with earlier findings of (Anon, 2007) that consumption of fresh vegetable produce has been on the increase.

5.4.2 Level of Education of Consumers

All the consumers interviewed had one form of education or the other. This shows the high level of awareness of the nutritional benefits of vegetables by consumers (Table 4.18).

5.4.3 Quality Parameters Look For In Vegetable by Consumers

According to the survey, a high number of the consumers 12 (40%) indicated that they look at general appearance of vegetables before buying whiles 7(23.3%) indicated they look at Texture. Appearance and texture are considered important quality parameters in fruits and vegetables as confirmed in this survey. A buyer might not buy a vegetable full of defect and blemishes.

5.4.4 Consumers Awareness of Nutritional and Health Issues on Vegetables

According to the study, 26 (86.7%) of the consumers agreed they are aware of the nutritional benefits of vegetables whiles the rest said otherwise. All the consumers 30 (100%) interviewed agreed they clean their vegetables before using, and out of 30 consumers interviewed, only 4(13.3%) said they ever had stomach disorder after consuming vegetables. All of these responses from consumers indicate they are fully aware about the benefits and health applications as a result of vegetable intake (Table 4.20).

5.5 VITAMIN COMPOSITION OF THE VEGETABLES

Vitamin A content varied in the four vegetables. The difference might be due to the genetic variation among the four vegetables. Likewise, there was a significant effect of the markets on the composition of vitamin A. Thus, activities such as processing, packaging, display of the vegetables carried out at the market centres might have caused the differences. The results showed that, vegetables collected from the Shia market contained the highest content of vitamin A while those sampled from the Ho Dome market contained the lowest. It is possible that, postharvest activities carried by handlers (growers and sellers) varied. Cultural practices, genetic factors, maturity at harvest, wounding and storage (Florkowshi *et al.*, 2009) are reported factors known to affect vitamin composition of fruits and vegetables. The interaction of the vegetable type and market effect highly showed a significant difference with cabbages and tomatoes from Ho Dome and Central markets recorded the highest and the lowest vitamin A respectively. The difference among the vegetables from their respective market centres is highly due to singly effect recorded by the factors.

No difference was seen among the markets' influence on the vegetables with regards to vitamin C content for the fact that, they may have been displayed and affected by sunlight intensity and heat temperature at equal magnitude. This is in support of Sawant (2011) research, for which it was argued that, sunlight, heat temperature and microwave radiation affect and destroy vitamin C in foods. Similarly, no difference among the interaction between the markets and vegetable type was recorded except with lettuce and cabbages sampled from Ho Dome and Shia markets respectively. That is, postharvest activities; like display of vegetables in sunlight, high temperatures (Boon *et al.* 2010), processing, storage and preparation (Emese and Nagymate, 2008: Davey *et al.*, 2000) could have had a great impact and caused the difference. Similarity seen among the rest of the interaction means may have resulted as due to them subjected to the same treatments.

Vegetables showed different significant levels of vitamin D. This may be due to cultural practices, genetical factors or environmental conditions. Carrot was very rich while tomatoes were comparatively poor in the vitamin. Lettuce was also richer in vitamin D than cabbage. Ho Central markets vegetables were generally considered best with regard to vitamin D while those from Shia market were significantly poor in the vitamin. Singly, the effect of vegetable types and market centres had a significant impact on the interaction. At each market, the quantity of vitamin D was high in carrot, followed by lettuce, then cabbage and the lowest, in tomato. This difference as seen from the results may have varied due to varietal variations, stage of maturity, temperature and exposure of the vegetables to light during transport and storage. Several reports also states that, micronutrients concentrations (IUFOST, 2013) as well as vitamins and postharvest compositional changes (Lee and Kader, 2000: Amarowicz *et al.,* 2009) of plant foods occur, depending on the conditions like temperature, exposure to light (Patras *et al.* 2010, Boon *et al.,* 2010) and duration of transport and storage (Xianquan *et al.*, 2005). Cavalieri (1998) and Kader (1992) also confirmed that, each subsequent step after harvest has the potential to either maintain or reduce quality; few postharvest procedures can improve the quality of individual units of the commodity.

5.6 LEVEL OF MICROBIAL CONTAMINATION

Microbial infections of food borne origin are a major public-health problem internationally and are significant cause of death in developing countries (WHO, 2006). And the vegetables sourced from the three markets analysed for contamination indicators showed the presence of faecal enterococci, *Escherichia coli* (which are forms of faecal coliforms) and moulds were isolated as the pathogenic organisms. These and other contaminants detected on the vegetables were in varying quantities. According to (Harris *et al.*, 2003), most of these microbiological contaminants of humans and animal faecal origin poses health threat to consumers. Manure, which had again an increased popularity as result of consumers seeking organically produced fresh produce (Suslow *et al.,* 2003) may be a source of contaminants like pathogenic bacteria and fungi (moulds) in soil when applied at a surface level. Coetzer (2006) regarded untreated manure as a potential source of heavily loaded pathogens. This was similar to report by Donkor *et al.,* (2010) that, high level of coliform and faecal coliform may be likely due to manure soil contamination. These pathogenic organisms infest vegetables through flooding and water splashing during irrigation.

The results on the vegetables showed that, tomato on general note, had the least level of bacteria contaminants with regard to faecal enterococci (*E. faecalis and E. faecium*), *E. coli* (types of faecal coliforms) and moulds irrespective of a higher total viable count of pathogenic organisms recorded, second to lettuce. Lettuce on many occasions was heavily contaminated with faecal coliforms, noted by a high *E. coil* and faecal enterococci and moulds. Similarly, cabbage was highly prone and contaminated with faecal enterococci and *E. coil* than in lettuce. This was indicated by high coliforms count (faecal origin). Moulds count in lettuce was very low as well as with viable counts of the pathogenic organisms. Carrot, a root vegetable may be regarded quite safe as it recorded a minimal of level of faecal enterococci, *E. coli* and moulds reflected by a very low total viable count of pathogens, though, recorded the highest number coliforms similar to that of lettuce.

Differences recorded among the vegetables with regards to the contaminant indicators may be mainly due to the kind of fertilizers and water used for irrigation. A reported finding of contaminants on lettuce, a leafy vegetable by Solomon *et al.* (2002) isolated *E. coli* 0157:H7 which infested the crop through root system from manure-contaminated soil and irrigation water. It thus means that, without direct exposure of pathogens (Chalmers *at al.*, 2000: Kudva *at al.*, 1998) cause by water splash and flooding to the vegetables, they could get contaminated through roots systems during absorption of soil water and nutrients. The micro organisms present in fruits and vegetables are direct reflection of the sanitary quality of the cultivation water, harvesting, transportation, storage, and processing of the produce (Beuchat, 1996; Ray and Bhunia, 2007). Also, genetic variations and degree of resistivity built due to morphological characteristics as well as postharvest activities like handling of the vegetables could influence level of contaminants. Proximity of the edible parts of vegetables especially lettuce and cabbage to the soil is a lead cause of very high incidence of *E. coli* and faecal enterococci recorded as well as other coliforms and moulds count.

The level of contamination due to activities carried by the sellers at the markets differed significantly with regard to the contaminant indicators. The results indicated that, postharvest activities and the surroundings of the Shia market may have contributed heavily to the level of contaminants found on vegetables sampled from there. Shia market had a very high total viable count of the microbial contaminants, which resulted in high faecal enterococci, *E. coli* (coliforms) and moulds count on the vegetables sourced. Contrary, Ho Central market contributed least to faecal coliforms like *E. coli* and moulds due low viable count of pathogens but very high faecal enterococci. Likewise, Ho Dome market recorded a very low faecal enterococci count but an extremely high *E. coli* and moulds which accounted for a high coliforms count. Some postharvest activities at the various markets like mode of transporting, handling and washing, packaging and display of the vegetables in the markets may have significantly contributed to the difference. Similarly, Drechsel *et al.* (2006) stated that, variation in quality of vegetables occur on farms and during postharvest handling of vegetables. Unclean surroundings and several contacts of the vegetables by humans may also serve as point of contamination as well as repeated washing of the vegetables in unchanged water.

These bad practices by most sellers contribute significantly to microbial contaminants on produces especially with lettuce, tomatoes and carrots. The interaction of the vegetables and the markets also showed a significant difference. These differences in the contaminants were greatly influenced by the activities carried by seller on the vegetables at the market centres as well as the morphological characteristics of the four vegetables due to genetic variations.

5.7 PESTICIDE RESIDUES ON THE VEGETABLES

Most vegetable producers resort to the use of very high potent chemicals (pesticides) for the control pests attacked on their farmers. Some of these pesticides take a longer time to degrade or breakdown after use. Producers' inabilities to correctly adhere to instructions on chemical labels cause them in many cases, to apply extreme volumes to their produces under siege. Many of these farmers spray the same wide range of pesticides on all vegetables and ignore pre-harvest intervals (Ntow *et al.*, 2006). As a result, these poisonous chemicals residues beyond acceptable level are detected upon test if enough time is not allowed for the chemicals to breakdown completely. These chemicals compromise on the quality of the vegetables unwholesome for consumption and poses health threat where levels of residues are high above the international acceptable minimal residue levels (MRL). The outcome of the residues detected in the vegetables showed that, heptachlor, Aldrin and *p, p'*-DDT were in relatively higher concentration ,this agrees with findings by Horna et al, (2007) that farmers in Ghana currently use higher than recommended doses of pesticides. While gamma HCH, *o*, *p'*-DDT and *p, p'*-DDE were found in relatively lower quantities. Delta HCH was also detected in a considerable lower volumes among the four vegetables. The difference recorded could be as result of direct treatment of the vegetables with chemicals while on the field and in some cases, residues could be from water source. According to Drechsel *et al* (2006), the use of polluted water is common in Ghana. And residues in water usually occur from indirect environmental contamination as result of persistence, mobility and solubility by chemicals which contaminated surface water and ground water (Hamilton and Crossley, 2004).

A very high concentration of delta HCH, heptachlor and *o, p'*-DDT with high gamma HCH, Aldrin, *p, p'*-DDT. Literature (Mukherjee and Gopal, 1996; Dogheim et al., 1996; Elliion et al., 2000) reveals that vegetables may contain remnants of insecticides above the prescribed maximum residue levels (MRL), which may pose health hazard to the consumers. Unlike cabbage, there was no *o, p'*-DDT, an isomer of commercial DDT (FDA, 2000) detected in carrot, lettuce and tomato. Similarly, no gamma HCH residue was found in carrot and tomato. Tomato had a very high residues of *p, p'*-DDT and *p, p'*-DDE but very low delta-gamma, heptachlor and Aldrin residue compared to the other three vegetables. The presence of DDT metabolites shows amount of exposure to DDT. This was agreed on by (Bumbus and Aust 1987), that high level of DDD and DDE are as a result of DDT which is known to biodegrade to DDE under aerobic and to DDD in anaerobic conditions. Very high gamma HCH and Aldrin as well as high *p, p'*-DDE were recorded in lettuce but had a minimal level of delta HCH and heptachlor residues. This findings agrees with (fordjuor, 2011), who reported high concentration of DDT (metabolites) in lettuce in a study to investigate pesticide contamination of vegetable farms along the Onyasia stream in ga east municipality greater Accra Region Ghana.Carrots sampled showed a considerable high level of delta HCH, heptachlor, *p, p'*-DDE and then, a low of Aldrin and *p, p'*-DDT residues. In fact, these residual concentrations of chemicals as shown in the result compromise on safety and quality. And all the chemicals residues detected in the vegetables revealed by result signal a very poor farming practices and use of the banned chemicals as well as misapplication of the chemicals by vegetables growers. Drechsel *et al.*, (2006) pointed out that, farmers in their quest to control pest and diseases use band chemicals such as DDT, Endosulfan, Lindane and Chlorphyrifos on vegetables.

Vegetables from Ho Central market showed absence of gamma HCH and *o, p'*-DDT residues but had a high delta HCH, Aldrin as well as an extremely high heptachlor and *p, p'*-DDT residues. No *o, p'*-DDT and a very low delta HCH and heptachlor were detected in vegetables from Shia market, yet also had a high gamma HCH and Aldrin. A significant equal *p, p'*-DDE residue was noted in vegetables sampled from the markets. Difference in the level of chemical residues detected in the vegetables from different market may be as result of the sellers purchasing their vegetables from different source with different farming practises instituted by vegetable growers.

Lettuce and cabbage sampled from the Shia and Ho Dome markets recorded a significant difference with regards to gamma HCH residues as indicated in Table 4.8 and 4.9. It is possible that, these leafy vegetables were sourced from similar farms and producers adapt to a peculiar pesticide for spraying of their farmers. Similarly, *o, p'*-DDE was only detected in cabbage from Ho Dome market. It means that, parent DDT had undergone degradation. According to FDA (2013), DDE is formed during degradation by elimination of HCl. A significant interaction difference were also noted among the interaction means with regards to delta HCH, heptachlor, Aldrin, *p,* *p'*-DDT. Thus, use of these chemicals varies depending vegetable types on the farm and their capability to be washed off as result of their solubility property.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

Even though the vegetable sampled had an appreciable vitamin content, high amount of microbial and pesticide residue detected on them could go a long way to affect the full benefit one might have derived from consuming them. The study has shown that, there are high microbial and pesticide contamination of vegetable consumed in the study area and could pose health risk to consumers. Safety practices associated with vegetables production and handling should be well check and practice religiously. Manure used as fertilizer should be treated either by composting or aging to eliminate pathogenic microorganisms and farmers should be educated on the need to allow sufficient period of time between the final fertilizer(organic and inorganic) application and harvest.

All postharvest procedures should aim at minimizing contamination. There is an additional need to wash and heats treat vegetables to before consumption

6.2 RECOMMENDATION

Results of this study indicate a need for further research to investigate the specific cause of high microbes on vegetables investigated in the study area. Also study should be carried out to investigate the specific pathogen present on the vegetables .Study should be carry out on the sanitation of these specific markets in the study. In-depth analysis should be carry out in the study area to identify food handlers (from farmer to consumer) contribution to microbial presence of food. Lastly there is the need for intensive education on safe handling of food in the supply chain. Organic farming where less or no inorganic fertilizers are used should also be encouraged.

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APPENDICES

Appendix I: Maximum residue levels, MRLs (µgg^{-1})

Maximum residue levels, MRLs (µgg^{-1})										
Commodity	lindane	Aldrin	Dieldrin	Endrin	p,p DDT	Heptachlor	O,p-DDD	Delta HCH	o,p-DDT	o,p-DDE
Tomatoes	0.01	0.01	0.01	0.01	0.05	0.01	0.05	0.01	0.05	0.05
lettuce	0.01	0.01	0.01	0.01	0.05	0.01	0.05	0.01	0.05	0.05
Cabbage	0.01	0.01	0.01	0.01	0.05	0.01	0.05	0.01	0.05	0.05
Carrot	0.01	0.01	0.01	0.01	0.05	0.01	0.05	0.01	0.05	0.05
Onion	0.01	0.01	0.01	0.01	0.05	0.01	0.05	0.01	0.05	0.05
Cucumber	0.01	0.02	0.02	0.01	0.05	0.01	0.05	0.01	0.05	0.05

Appendix II: ANOVA Table of vitamin A, C and D

Analysis of Variance Table for vitamin A

Source	DF	SS	MS	F	P
Reps	2	0.00105	5.250E-04		
Market	2	17.0650	8.53251	71738.3	0.0000
Vegetable	3	7076.97	2358.99	2.0E+07	0.0000
Market*Vegetable	6	91.3319	15.2220	127981	0.0000
Error	22	0.00262	1.189E-04		
Total	35	7185.37			

Grand Mean 75.618 CV 0.01

Analysis of Variance Table for vitamin C

Source	DF	SS	MS	F	P
Reps	2	109.45	54.723		
Market	2	18.96	9.481	0.17	0.8424
Vegetable	3	895.85	298.615	5.44	0.0059
Market*Vegetable	6	288.77	48.129	0.88	0.5274
Error	22	1206.96	54.862		
Total	35	2519.99			

Grand Mean 31.900 CV 23.22

Analysis of Variance Table for vitamin D

Source	DF	SS	MS	F	P
Reps	2	0.00487	0.002		
Market	2	1.79389	0.897	464.73	0.0000

Vegetable	3	1067.71	355.903	184401	0.0000
Market*Vegetable	6	22.4802	3.747	1941.24	0.0000
Error	22	0.04246	0.002		
Total	35	1092.03			

Grand Mean 27.124 CV 0.16

Appendix III: ANOVA tables of E. coli, faecal enterococci, faecal coliforms, total coliforms, total moulds and total viable count

Analysis of Variance Table for Escherichia coli

Source	**DF**	**SS**	**MS**	**F**	**P**
Reps	2	0.00002	0.00001		
Market	2	0.50585	0.25293	4022.42	0.0000
Vegetable	3	6.56660	2.18887	34810.9	0.0000
Market*Vegetable	6	2.50855	0.41809	6649.17	0.0000
Error	22	0.00138	0.00006		
Total	35	9.58240			

Grand Mean 5.0833 CV 0.16

Analysis of Variance Table for Faecal Enterococci

Source	DF	SS	MS	F	P
Reps	2	1.667E-05	8.333E-06		
Market	2	3.44645	1.72323	21258.5	0.0000
Vegetable	3	177.889	59.2963	731506	0.0000
Market*Vegetable	6	12.1812	2.03019	25045.4	0.0000
Error	22	0.00178	8.106E-05		
Total	35	193.518			

Grand Mean 5.7242 CV 0.16

Analysis of Variance Table for Faecal Coliforms

Source	DF	SS	MS	F	P
Reps	2	0.0001	0.00005		
Market	2	0.0708	0.03541	670.95	0.0000
Vegetable	3	9.6289	3.20963	60813.9	0.0000
Market*Vegetable	6	0.6218	0.10363	1963.58	0.0000
Error	22	0.0012	0.00005		
Total	35	10.3228			

Grand Mean 6.1219 CV 0.12

Analysis of Variance Table for Total Coliforms

Source	DF	SS	MS	F	P
Reps	2	0.0004	0.00019		
Market	2	0.7280	0.36402	9.93	0.0008
Vegetable	3	24.2822	8.09406	220.68	0.0000

Market*Vegetable	6	1.0186	0.16976	4.63	0.0035
Error	22	0.8069	0.03668		
Total	35	26.8361			

Grand Mean 8.0161 CV 2.39

Analysis of Variance Table for TVC

Source	**DF**	**SS**	**MS**	**F**	**P**
Reps	2	0.00007	0.00003		
Market	2	0.01115	0.00557	79.99	0.0000
Vegetable	3	0.75907	0.25302	3630.36	0.0000
Market*Vegetable	6	0.17505	0.02917	418.60	0.0000
Error	22	0.00153	0.00007		
Total	35	0.94687			

Grand Mean 5.2708 CV 0.16

Appendix III: ANOVA tables of Aldrin, Heptachlor, delta HCH, gamma HCH, o,p-DDT, p,p-DDE and p,p-DDT

Analysis of Variance Table for Aldrin

Source	DF	SS	MS	F	P
Reps	2	0.0013	0.00063		
Market	2	1.6373	0.81864	1423.32	0.0000
Vegetable	3	3.7296	1.24319	2161.47	0.0000
Market*Vegetable	6	7.8097	1.30162	2263.04	0.0000
Error	22	0.0127	0.00058		
Total	35	13.1905			

Grand Mean 0.7749 CV 3.09

Analysis of Variance Table for Heptachlor

Source	DF	SS	MS	F	P
Reps	2	0.00008	0.00004		
Market	2	1.13566	0.56783	2377.85	0.0000
Vegetable	3	4.43876	1.47959	6195.94	0.0000
Market*Vegetable	6	2.25558	0.37593	1574.25	0.0000
Error	22	0.00525	0.00024		
Total	35	7.83534			

Grand Mean 0.5132 CV 3.01

Analysis of Variance Table for delta HCH

Source	DF	SS	MS	F	P
Reps	2	0.00014	0.00007		
Market	2	0.01715	0.00858	67.65	0.0000
Vegetable	3	0.13522	0.04507	355.56	0.0000
Market*Vegetable	6	0.09511	0.01585	125.04	0.0000
Error	22	0.00279	0.00013		
Total	35	0.25042			

Grand Mean 0.1613 CV 6.98

Analysis of Variance Table for gamma HCH

Source	DF	SS	MS	F	P
Reps	2	1.735E-07	8.677E-08		
Market	2	7.215E-04	3.608E-04	2980.55	0.0000
Vegetable	3	0.00144	4.787E-04	3955.21	0.0000
Market*Vegetable	6	0.00500	8.327E-04	6879.19	0.0000
Error	22	2.663E-06	1.210E-07		
Total	35	0.00716			

Grand Mean 6.29E-03 CV 5.53

Analysis of Variance Table for o,p-DDT

Source	DF	SS	MS	F	P
Reps	2	0.00003	0.00001		
Market	2	0.01384	0.00692	524.85	0.0000
Vegetable	3	0.02076	0.00692	524.85	0.0000
Market*Vegetable	6	0.04152	0.00692	524.85	0.0000
Error	22	0.00029	0.00001		
Total	35	0.07643			

Grand Mean 0.0139 CV 26.19

Analysis of Variance Table for p,p-DDE

Source	DF	SS	MS	F	P
Reps	2	0.00051	0.00026		
Market	2	0.00073	0.00037	2.18	0.1373
Vegetable	3	0.06889	0.02296	136.76	0.0000
Market*Vegetable	6	0.27108	0.04518	269.09	0.0000
Error	22	0.00369	0.00017		
Total	35	0.34491			

Grand Mean 0.0730 CV 17.76

Analysis of Variance Table for p,p-DDT

Source	DF	SS	MS	F	P
Reps	2	0.0009	0.00047		
Market	2	3.2630	1.63148	1924.82	0.0000
Vegetable	3	4.7711	1.59038	1876.32	0.0000

Market*Vegetable	6	4.0450	0.67416	795.38	0.0000
Error	22	0.0186	0.00085		
Total	35	12.0987			

Grand Mean 0.6612   CV 4.40

Appendix IV: Display of vegetables at markets

Plate 1: Sample of tomato fruits at market centre

Plate 2: Carrots displayed for sale

Plate 3: Lettuces packaged in plastic bowl and basket

Plate 4: Cabbages packed into fertilizer sacks and pans

Plate 6: Cabbage on display for sale

Plate 5: Refuge container at point of sale

Appendix 1V: Sample of questionnaire administered for during the survey

SAMPLE OF QUESTIONNAIRE ADMINISTERED DURING THE SURVEY

QUESTIONNAIRE FOR CHEMICAL SELLERS

BACKGROUND INFORMATION

1. Age range:

Below 18 years ( ) between 18 – 24 years ( ) between 25 – 40 years ( )

Between 41 -55 years ( ) Above 55 years ( )

2. Gender: Male ( ) / Female ( )

3. Level of Education A. No Formal Education ( ) B. Basic Education ( ) C. Secondary Education ( ). D. Tertiary ( ) E. Others please specify………………………………………

4. How long have you been selling agro chemical A. less than 5 years ( ) B.6 -10 years ( ) C.11 or more years

5. Are you a registered agro chemical dealer? A. yes ( ) b. no ( ), if no, go to 7

6. If yes, which associations are you registered with?

Specify…………………………..

7. Which of these companies are your suppliers? A. Chemico Ghana Ltd ( ) B. Sunshine ( ) C. Dizengoff Ghana ( ) D. K . Badu ( ) E. Wienco Ghana ( ) F others please specify……….

8. Are these these companies registered to sell agro chemicals? A. yes ( ) b. no ( )

9. Do you educate buyers (farmers) on health concerns and right usage of chemical? A. yes ( ) b. no ( )

10. Do you ensure that only environmentally acceptable and un-prohibited chemicals are sold to farmers? A. yes ( ) b. no ( ), if no, give reasons……………………………………………

11. Do you receive feed backs from farmers on the performance of chemicals bought from your shop? A. yes ( ) b. no ( )

12. If yes, what are some of these feedbacks? A. the chemical worked well ( ). B traces of the chemicals can still be seen on produce ( ) C. undissolved chemicals can still be seen in the soil ( ) D. others please specify…………..

QUESTIONAIRE FOR VEGETABLE FARMERS

BACKGROUND INFORMATION

1. Age range:

Below 18 years ( ) between 18 – 24 years ( ) between 25 – 40 years ( )

Between 41 -55 years ( ) Above 55 years ( )

2. Gender: Male ( ) / Female ( )

3. Level of Education A. No Formal Education ( ) B. Basic Education ( ) C. Secondary Education ( ). D. Tertiary ( ) E. Others please specify……………………………………….

PRE-PRODUCTION PRACTICES

4. Which of these vegetables do you grow? A. cabbage ( ) B. lettuce ( ) C. tomatoes D. Carrot ( ) E .Others please specify……………………………………………………………………………

5. What is the average area planted? A. less than 1 hectare ( ) B. 1-5 hectare C. 6-10 hectare ( ) C.11-15 hectares.( ) D. above 16 hectares ( )

6. How long have you been growing vegetables A.2-3yrs ( ) B.4-5yrs ( ) C.6-7yrs ( ) D. Above 7yrs ( )

7. Does the soil condition limit the quality of production? A. yes ( ) B. no ( )

8. Where do you get your planting materials from? A. from certified agro seed dealers ( ) B. from friends ( ) C. produce my own planting materials ( ) D. others please specify……………………

9. Are seeds or planting materials of good quality A. yes ( ) B. no ( ) If no, go to 11

10. If yes, can adequate supplies be obtained when needed? A. yes ( ) B. no ( )

PRODUCTION PRACTICES

11. What cultural practices are performed at the farm? A. watering ( ) B. pest control ( ) C. fertilizer application ( ) D. others please specify…………………………………………

12. Do you apply manure to your crops? A. yes ( ) B. no ( ), if no, go to 12

13. If yes, what type of manure? A. organic ( ) B. inorganic ( ) if inorganic, go to 15

14. If organic, which are they well decomposed before use? A. yes b. no

15. What is the mode of application of manure? A. side placement ( ). B. spraying ( ) C. broadcasting ( ) D. through irrigation sprinklers ( )

16. which of these organic manures do you use most A. poultry droppings ( ) B. human waste ( ). C. compost ( ) D. other animal droppings ( )

17. Name the inorganic fertilizer you mostly use………………………………………

18. What is your source of water for watering? A. dug well ( ) B .pipe C. rain ( ) D .river ( ) E. irrigation ( ) F. other please specify…………………………………………………

19. If irrigation, what is the nature of the water used for irrigation? A .clean ( ) B. not clean ( ) C .other please specify……………………………………………………………….

20. Are there any insects or pest that affects the quality of produce?

A. yes ( ) B .no ( ) if no, go to 23

21. If yes, name the pest/insect A. worms ( ) B. insect ( ) C. rodents D other please specify

………………………………………………………………………………………..

22. How does the above pest/insect affect the quality of produce? A. bore hole ( ) B. bite product ( ) C. dropping ( ) D. others please specify……………………………………….

23. Do you apply pesticides to the crop as a pre harvest treatment? A. yes ( ) B. no ( )

24. If yes name it……………………………………………………………………

25. How many days interval do you wait before harvesting after pesticides application? A. below 5 days ( ) B.6-10 days ( ) C.11-15 days D.16-20 days ( ) E. above 21 days ( )

HARVESTING AND ON THE FARM PRACTICES

26. Who harvest the crop? A. skilled labourers ( ) B. unskilled labourers ( ) C .others please specify…………………………………………………………………

27. What tools are used for harvesting produce? A. sterilized tools ( ) B. unsterilized tools ( ) C. others please specify………………………………………………

28. What containers are used for collecting the harvest produce? A. basket ( ) B. bins () C. plastic trays ( ) D. others please specify……………………………………………………………

29. How often are these containers cleaned after use? A. not cleaned at all ( ) B. after every use ( ) C. Once in a while ( ). D others please specify………

30. How is harvesting done? A plucking ( ) B. uprooting ( ) C. cutting ( ) D .pulling ( ) E. others please specify……………………………………………………………….

31. Does the method of harvest affect the quality of produce available for market? A. yes ( ) B. no ( ) if no, go to 33.

32. If yes explain. A. cracks ( ) B. breaks ( ) C. punctures ( ) D. bruise ( ) E. others please specify…………..

33. What criteria are used by the pickers in selecting the product for harvest? A. full ripe ( ) B. shape ( ) C. Colour change ( ) D. Texture ( ) others please specify………………………………

34. What kinds of post harvest treatments are used? A. Cleaning ( ) B. trimming ( ) C .waxes ( ) D. chemical treatment ( ) E .hot water dip ( ) F. others please specify……………………………

…………………………………………………………………………………

35. Does the post- harvest treatment practices have effects on the quality of the produce

A. yes ( ) B. no ( ) if no, go to 37

36. If yes explain………………………………………………………………………………

…………………………………………………………………………………………

ON FARM STORAGE

37. What kind of packages is used to package the produce for transport and storage?

A. jute sack ( ) B. wooden boxes ( ) C basket ( ) D. polythenne bags ( ). D. others please specify ……………………………………………………………………….

38. Are packages reused or recycled? A. yes ( ) B .no ( ) if no, go to 40.

39. If yes how are the containers treated before re-used? A. cleaned with water ( ) B. clean with disinfectants ( ) C. others please…………………………………………………………………

40. Are empty fertilizer, pesticides and fungicides bags washed and use as packaging materials? A. yes ( ) B. no ( )

41. Does jute bags used for packaging lined with plastic film before using A. yes ( ) B. no ( )

44. Do you cool the produce after harvest? A. yes ( ) B. no ( ) if no, go to 46.

45. If yes how is the produce cooled? A.dip in water ( ) B. pass through water ( ) C. others please specify………………………………………………………………………………

46. Do you store the vegetables A. yes ( ) B. no ( ) if no, go to 48.

47. If yes where do you store the vegetables A. room ( ) B. ware house ( ) C. Farm ( )

48. How long do you store the produce? A 1 day ( ) B.2-4 weeks ( ) C.5-7 weeks ( ) D above 7 days ( )

TRANSPORTATION OF VEGETABLES

49. What type of vehicle do you use to transport the produce? A. open truck B. cargo truck C. others please specify………………………………………………………………………..

50. Do you clean the vehicle before loading? A. yes ( ) B. no ( ) if no, go to

51. If yes how is it done? A. washing with water ( ) B. Cleaning with disinfectants ( ) C. fumigation ( ) D. others please specify……………………………………………………………

52. How is produce loaded and unloaded? A. carried on head ( ) B. throwing ( ) C. fork lift ( ) D. others please specify…………………………..

53. Is the produce loaded together with other produce? A. yes ( ) B. no ( )

54. How long does it take to transport the vegetables to the market? A.1 day ( ) B.2 days ( ) C.3 days ( ) D. above 3 days ( )

55. Do you have problem with your transportation? A. yes ( ) b. no ( )

56. If yes state the problems A. rotten ( ) B. sprouting ( ) C. decaying ( ) D. browning ( ) E. others please specify……………………………………….

QUESTIONNAIRE FOR CONSUMERS ONLY

BACKGROUND INFORMATION

1. Age range:

Below 18 years ( ) Between 18 – 24 years ( ) Between 25 – 40 years ( )

Between 41 -55 years [ ] Above 55 years [ ]

2. Gender: Male [ ] / Female [ ]

3. Level of Education A. No Formal Education ( ) B. Basic Education ( ) C. Secondary Education ( ).D. Tertiary ( ) E. Others please specify

…………………………………………

4. Which of these vegetables do you consume most?

A. cabbage ( ) B. lettuce.( ) C. tomatoes ( ) D. carrot ( )

5. How often do you consume vegetable in a week?

A. Once ( ) B. twice ( ) C. thrice ( ) D. four times and above ( )

6. What is the main source of the vegetables you often eat?

A. Self ( ) B. Sellers ( )

7. What quality parameters do you look for in a vegetable for food?

A. appearance ( ) B. aroma ( ) C. colour ( ) D. texture ( )

8. Do you store vegetables after buying? A. yes () B. no ( ) If no, go to10

9. If yes, which of the following storage method is applicable to you? A. refrigerator

A. ( ) B. floor ( ) C. in the open kitchen ( )

10. Are you aware of the nutritional benefits of vegetables A. yes ( ) B. no( )

11. Do you think consuming vegetable raw is more nutritious than heat treatment?

A. Yes ( ) B. No ( )

12. As a consumer, do you think vegetables provides more healthy food alternative as compared to other food products? A. yes ( ) B. no ( )

13. Do you clean your vegetable before consuming A. yes ( ) .B no ( )

14. If yes, which of the following cleaning methods do you use?

A. in a running pipe ( ) B. in a bowl ( ) C. Vinegar ( ) D. napkin ( )

15. What is your reason for cleaning? A. better appearance ( ) B. remove dirts ( )

C. removes microbes ( ) D. removes chemical residues ( )

16. Do you often experience any stomach discomfort and taken ill following intake of vegetables? A. yes ( ) B. no ( )

17. Which of the following do you use your vegetables for?

A. soup ( ) B. salad ( ) C. stew ( ) D. others please specify

…………………………………………………………………………………………………….

18. Any health concerns pertaining to vegetable consumption you will like us to know?